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RESEARCH ARTICLE

Health literacy across personality traits among older adults: cross-sectional evidence from Switzerland

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Abstract

This research aims to better understand the association of personality traits (PT)—Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism—with health literacy (HL) skills of adults aged 58 years and older in a nationally representative sample from Switzerland. Analyses were conducted on a subsample (n = 1546) of respondents living in Switzerland from wave 8 (2019/2020) of the Survey of Health, Ageing, and Retirement in Europe (SHARE). PT were assessed with the Big-Five inventory ten (BFI-10). HL was measured using the short version of the European Health Literacy Survey questionnaire (HLS-EU-Q16). We used multivariable regressions to explore how respondents' PT are independently associated with (1) the HLS-EU-Q16 and (2) seven sub-indices derived from this HL scale. Results demonstrated that even when controlling for social, regional, and health characteristics, PT were significantly associated with HL among older adults in Switzerland. More open individuals showed better HL competencies. By contrast, individuals who scored higher on neuroticism expressed more difficulties regarding concrete health-relevant tasks or situations. These findings call for public health policies targeting older adults with lower levels of openness who are less likely to engage in self-examination, and individuals with higher levels of neuroticism who tend to experience more negative emotions. Moreover, health information and communication strategies content development that accounts for different personality types and addresses the needs of individuals with low levels of openness and high neuroticism may help improve HL among older adults whose personalities may otherwise put them at a disadvantage in handling health information.

Keywords Big five ten · Health literacy · Population-based study · SHARE · Switzerland

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Introduction

Individuals' ability to find, understand, appraise, and use health information to handle health-related issues for themselves and others is reflected by their health literacy skills (Santana et al. 2021). Health literacy is, therefore, viewed as an important factor in ensuring patient autonomy, improving patient satisfaction, and achieving better outcomes in terms of health and healthcare (Kickbusch et al. 2013; Nielsen-Bohlman et al. 2004; Okan et al. 2019). Albeit health literacy is important throughout individuals' life course, health literacy is particularly central at an older age. Aging populations are characterized by the increasing importance of physical and cognitive decline and rising rates of chronic disease. In such context, health literacy skills are particularly important since they influence how older adults recognize their health issues, communicate with healthcare providers, and make medical decisions (Ladin et al. 2018). Moreover, health literacy is also a strong predictor of health disparities between individuals and is associated with sociodemographic factors such as age, language, education, and social status (Levin-Zamir et al. 2016; Meier et al. 2022; Schaeffer et al. 2017; Sørensen et al. 2015). Health literacy skills are relevant for individuals' health behavior, and despite the crucial role of health literacy in maintaining a good quality of life during the life course, little is known regarding interindividual differences in health literacy levels related to personality. Previous research mostly highlighted the importance of social factors and health status for health literacy (Kickbusch et al. 2013); however, little research has explored the role of personality and its association with health literacy (Iwasa and Yoshida 2020). Based on the Swiss Survey of Health Ageing and Retirement in Europe (SHARE) dataset, this study aims to fill this gap.

The Big Five personality construct is a well-established frame of reference in psychology (e.g. John and Srivastava 1999; McCrae and Costa 2003; McCrae and John 1992). It assesses how individuals position themselves relative to a list of statements. It aims to better understand individual differences in personality along five principal dimensions: Openness to experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (John et al. 2008). Individuals with higher openness to experience tend to be more creative and open to new propositions or new intellectual experiences. Individuals with higher levels of conscientiousness tend to be more meticulous, responsible, hardworking, and more goal oriented. More extraversion is related to sociable, outgoing, and talkative individuals. Then, individuals with higher levels of agreeableness are usually more compliant and altruistic; they tend to act in a cooperative and unselfish manner. Finally, individuals with neurotic tendencies experience a chronic level of emotional instability and proneness to psychological distress; they may more frequently suffer from negative emotions such as anger, worry, and sadness. Personality traits thus reflect constant patterns of differences in how individuals think, feel, and behave (Roberts et al. 2007). In the context of healthy aging, personality traits play some crucial roles: they are associated with older adults' healthcare utilization (Friedman et al. 2013; Hengartner et al. 2016; Nolan et al. 2019); positive health behaviors (Marks and Lutgendorf 1999), preventive healthcare use (Aarabi et al. 2021), negative health behaviors and outcomes such as alcohol consumption (Hakulinen et al. 2015a, b), smoking behavior (Hakulinen et al. 2015a, b), risk of diabetes (Jokela et al. 2014), functional impairments (Chapman et al. 2012; Hajek and König 2021; Krueger et al. 2006) and risk of death (Jokela et al. 2013). Recent evidence also showed that personality traits were associated with precautionary behavior against COVID-19 (Airaksinen et al. 2021). As personality traits shape individuals' feelings, thinking, and behaviors and influence how individuals adjust to health-related issues, personality traits' associations with individuals' health literacy levels need to be further explored to promote health in older adults. A better understanding of the role of personality traits allows healthcare providers to tailor their communication with patients.

Based on the research mentioned above, personality dimensions are theoretically relevant to understanding better health literacy levels. Interindividual personality differences might directly or indirectly influence individuals' health literacy because personality is related to broad temperamental tendencies. These general temperamental tendencies determine individuals' cognitions, affects, and experiences. Therefore, each individual will interpret health-related issues and their surroundings differently. Personality traits will also influence how individuals deal with their health challenges. Moreover, personality traits will impact the way individuals experience different exposure to health-related outcomes. More concretely, from a theoretical perspective, the role of personality traits in shaping the ways individuals gain access to age and context-specific information from various sources seems to be obvious. In that sense, the different personality traits might be related to the way individuals are able to discriminate between multiple sources of information; personality traits influence how individuals understand and personalize health information that has been obtained; and finally, interindividual personality differences influence an individual's ability to apply relevant health information for personal benefit appropriately.

Research questions and hypotheses

The objective of this study is to shed light on the role of personality traits and their associations with health literacy. However, conceptually, health literacy is composed of several subdimensions and components. Therefore, one important further aim of our research is to better understand the association of personality traits not only with general health literacy levels but also with seven key subdimensions of health literacy: 1. Healthcare; 2. Disease prevention; 3. Health promotion; 4. Accessing/obtaining health information; 5. Understanding health information; 6. Processing/appraising health information; and 7. Applying/using health information.

To this end, we explore the following hypotheses: Since openness is linked with motivation to seek new experiences and to engage in self-examination (e.g. John and Srivastava 1999), we expect this personality trait to be related to the ease of finding health-related information. By contrast, lower levels of openness should be linked to feeling more comfortable with familiar and traditional experiences (e.g. John and Srivastava 1999). Besides conscientiousness is generally a major indicator of health, well-being, and longevity (e.g. John and Srivastava 1999), this trait is a determinant of maintaining long-term goals. Therefore, we argue that it might help individuals to address long-term consequences of the increasing frailty in aging or undergo long-term treatment in case of illnesses. Extraversion is, among other dimensions, linked with self-confidence (e.g. John and Srivastava 1999) and may thus contribute to processing and or appraising health-related issues and information with calm. Individuals who score higher on agreeableness tend to express more prosocial orientation, which likely allows them to have a large social network. Thus, these individuals may be exposed to a wide variety of sources of health information that could challenge their ability to discriminate between various sources of information. Finally, individuals with a high degree of neuroticism may express poorer reactions to illnesses and negative emotions. Such individuals may address health-related issues with negative emotions such as anxiety, anger, guilt, and depression, leading them to express poorer health literacy (e.g. John et al. 2008).

Objectives of the present study

Given the potential separate benefits of health literacy and certain personality traits on health, studying the relationship between personality and health literacy can help highlight key opportunities and challenges for policies and interventions to promote healthy aging. Exploring the correlation between health literacy and personality traits among an aging population helps to better understand how older individuals' attitudes resulting from their personality may be associated with health literacy skills and, thus, health behaviors. Despite the available literature on the benefits of health literacy (Kickbusch et al. 2013; Nielsen-Bohlman et al. 2004; Okan et al. 2019) and the association of personality traits with a large array of health behaviors (Aarabi et al. 2021; Chapman et al. 2012; Hajek and König 2021; Hakulinen et al. 2015a, b; Hakulinen et al. 2015a, b; Jokela et al. 2013; Krueger et al. 2006; Marks and Lutgendorf 1999), there are, as far as we know, no existing national representative studies to date that comprehensively describe the direct relationship between health literacy and personality traits among older adults. To the best of our knowledge, only one study based on a sample of community-dwelling older Japanese individuals investigates the associations between health literacy and its correlates, notably personality (Iwasa and Yoshida 2020). This lack of research on this field and the lack of representative studies based on random samples of older individuals lead us to address this gap in the literature. The aim of our research is to explore the correlations between health literacy and individuals' personality traits in the Swiss-SHARE dataset. Our study presents several strengths: first, the question under interest is studied on a nationally representative sample of adults aged 58 years and older. The second strength is to consider a population that is not limited to community-dwelling individuals but older individuals in various kinds of accommodations. Finally, our study includes people at different stages of the aging process, i.e., people at the end of their professional career, young old, and the oldest old (Baltes and Smith 2003). These characteristics of our study provide greater scope for our results.

Methods

Study design and sample

Our data come from SHARE, which collects information on the health, socioeconomic status, and social networks of individuals aged 50 years and older using Computer-Assisted Personal Interviewing (CAPI). SHARE is a biennial population-based longitudinal study that started in 2004 and now includes 27 European countries and Israel (Börsch-Supan et al. 2013). SHARE samples are designed to be nationally representative of the target population of adults 50 years and older; thus, they are periodically refreshed to remain representative. Each survey round contains an internationally harmonized in-person interview and an optional country-specific paper-and-pencil self-administrated questionnaire. Our analyses are based on SHARE wave 8 data collected between October 2019 and the beginning of March 2020. They include respondents from Switzerland who participated in both the main questionnaire and the national paper-and-pencil self-administered questionnaire, which contained our health literacy outcome measure. On two occasions, respondents consented to participate in our study, first when they agreed to schedule an interview and second when they attended the in-person interview. We only include respondents aged 58 and older since the last refreshment sample for SHARE Switzerland was in 2011. The 8th wave of SHARE included 2005 targeted respondents or their partners which means that the individuals' response rate is 81%; among them, 94.3% also completed the national paper-and-pencil self-administrated questionnaire (N = 1891). Excluding respondents younger than 58 years old (partners of target respondents) and those with missing responses on variables used in the analysis, our final analytical sample counts 1546 respondents.

Measures

Outcome variables

Health literacy Health literacy is assessed by the short version of the European Health Literacy Survey—HLS-EU-Q16 (Pelikan et al. 2019) developed by the HLS-EU consortium. This scale consists of 16 items of concrete health-relevant tasks or situations that respondents have to evaluate on a 4-point Likert scale with possible answers ranging from "very easy," "fairly easy," "fairly difficult," to "very difficult" (Appendix 1). Each item is dichotomized (Pelikan et al. 2019) with a value of "0" if respondents expressed any difficulty ("fairly difficult" or "very difficult") and "1" otherwise. Respondents with a maximum of one or two missing values on the 16 items are included in the analysis, with the missing values treated as a "0". Adding all binary variables allows the construction of an aggregate health literacy score ranging from 0 to 16, which can be divided into three categories, i.e., inadequate (0–8), problematic (9–12), and sufficient health literacy (13–16). The internal consistency for the whole health literacy scale is excellent as shown by the Cronbach alpha ($\alpha = 0.91$). Moreover, health literacy is composed of a large set of dimensions. To this end, the scale provides seven sub-indices measuring health literacy within three domains, i.e., healthcare ($\alpha = 0.83$), disease prevention ($\alpha = 0.75$), and health promotion ($\alpha = 0.79$), as well as four stages of information processing, i.e., accessing/obtaining health information ($\alpha = 0.72$), understanding health information ($\alpha = 0.78$), processing/appraising health information ($\alpha = 0.67$) and applying/using health information ($\alpha = 0.65$). All the sub-indices present good to excellent internal consistency as shown by the Cronbach's alphas ranging from 0.65 to 0.90. As the sub-indices contain a different number of items, they are standardized on a scale from a minimum of 0 to a maximum of 50, following the formula: $\text{Index} = (\text{mean} - 1) \times 50/3$ (Sørensen et al. 2015).

Explanatory variable

Personality Personality traits were assessed using the 10-item version of the Big Five Inventory (BFI-10; Rammstedt and John 2007), an abbreviated version of the Big Five Inventory (John et al. 1991) developed by Rammstedt and John (2007). The BFI-10 is available in the general SHARE questionnaire. This extra short personality measure is specifically designed for large multi-topic panel surveys with great time constraints. Despite its brevity, the instrument has shown acceptable psychometric properties, meaning that it is a good compromise to measure personality. The scale contains two items for each of the five factors: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Respondents evaluate statements regarding their personality on a 5-point scale with possible answers: "strongly disagree", "disagree", "neither agree", "not disagree", "agree", and "strongly agree" (Appendix 2). Each personality trait is thus evaluated on a scale from 1 to 5.

Independent and controlled variables

We adjusted the analysis for gender (0 = male, 1 = female), age group (58–64 years, 65–74 years, 75+years), and education level (low = 0–2, secondary = 3–4, tertiary = 5–6) using the "International Standard Classification of Education" (Hoffmeyer-Zlotnik and Wolf 2003). We also controlled for the presence of a partner in the household (0 = has a partner, 1 = has no partner), the self-perceived financial situation as measured by the question: "Is your household able to make ends meet?" with answers being coded as 1 = "easily", 2 = "fairly easily", and 3 = "with difficulty". The language used to answer the questionnaire helps to differentiate Switzerland's three main linguistic regions (Swiss-German, French, or Swiss-Italian). Further information on the living environment comes from a variable assessing whether respondents lived in an urban or rural area (0 = urban, 1 = rural). Finally, we added two variables assessing respondents' health status: first, a measure of self-rated health (1 = "poor/fair", 2 = "good", 3 = "very good/excellent"); second a measure of the respondent's difficulties with a range of activities of daily living (ADL) evaluating if respondents had any limitations (0 = no, 1 = yes) with a list of activities (ADL; Katz et al. 1963; Steel et al. 2003).

Statistical methods

As advised, cross-sectional weights provided in the SHARE data (Börsch-Supan 2022) have been used to calibrate the sample to obtain descriptive statistics representative of the population of interest. We also determined the distribution of health literacy scores per personality traits level using weighted proportion. Partial associations between health literacy levels with respondents' personality traits and sociodemographic characteristics were estimated using unweighted ordinary least squares (OLS) regression (health literacy score) and multivariable ordered probit model (health literacy grouped), reporting results in terms of average marginal effects (AME). By testing these associations on two different statistical models, we can examine the robustness of our estimates. In addition, we used unweighted OLS regression to determine the partial association between the standardized health literacy score and its seven sub-indices with respondents' personality traits and sociodemographic characteristics. Finally, as the SHARE study surveyed the targeted respondents and the partner, we accounted for the possibility of dependencies in the observations by clustering the estimated standard errors at the household level. The analyses were performed using STATA/SE 17.0 (STATA Corporation, College Station, TX) with statistical significance levels of $*p<0.05$, $**p<0.01$, $***p<0.001$.

Table 1 Characteristics of the study population, adults aged 58+, SHARE Switzerland, 2019/2020, n = 1546

	Unweighted	Weighted	
	N	%	95% CI
Gender			
Male	726	51.8	[47.4–56.1]
Female	820	48.2	[43.9–52.6]
Age groups			
58–64 years	375	49.8	[44.7–54.9]
65–74 years	635	26.9	[23.8–30.2]
75+ years	536	23.3	[20.6–26.3]
Education			
Low	279	16.1	[13.2–19.6]
Secondary	968	63.4	[58.7–67.8]
Tertiary	299	20.5	[16.7–24.9]
Partnership status			
Has a partner	1151	70.5	[65.9–74.7]
No partner	395	29.5	[25.3–34.1]
Make ends meet			
Easily	856	56.9	[52.2–61.6]
Fairly easily	490	30.2	[26.2–34.6]
With difficulty	200	12.8	[10.0–16.3]
Language			
German	1106	71.0	[66.1–75.4]
French	385	26.1	[21.8–31.0]
Italian	55	2.9	[1.9–4.3]
Living area			
Urban	709	41.7	[37.0–46.6]
Rural	837	58.3	[53.4–63.0]
Self-rated health			
Poor/fair health	297	16.9	[13.8–20.4]
Good health	660	38.9	[34.5–43.6]
Very good/excellent health	589	44.2	[39.2–49.4]
ADL limitations			
No	1437	93.5	[91.1–95.3]
Yes	109	6.5	[4.7–8.9]

Unweighted and weighted number of observations for the whole sample. N = number; CI = confidence interval

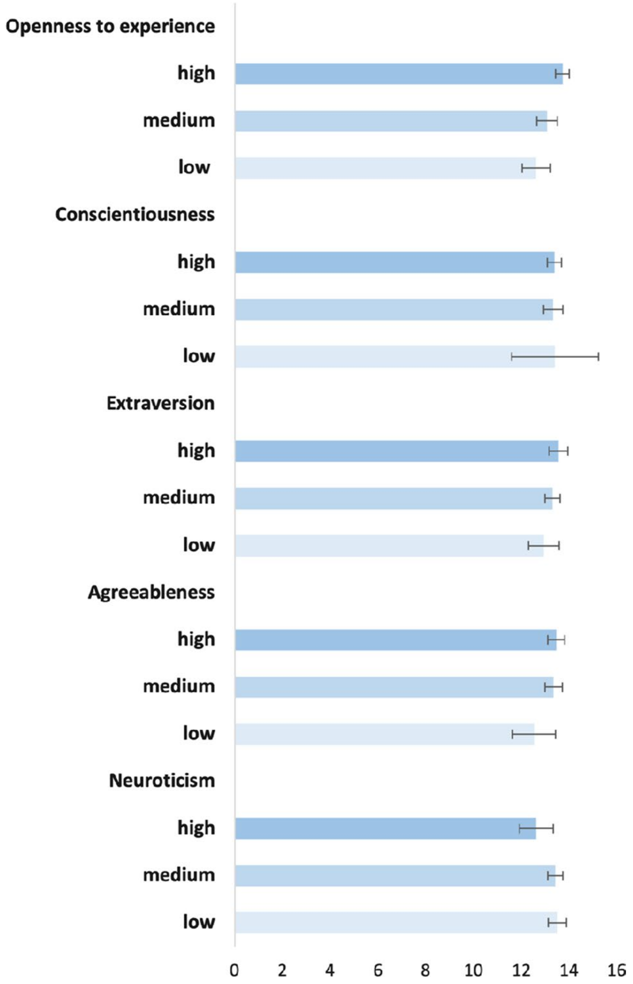

Fig. 1 Health literacy's weighted average scores per personality traits levels and 95% confidence intervals, adults aged 58+, SHARE Switzerland, 2019/2020, n = 1546. The health literacy score ranges from 0 to 16, while the personality traits levels are regrouped into three categories: low (1; 1.5; 2), medium (2.5; 3; 3.5) and high (4; 4.5; 5)

Results

Table 1 displays the numbers for both the unweighted and the weighted sample. Our weighted analytical sample contained 48.2% of women (Table 1); the average age was 71.6 years old (SD: 8.4), with 26.9% of respondents aged between 65 and 75 years old and 23.3% older than 75 years old. Regarding the education level, 16.1% had a low level of education, 63.4% had a secondary level education, and the remaining respondents had at least a tertiary education. Most respondents had a partner (70.5%), no financial difficulties (87.1%), came from the German-speaking part of Switzerland (71.0%) and lived in a rural area (58.3%). Finally, most respondents self-rated their health as good or excellent (83.1%), and 6.5% had one or more difficulties with ADL.

The weighted distribution of health literacy scores for each personality trait level showed significant associations for three of the five traits (Fig. 1). Individuals expressing being more open to experiences ($p < 0.001$) and those with higher levels of extraversion seemed to have higher health literacy levels ($p = 0.026$), while respondents with higher scores on neuroticism tended to have lower health literacy scores ($p = 0.031$).

Table 2 presents the partial associations of health literacy with respondents' personality traits and sociodemographic characteristics. Regarding personality traits, individuals with a higher degree of openness to experiences were more likely to have higher health literacy scores ($p < 0.001$) and were less likely to have problematic and inadequate levels of health literacy ($p < 0.001$). Respondents expressing higher neuroticism had lower health literacy scores ($p < 0.01$) and were more likely to have problematic and inadequate levels of health literacy ($p < 0.05$). Concerning the associations with individuals' social, regional, and health characteristics, multivariable analyses indicated that—holding other characteristics fixed—health literacy was lower in men, individuals with low levels of education, individuals with trouble making ends meet, and those with poor self-rated health or ADL limitations.

The second part of the analysis considers the link between personality traits and the sub-dimensions of the health literacy scale for whom hypotheses have been developed. The associations between the standardized health literacy score and the seven standardized sub-indices with respondents' personality traits and sociodemographic characteristics yielded similar results regarding gender, education, self-rated health, ADL limitations, openness to experience, and neuroticism (Table 3). However, we also found some statistically significant associations with other personality traits. Respondents with a lower level of conscientiousness were more likely to report greater ease in understanding health information ($p < 0.05$). Having a higher level of extraversion was associated with higher health literacy scores ($p < 0.05$), higher healthcare-related health literacy ($p < 0.01$), facilities in obtaining health-related information ($p < 0.001$), and greater ease in applying health information ($p < 0.05$). Finally, respondents with higher levels of agreeableness had lower healthcare-related health literacy ($p < 0.05$) and were more likely to report difficulties appraising health information ($p < 0.05$).

Discussion

To the best of our knowledge, our study is the first representative population-based study exploring the associations between different personality traits and the level of health literacy among older adults. When considering the entire health literacy scale, we found that individuals expressing being more open to experiences were more likely to have higher health literacy levels. This result may reflect that more open individuals tend to seek new experiences that might help them to access specific information from various sources, to seek appropriate healthcare services, and to find health-related information (e.g. John et al. 2008; John and Srivastava 1999), which are crucial components of effective health literacy. More open individuals also have a more fluid style of awareness (e.g. John et al. 2008) that allows them to make new associations between distantly related ideas that might help them adopt a more comprehensive understanding of their health status. In addition, more open individuals tend to engage in self-examination (e.g. John and Srivastava 1999), which may make them more aware of their health situation and help them better appraise and use health-related information.

Second, individuals with higher scores on neuroticism were more likely to have inadequate health literacy. Individuals with higher scores on neuroticism are also more prone to negative emotions, express lower emotional intelligence, and are at risk for mental disorders such as phobia, depression, panic fears, and other anxiety disorders (e.g. John et al. 2008), which may involve decreased motivation and interpersonal activities. These characteristics might slow down or diminish individuals' ability to seek, understand and appraise health-related information, as well as negatively influence their judgment and decision. Finally, neuroticism is a function of the limbic system activity (Eysenck 1983) which means that individuals with a higher neuroticism score have a reactive sympathetic nervous system that is more sensitive to the environment around them. Individuals with higher neuroticism might overreact and become very anxious when facing health-related information from different healthcare providers; in addition, facing health related-outcomes such as the symptoms of an illness can also

Table 2 Partial associations of health literacy with respondents' personality traits and sociodemographic characteristics, adults aged 58+, SHARE Switzerland, 2019/2020, n = 1546

	OLS regression (HL score)	Oprobit (problematic) AME (SE)	Oprobit (inadequate) AME (SE)
Gender (male)			
Female	0.64***	−0.03***	−0.06***
	(0.14)	(0.01)	(0.01)
Age group (58–64 years)			
65–74 years	0.12	−0.01	−0.01
	(0.19)	(0.01)	(0.02)
75+years	−0.08	0.01	0.02
	(0.21)	(0.01)	(0.02)
Education (low)			
Secondary	0.33	−0.02	−0.03
	(0.22)	(0.01)	(0.02)
Tertiary	1.03***	−0.05***	−0.11***
	(0.24)	(0.01)	(0.03)
Partnership status (has a partner)			
No partner	0.19	−0.01	−0.02
	(0.18)	(0.01)	(0.02)
Make ends meet (easily)			
Fairly easily	−0.19	0.01	0.02
	(0.17)	(0.01)	(0.02)
With difficulty	−0.85**	0.04*	0.06*
	(0.27)	(0.02)	(0.02)
Language (Swiss-German (ch))			
French (ch)	0.09	0.00	0.01
	(0.19)	(0.01)	(0.02)
Swiss-Italian (ch)	−0.34	0.01	0.02
	(0.48)	(0.03)	(0.05)
Living area (urban)			
Rural	−0.12	0.01	0.02
	(0.15)	(0.01)	(0.02)
Self-rated health (bad health)			
Good health	0.59**	−0.02	−0.04
	(0.23)	(0.01)	(0.02)
Very good/excellent health	1.13***	−0.06***	−0.10***
	(0.23)	(0.01)	(0.02)
ADL limitations (no)			
Yes	−1.83***	0.12***	0.13***
	(0.39)	(0.03)	(0.02)
Openness (Big Five personality inventory)	0.29***	−0.02***	−0.03***
	(0.08)	(0.00)	(0.01)
Conscientiousness (Big Five personality inventory)	0.01	0.00	0.00
	(0.11)	(0.01)	(0.01)
Extraversion (Big Five personality inventory)	0.08	−0.00	−0.01
	(0.08)	(0.00)	(0.01)
Agreeableness (Big Five personality inventory)	−0.15	0.01	0.01
	(0.10)	(0.01)	(0.01)
Neuroticism (Big Five personality inventory)	−0.23**	0.01*	0.02*
	(0.08)	(0.00)	(0.01)
Observations	1546	1546	1546

Ordinary Least Squares (OLS) regression of the Health Literacy (HL) score on the covariates, and an oprobit regression of the three-category HL score on the covariates. The table shows average marginal effects (AMEs) and standard errors in brackets with significance level: *$p < .05$, **$p < .01$, ***$p < .001$

Table 3 Partial associations of health literacy sub-indices with respondents' personality traits and sociodemographic characteristics, adults aged 58+, SHARE Switzerland, 2019/2020, n = 1546

	HL score	Healthcare (hc_hl)	Disease prevention (dp_hl)	Health promotion (hp_hl)	Access/obtain (oi)	Under-standing (ui)	Process/ appraise(pi)	Apply/use (ai)
Gender (male)								
Female	1.77***	1.54***	1.76***	2.19***	2.03***	1.57***	2.17***	1.44**
	(0.36)	(0.39)	(0.43)	(0.46)	(0.43)	(0.38)	(0.50)	(0.44)
Age group (58–64 years)								
65–74 years	0.25	0.43	0.41	−0.25	0.10	0.49	−0.33	−0.10
	(0.49)	(0.50)	(0.58)	(0.61)	(0.58)	(0.49)	(0.66)	(0.58)
75+years	−0.06	0.98	−0.72	−1.05	−0.56	−0.02	−0.03	0.52
	(0.54)	(0.55)	(0.65)	(0.67)	(0.65)	(0.55)	(0.71)	(0.63)
Education (low)								
Secondary	1.09*	1.00	1.14	1.16	0.90	1.44**	0.83	0.88
	(0.53)	(0.56)	(0.64)	(0.70)	(0.63)	(0.56)	(0.71)	(0.64)
Tertiary	3.57***	3.35***	3.34***	4.23***	3.15***	4.38***	2.92**	3.16***
	(0.65)	(0.66)	(0.79)	(0.88)	(0.78)	(0.67)	(0.89)	(0.80)
Partnership status (has a partner)								
No partner	1.02*	0.87	1.10*	1.17*	0.72	1.27**	1.03	0.88
	(0.46)	(0.48)	(0.55)	(0.58)	(0.56)	(0.47)	(0.61)	(0.57)
Make ends meet (easily)								
Fairly easily	−0.92*	−0.98*	−1.20*	−0.48	−1.19*	−0.90*	−0.95	−0.58
	(0.43)	(0.45)	(0.52)	(0.55)	(0.52)	(0.44)	(0.58)	(0.52)
With difficulty	−2.27***	−2.78***	−1.71*	−2.08*	−3.82***	−2.32***	−1.06	−1.33
	(0.65)	(0.70)	(0.76)	(0.82)	(0.81)	(0.65)	(0.84)	(0.79)
Language (German (ch))								
French (ch)	−0.68	−1.02*	0.07	−1.00	−1.06	−1.40**	1.01	−0.41
	(0.48)	(0.50)	(0.57)	(0.60)	(0.58)	(0.47)	(0.62)	(0.58)
Italian (ch)	−1.73	−0.93	−2.64*	−2.00	−2.26	−2.77*	0.48	−1.16
	(1.19)	(1.20)	(1.32)	(1.46)	(1.44)	(1.36)	(1.40)	(1.19)
Living area (urban)								
Rural	−0.28	−0.15	−0.24	−0.55	−0.08	−0.55	0.08	−0.36
	(0.39)	(0.40)	(0.46)	(0.48)	(0.47)	(0.39)	(0.51)	(0.47)
Self-rated health (poor/fair health)								
Good health	1.13*	0.87	1.07	1.64*	1.45*	0.89	1.29	0.99
	(0.53)	(0.58)	(0.63)	(0.67)	(0.66)	(0.55)	(0.71)	(0.64)
Very good/ excellent health	2.86***	2.29***	2.64***	4.13***	3.06***	2.54***	3.89***	2.20**
	(0.58)	(0.62)	(0.68)	(0.73)	(0.72)	(0.59)	(0.78)	(0.70)
ADL limitations (no)								
Yes	−3.48***	−4.23***	−2.48**	−3.42**	−4.40***	−3.00***	−2.85**	−3.84***
	(0.83)	(0.95)	(0.96)	(1.11)	(0.97)	(0.91)	(1.05)	(1.10)
Openness	1.01***	0.81***	1.09***	1.24***	1.14***	1.04***	1.02***	0.74**
	(0.22)	(0.22)	(0.26)	(0.28)	(0.26)	(0.22)	(0.30)	(0.26)
Conscientious-ness	0.48	0.46	0.51	0.47	0.33	0.57*	0.48	0.48
	(0.27)	(0.27)	(0.32)	(0.37)	(0.32)	(0.27)	(0.37)	(0.32)
Extraversion	0.44*	0.67**	0.32	0.17	0.82***	0.08	0.49	0.57*
	(0.21)	(0.22)	(0.24)	(0.27)	(0.25)	(0.22)	(0.28)	(0.25)
Agreeableness	−0.47	−0.54*	−0.43	−0.41	−0.44	−0.39	−0.72*	−0.44
	(0.25)	(0.27)	(0.30)	(0.33)	(0.32)	(0.25)	(0.35)	(0.30)
Neuroticism	−0.70***	−0.75***	−0.66**	−0.67**	−0.87***	−0.51*	−0.94***	−0.61*
	(0.20)	(0.21)	(0.24)	(0.26)	(0.25)	(0.21)	(0.26)	(0.25)

Table 3 (continued)

	HL score	Healthcare (hc_hl)	Disease prevention (dp_hl)	Health promotion (hp_hl)	Access/obtain (oi)	Under-standing (ui)	Process/ appraise(pi)	Apply/use (ai)
Constant	29.23***	31.41***	27.09***	28.09***	28.55***	32.18***	24.58***	28.88***
	(1.93)	(2.06)	(2.20)	(2.51)	(2.29)	(2.00)	(2.52)	(2.23)
Observations	1546	1546	1546	1546	1546	1546	1546	1546

Regressions of the standardized health literacy score and the sub-Indices on covariates. Sub-indices abbreviations: health care (hc_hl), disease prevention (dp_hl), health promotion (hp_hl), access/obtain health information (oi), understanding health information (ui), process/appraise health information (pi), apply/use health information (ai). Estimates and standard errors in parentheses, significance level: $*p<.05$, $**p<.01$, $***p<.001$

generate extra negative emotions. Therefore, higher levels of neuroticism may undermine their health literacy skills.

One strength of our study is that we adopt a rather detailed perspective by also considering the multiple sub-dimensions of health literacy linked with respondents' personality traits. Some of our hypotheses align with the results: respondents with higher levels of conscientiousness were more likely to report greater ease in understanding health information. This finding may reflect that conscientious individuals tend to be more organized and more goal-oriented (e.g. John and Srivastava 1999), which helps them to better understand health-related issues and behave accordingly. Respondents with higher levels of agreeableness were more likely to report difficulties regarding healthcare-related health literacy and to report difficulties appraising health information. Individuals with higher levels of agreeableness are generally more trusting, tolerant, compliant, and cooperative (e.g. John and Srivastava 1999). For those individuals, difficulties appraising health information might be generated by their social network, which may transmit conflicting health information: being more trusting (e.g. John and Srivastava 1999) may reduce individuals' capacity to appropriately appraise and select health information from individuals surrounding them. Finally, individuals with higher levels of extraversion have higher health literacy scores, especially in the healthcare domain, which might be linked with self-confidence. Higher competence in obtaining health information may stem from being more talkative and having higher social capacity. Their greater ease in applying health information may originate from higher levels of self-confidence of these individuals (e.g. John and Srivastava 1999).

Limitations

Despite its numerous strengths, our study suffers from several limitations. Firstly, HLS-EU-Q16 (Pelikan et al. 2019) and the Big Five Inventory Ten (BFI-10; Rammstedt and John 2007) are subjective measures that may be subject to reporting heterogeneity and bias in case of systematic reporting differences. Regarding the health literacy scale, respondents may over or underestimate their skills. However, subjective health literacy assessments seem to be the most appropriate method for self-administered paper-and-pencil questionnaires, as when using test-based evaluations, it is not possible to prevent respondents from consulting the internet or asking household members to help them answer the questions, which could significantly bias the results from a more test-based approach to assessing health literacy. In addition, the short version of the HLS-EU-Q16 questionnaire has several advantages, including convenience and validity (Eronen et al. 2019; Lorini et al. 2019). Indeed, health literacy represents individuals' rating of their perception of their own health-related skills. In that sense, health literacy is linked with self-efficacy and control beliefs of individuals' healthcare-related tasks (Berens et al. 2022). Future research should, however, better target other aspects of the health literacy construct: more objective components of health literacy should be studied to have a more comprehensive and exhaustive understanding of the complexity of this construct.

Regarding the BFI-10 (Rammstedt and John 2007), despite its brevity, the instrument has shown acceptable psychometric properties (Steyn and Ndofirepi 2022). High reliability and validity when measuring individuals' personality traits have been demonstrated (Rammstedt and John 2007). That is, albeit ultra-short personality measures present the advantage of avoiding items redundancy and allowing the measurement of psychological construct in surveys when time is severely limited, they are, to some extent, inferior to regular personality assessment (Gosling et al. 2003; Rammstedt and John 2007). They should not substitute to them. A disadvantage of extra short personality trait measures is their inability to assess individual facets of multi-faceted constructs of personality traits (Gosling et al. 2003). In addition, psychological scales were originally constructed for personal assessment purposes with questionnaires administered to individuals by trained professionals. In large interdisciplinary surveys like SHARE, these scales must be adapted to assess psychological constructs in the whole population (Rammstedt and Beierlein 2014). Moreover, it is trained interviewers, but not trained psychologists or psychotherapist, who administer or read the surveys questions (Ryser 2023). Furthermore, recent research based on lexical studies of personality structure emphasized the importance of the Ashton and Lee (2014) HEXACO six-factor model. This model partially overlaps the big five model but highlights the importance to considers an additional Honesty-Humility factor in future research (Ashton et al. 2014). Finally, personality traits are relatively enduring patterns with biological bases (McCrae and Costa Jr 1996), and despite previous research supporting personality traits' one-direction associations with health literacy (Iwasa and Yoshida 2020), reverse causality cannot be ruled out. The study design does not allow causality to be determined. However, reverse causality should be better explored and understood in future research, especially in light of recent developments in the research of the evolution of personality traits over the life span (e.g. Graham et al. 2020) and as a function of life events (Bleidorn et al. 2018).

Lastly, selection effects and attrition add concerns about the representativeness of SHARE samples. However, this problem is common in all longitudinal and population-based surveys (Banks et al. 2011). Moreover, considerable effort is being made to minimize these biases in the SHARE survey in Switzerland. Furthermore, missing responses did not appear to be a significant concern in our study as it was relatively low (18.2%). No population group appeared to be systematically over-represented among the respondents excluded from our analyses because of item non-response.

Conclusion

Previous research has shown that one-third of Swiss older adults have difficulty managing their health (Meier et al. 2022). Low levels of health literacy negatively impact individuals' quality of life, particularly in older adults with a more vulnerable health status (Ladin et al. 2018). In our study, we found that individuals with relatively low openness to experience and high neuroticism were particularly at risk of presenting inadequate health literacy levels. Public health policies should focus on individuals with lower openness levels, which is linked with a lower capacity to engage in self-examination, and those displaying higher neuroticism, which may be more anxious when dealing with health-related information. These policies should thus incorporate personality traits in the personalization of services, such as in health or eHealth communication tools for the general population and the training of healthcare providers. For instance, public health policies aiming at improving health literacy could be more convincing or nudge-driven for older adults with low openness as well as more factual and calming for those with high neuroticism.

Appendices

Appendix 1: The 16 items from the HLS-EU-Q16 scale Pelikan, Ganahl, Van den Broucke, Sorensen (2019):

First, we would like to ask you how comfortable you feel when dealing with health-related information

For you, how easy or difficult is it to…

Answer categories: "Very easy", "Fairly easy", "Fairly difficult", "Very difficult"

Healthcare

1. Understand your doctor's or pharmacist's instructions on how to take a prescribed medicine?
2. Follow instructions from your doctor or pharmacist?
3. Understand what doctor says to you?
4. Find out where to get professional help when you are ill?
5. Find information on treatments of illnesses that concern you?
6. Use the information the doctor gives you to make decisions about your illness?
7. Judge when you may need to get a second opinion from another doctor?

Disease prevention

8. Understand health warnings about behaviour such as smoking, low physical activity, and drinking too much?
9. Understand why you need health screenings?
10. Find information on how to manage mental health problems like stress or depression?
11. Decide how you can protect yourself from illness based on information in the media?
12. Judge if the information on health risks in the media is reliable?

Health promotion

13. Understand advice on health from family members or friends?
14. Judge which everyday behaviour is related to your health?
15. Find out about activities that are good for your mental well-being?
16. Understand information in the media on how to get healthier?

Appendix 2: The items from the Big Five personality inventory (BFI-ten Rammstedt and John 2007):

Openness to experience	I see myself as someone who has few artistic interests
	I see myself as someone who has an active imagination
Conscientiousness	I see myself as someone who tends to be lazy
	I see myself as someone who does a thorough job
Extraversion	I see myself as someone who is reserved
	I see myself as someone who is outgoing, sociable
Agreeableness	I see myself as someone who is generally trusting
	I see myself as someone who tends to find fault with others
Neuroticism	I see myself as someone who is relaxed, handles stress well
	I see myself as someone who gets nervous easily

Answer categories: "Disagree strongly", "Disagree a little", "Neither agree nor disagree", "Agree a little", "Agree strongly"

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Data availability This article uses data from Börsch-Supan (2022). Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 8. Release version: 8.0.0. SHARE-ERIC. Data set. https://doi.org/10.6103/SHARE.w8.100. Study data already deidentified are available to the scientific community upon submitting a data requestion application to the SHARE study.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Our study obtained ethical approval number 66/14 from the ethics committee of the canton of Vaud, Switzerland, in March 2014.

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REVIEW

Gerontechnology for better elderly care and life quality: a systematic literature review

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Abstract

Gerontechnology as multidisciplinary research has expanded in recent years due to its significant role in ensuring better care and improved quality of life for older adults and their caregivers. With a substantial increase in studies on reasons behind less inclination of older individuals to accept gerontechnology, barriers to its non-acceptance appear to be persistent. In addition, there is a dearth of research on the adoption of gerontechnology from the perspectives of social caregivers, given that caregivers bear a substantial burden in the form of chronic stress, which adversely affects their health and that of older people. Therefore, the aim of this study is to present a holistic perspective of older adults and their caregivers by systematically reviewing literature on gerontechnology acceptance. Adopting the preferred reported items for systematic and meta-analysis (PRISMA) framework, publications specifically on gerontechnology from 2002 to 2022 in Scopus, Web of Science and PubMed, that focused on older people (50 years and above) and caregivers (informal and formal) were reviewed. We critically evaluated 25 publications and synthesised them thematically. The results highlight that gerontechnology acceptance by older adults and their social caregivers is highly contingent on certain personal, physical, socio-cultural and technological indicators. However, this paper concludes that a generalised policy approach for gerontechnology and a better quality of life may be ineffective, considering that older adults and social caregivers constitute two heterogeneous groups.

Keywords Gerontechnology · Older persons · Social caregivers · Health-related well-being · Life quality

Introduction

One of the greatest global concerns for healthcare and social institutions is the ageing population (WHO 2018). While demographic trends differ among countries and regions of the world, the ageing population is increasingly becoming a challenge in both developed and developing countries (Scott et al. 2019). Policymakers have proposed gerontechnology: a creative, multidisciplinary solution to deal with this challenge by linking ageing and technology. Conceptually, gerontechnology denotes a scientific study of ageing, examining the biological, psychological and sociological factors associated with the ageing process (Halicka and Surel 2021), which can help older adults identify and slow down the effects of age-related physical and cognitive difficulties (Sale 2018). Gerontechnology therefore has enormous potential to ensure better care and improved quality of life (QoL) for older adults.

Although gerontechnology is supportive of daily life, it is widely recognised that older people do not show as much interest in adopting new technologies as younger populations (e.g. Gullà et al. 2015; Wu et al. 2015; Yusif et al. 2016). Several studies have been conducted over the last few decades to investigate the numerous reasons why older individuals are less inclined to use gerontechnology (e.g. Berkowsky et al. 2017; Chen and Chan 2014). However, barriers to the non-acceptance of gerontechnology by older people appear to be persistent (Lee and Tak 2022). This is attributable to a misconception as to which gerontechnologies are desirable for older adults, as well as the factors and perspectives that determine their usage or non-usage (Harris et al. 2022). In addition, social caregivers often play a vital role in assisting

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community-dwelling older adults in managing their health (Bevilacqua et al. 2020; Papetti et al. 2014). Studies have demonstrated that the growing, caring needs of an ageing society can be met by increasing not only the technologies developed to assist older people but also the number of carers (Cook et al. 2020; Robinson et al. 2020). By virtue of this, past studies have established that gerontechnology can be a useful tool for caregivers in several ways, including peer networking, professional support and resource identification (Hopwood et al. 2018; McHugh and Lawlor 2012). Furthermore, caregivers bear a substantial burden in the form of chronic stress, which adversely affects their health and that of older people (Adelman et al. 2014). However, there is a dearth of research on the adoption of gerontechnology from the perspectives of social caregivers. Most previous studies exploring caregivers' perspectives have focused on telehealth and assistive technologies for all populations (e.g. Cook et al. 2018; Mostaghel 2016; Peek et al. 2014).

Given the important role of social caregiving, the perceived needs and challenges of gerontechnology in older adults and their social caregivers remain important for social policy interventions. Until now, no systematic review of gerontechnology has provided evidence for these two different groups. In our study, instead of focusing only on older adults, the main objective is to systematically review evidence on the opinions of older adults and social caregivers on gerontechnology acceptance. Secondly, this review also discusses the effects of gerontechnology on better QoL and social caregiving for older adults. We believe our findings will benefit various stakeholders, such as designers, engineers and researchers, to study and fully develop gerontechnology products and services. This, in turn, will reduce the care burdens of social caregivers and enhance the QoL for older adults, particularly in regions where the ageing population is rising exponentially.

Methods

This systematic review was carried out in accordance with the suggested step-by-step strategy outlined in the PRISMA guidelines (Moher et al. 2009), ensuring the reliability, usefulness and scientific soundness of the review (Hale and Griffiths 2015). A detailed description of the procedure is provided in the following subsections.

Search strategy

Table 1 Search string of key terms

Order of search	Terms
1	Gerontechnology AND adoption
2	Gerontechnology AND caregivers OR social care
3	Gerontechnology AND health
4	Gerontechnology AND quality of life OR wellbeing OR happiness

We conducted an extensive search in Scopus, Web of Science and PubMed to cover empirical studies that reported on the adoption of gerontechnology among older people (50 years and above) and caregivers (informal caregivers and nursing homes). These databases were selected due to their prominence and contributions to ageing, gerontechnology and geriatrics issues. The review specifically focused on four broad search terms: (1) 'gerontechnology', (2) 'adoption', (3) 'older adults' and (4) caregivers. While some reviews (e.g. Mostaghel 2016; Peek et al. 2014; Yusif et al. 2016) had focused on the generic term 'technology', we specifically focused on the terminology 'gerontechnology' to ensure that those publications captured are specifically focused on the technologies to assist older adults. To keep our search as broad as possible, the review limited the search string to the fields of title, abstract and keywords in each database. The combination of the key terms with Boolean operators, for example, in Scopus, included: ('gerontechnology') AND ('adoption'), ('gerontechnology') AND ('caregivers') OR ('social care'), ('gerontechnology') AND ('health'), ('gerontechnology') AND ('well-being') OR ('quality of life') OR ('happiness') OR ('life satisfaction'). Table 1 explains how the final search string of the key terms used in the review was arrived at. To ensure a comprehensive search, the review was limited to a 20-year publication period (2002–2022) in all databases.

Eligibility criteria

Guided by the aims and objectives of the review, all publications were subjected to predetermined inclusion and exclusion criteria. Studies were included if they examined the reasons for the adoption of gerontechnology. Studies that examined whether and how gerontechnology reduces caregivers' burden were also included. In addition, studies that were empirical, employing qualitative, quantitative or both methodologies, and written or published in English were also included. Furthermore, those studies that considered older people or/and caregivers as study populations were included. Following the inclusion criteria, the review excluded studies that were focused on technologies for all populations and not on gerontechnology as an intervention for reducing caregivers' burdens. Moreover, empirical studies that involved individuals or groups other than older people and caregivers were excluded. The review also excluded reviewed papers, theoretical and conceptual articles. Lastly, articles published in a non-English language were in the exclusion criteria.

Screening

In the initial stage, the database search was conducted by two independent researchers (HG and OSA). Subsequently, the studies' titles and abstracts were screened based on the predetermined inclusion and exclusion criteria. Then, an expert researcher was consulted to resolve all discrepancies in the required studies that met the inclusion criteria. All outstanding issues were discussed with the two researchers and resolved under the supervision of the expert researcher. All studies were exported into Microsoft Excel software, where duplicates were eliminated. In the final stage, the full text of the various studies was screened after duplication removal. Two independent researchers managed the screening at this stage and decided which studies should finally be included in the review.

Data extraction and quality appraisal

After the final screening stage, a data extraction guide on the topic was developed following previous studies (e.g. Merkel and Kucharski 2019; Sundgren et al. 2020). The two independent researchers developed separate extraction templates for the articles; however, upon discussion, consensus was reached, and the templates were aggregated into one data extraction template (see Table 2). The methodological validity of all publications selected for inclusion were evaluated using the Mixed Methods Appraisal Tool, 2018 version (MMAT). The appraisal tool was selected because it was designed for the appraisal of systematic reviews that include qualitative, quantitative and mixed methods studies (Hong et al. 2018). Besides, it is extensively clear, designed to allow the authors evaluate the reliability and validity of all included publications. Therefore, for each study, a scoring logic of 'yes' was assigned as an indication of satisfying a quality criterion. Any study that received a "no" in the scoring logic did not meet the quality standards. On the other hand, if the paper did not present sufficient information to determine whether a criterion was met, or if the information reported was ambiguous, then the study was assigned the "Can't tell" response (see Table 3). The authors followed up for supplementary papers or contacted the authors to request for more clarification. As prescribed in the MMAT guidelines (Hong et al. 2018), a sensitive analysis of contrasting the results of the ratings of each criterion was followed to better inform the quality of all included studies.

Data analysis

Once the data extraction template was complete, the next stage was to analyse the data. A thematic analysis approach was conducted iteratively by the two independent researchers. The researchers developed themes and presented them to one another to reach a collective understanding. Finally, with an expert researcher's consultation, the data's thematic areas were reviewed and concluding themes were formulated.

Results

First, this section of the review captures the process of collation and the selection of studies. Second, it presents the results on the characteristics of the reviewed studies. Finally, it presents the synthesis of the results thematically according to the research questions.

Collation and selection of studies

The results of the search yielded a total of 552 articles. All articles were exported in CSV Excel file format. After removing duplicate articles, 144 citations remained for title screening. In the next phase, the abstracts of 235 potentially eligible titles were examined. Then, 52 full texts were considered for inclusion, of which only 25 were included in the synthesis and review (Fig. 1).

Description of reviewed studies

The findings in Table 2 demonstrate that out of the 25 studies, 10 were qualitative, 12 adopted a quantitative approach, and 3 employed a mixed-method design. Pertaining to study context, most studies were conducted in Europe ($n=9$). This was followed by those conducted in Asia ($n=7$), Africa ($n=5$) and North America ($n=4$). Out of the 25 studies, five focused on caregivers as study participants, and two focused on both older persons and caregivers. The remaining 18 studies extensively focused on older persons.

Moreover, outcomes of gerontechnology adoption on older people's QoL were conceptualised to encompass healthcare and well-being issues ($n=4$), as well as health attitudes and behaviours ($n=2$). Most studies also reported the exact age of older adults to include 55 years or more ($n=21$). However, one study conceptualised the ages of older workers from 40 years and over. In this article, the justification for including 40-year-old persons was not reported, although it had included a substantial number of older persons aged 50 years and above. In this review, three main theoretical models were espoused: the technology

Table 2 Catalogue of included studies

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
1	Huang et al. (2021)	China	To explore the intention of Chinese community-dwelling older adults to adopt gerontechnology and its influencing factors	Mixed-methods approach; sequential explanatory design Phase 1: Questionnaire—multifactor logistic regression $N = 1180$ Phase 2: Semi-structured interview—thematic analysis $N = 18$		Most older adults showed adoption intention towards gerontechnology. Predicting, enabling and need factors influenced adoption of gerontechnology.
2	Joseph et al. (2018)	Malaysia	To examine the factors of older adults' adoption intention of gerontechnology (mobile bathtubs)	Mixed-methods approach Qualitative: focus group discussion $N = 12$ Quantitative: survey $N = 37$ Age: not reported		The findings show that perceived ease of use and perceived usefulness, along with specific design features of mobile bathtub were determinants of adoption intention among older adults.
3	Chen and Chan (2014)	Hong Kong	The aim of this study was to examine the factors that influence the acceptance of gerontechnology by older Hong Kong Chinese	Quantitative: survey $N = 1012$ (seniors) Age = 55+ years	Technology acceptance model (TAM) unified theory of acceptance and use of technology (UTAUT)	The models adopted in this study proved useful. However, in contrast to TAM and UTAUT, significant effects for perceived usefulness, perceived ease of use and attitude towards using the technology on usage behaviour were not found in this study. Personal attributes like technology self-efficacy, anxiety and facilitating conditions (FCs) were more decisive than perceived benefits for predicting gerontechnology usage behaviour.

Table 2 (continued)

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
4	Chen and Chan (2013)	Hong Kong	To explore the attitudes and experiences of older people towards using gerontechnology and determine the factors accounting for its use and non-use	Qualitative: Interviews: $n=26$ Focus group discussion: $n=24$ $N=50$ Age = 55–85 years		Positive attitudes were most frequently related to enhanced convenience and advanced features. Negative attitudes were most frequently associated with health risks and social problems arising from using technology. Outcome expectations, social influences (SIs) and support from facilitators influenced usage, whereas non-use of gerontechnology relates to the personal, technological and environmental factors that lead to non-usage.
5	Halicka and Surel (2021)	Poland	To determine the most desired group of gerontechnologies among current and trend users	Quantitative: survey $N=1152$ Age = 40+		Most desirable gerontechnology was health related and selected primarily based on its innovativeness and not as result of its usage.
6	Delbreil and Zvobgo (2013)	Switzerland and France	The purpose of the study was to examine health professionals' recognition of sensor technology as a means to enhance quality of life (QoL) of care recipients with dementia	Mixed-methods approach: interviews and questionnaires Multiple regression analysis $N=$ not reported	Technology acceptance model (TAM)	Positive attitude towards gerontechnology as a means to enhance QoL of older persons.
7	Khan et al. (2021)	Pakistan	To investigate the elderly's intention to adopt mobile phone technology for healthcare (mHealth)	Quantitative: survey $N=286$ Structural equation modelling	Unified theory of acceptance and use of technology (UTAUT)	Performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FCs), perceived ubiquity (PU), and perceived trust (PT) have a positive significant relationship with mHealth adoption intention (AI). The results do not indicate a negative relationship between technological anxiety (TA) and mHealth AI. Gender significantly moderates the relationship between PE and SI and mHealth AI.

Table 2 (continued)

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
8	Chen et al. (2021)	USA	To understand barriers and design opportunities to improve healthcare and QoL for older adults through voice assistants	Qualitative: interviews: $N = 21$ $n = 16$ (older persons) $n = 5$ (caregivers)		The study highlights challenges in the designing of intelligent voice assistants (IVAs) for older adults, especially for healthcare-related tasks.
9	Cohen et al. (2017)	Switzerland	To explore the perception of acceptability among community health nurses (CHNs) of an intelligent wireless sensor system (IWSS) for use in daily practice for the detection of health issues in home-dwelling older adults receiving home healthcare	Descriptive and qualitative data from a pilot randomised controlled trial $N = 17$ (CHNs)	Technology acceptance model (TAM)	A majority of the CHNs were dissatisfied with its performance and intrusiveness; they reported multiple difficulties in ease of use of the IWSS technology in daily practice.
10	Özsungur (2022)	Turkey	To analyse the effects of successful aging on technology acceptance and use behaviours via developing a model	Quantitative: survey $N = 687$ (participants in five retirement rest homes) Structural equation model	Unified theory of acceptance and use of technology (UTAUT)	Well-being of older persons is affected by the technology acceptance model in general, except the use of technology
11	Arthanat et al. (2019)	USA	To examine ownership of smart home (SH) technology by older adults and their readiness to adopt SH technology and identify the client factors relating to the adoption	Quantitative: survey $N = 445$ older persons Age = 60+ Stepwise regression model		Marital status, home security and overall Information and Computer Technology (ICT) ownership are predictors of SH ownership, whereas being female, concern over home security and perceived independence contributed to SH readiness. Consideration of the identified client profiles, health and personal factors will strengthen SH integration for ageing in place.
12	Reitsma et al. (2019)	Dutch	To find out the needs that motivate the use of gamified wearables by seniors	Qualitative: interviews: laddering technique $N = 12$ Age: 60–70 and 70+		The need to be healthy and accomplished can be fulfilled by the gamified wearables and motivated seniors to use them. While for some older persons, the safety need for good health is fulfilled by the gamified wearable, other needs are undermined.

Table 2 (continued)

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
13	Lebron et al. (2015)	USA	To observe how the provision of a wireless activity tracker influences the conscious health attitudes and behaviours of older persons	Randomised clinical trial $N = 6$ (older persons) Age: not reported		Older persons anticipated the acceptance of technology due its comfort. However, the perceived benefits of the technology influenced older people's decision to adopt the technology. Older persons perceived an improvement in their health with the introduction of technology.
14	Portet et al. (2013)	France	To assess the acceptance and objections of smart home voice interface among older persons	Experimental design and interviews $N = 18$ Older persons ($n = 8$); relatives ($n = 7$) and caregivers ($n = 3$) Mean age (older person): 79		Overall acceptance of technologies but with technology anxiety of controlling the lifestyle of older persons.
15	Cajita et al. (2018)	USA	To assess the perceptions of older adults with heart failure regarding the use of mobile technology and identify potential facilitators of and barriers to mHealth adoption	Descriptive exploratory study Semi-structured interviews Content analysis $N = 5$ Age: 66–83 years	Technology acceptance model	Older adults were willing to adopt the mobile health technology, albeit with reservations.
16	Cohen et al. (2016)	Switzerland	To explore the acceptability of intelligent wireless sensor system (IWSS) among home-dwelling older adults in rapidly detecting their health issues	Randomised clinical trial $N = 34$ (older patients)		The IWSS displayed low-to-moderate acceptability among the older participants and their informal caregivers. While older patients were unsatisfied with its ease of use due to multiple obstacles, informal caregivers were more satisfied with its usefulness, having an intention to use IWSS technology.

Table 2 (continued)

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
17	Freiesleben et al. (2021)	Germany	To investigate the barriers to the adoption of locating technologies from a multi-stakeholder professional perspective and explore strategies to optimise adoption	Qualitative: Focus group $N = 22$ Content analysis		Barriers to adoption centred on awareness, technological knowledge, product characteristics and capital investment-based limitations. The study shows that focusing on services to increase digital autonomy and information dissemination strategies has been largely overlooked and may be particularly effective.
18	Peek et al. (2016)	Netherlands	To explore which factors influence the level of use of various types of technology by older adults who are ageing in place and describe these factors in a comprehensive model	Qualitative: Semi-structured interview $N = 53$ Aged: 68–95 years Thematic analysis		Older adults' perceptions and use of technology are embedded in their personal, social and physical context. Awareness of these psychological and contextual factors is needed to facilitate ageing in place through the use of technology.
19	Turnbull et al. (2021)	Hong Kong	To examine the experiences and perceptions of Hong Kong residents aged over 60 years in relation to mHealth technologies and health literacy	Qualitative: Exploratory design Aged: 60 years Thematic analysis		Older persons were interested in using mHealth technologies. However, their use of digital devices was hindered by a lack of the necessary skills to use these gadgets and their loss of memory.
20	Abdul Rahman et al. (2021)	Malaysia	This study presents a survey that explores older adults' perceptions and expectations toward fall detection devices	A cross-sectional survey $N = 336$ (community-dwelling older adults aged 50 years and older) Chi-square Test		Most older persons expected that features for a fall-detection device include: user friendliness, followed by affordability price and accuracy.
21	Tu and Liu (2021)	China	To examine the moderating effects of subjective well-being (SWB) on the UTAUT model for the elderly's intention and behaviour regarding the use of gerontechnology	Questionnaire $N = 487$ (older persons) Structural equation model (SEM)	Unified theory of acceptance and use of technology	In all, performance expectancy (PE), effort expectancy (EE) and social influence (SI) positively affected the elderly's behavioural intention (BI) to use gerontechnology.

Table 2 (continued)

No.	References	Study Setting	Research objective	Methods	Theoretical model	Main results
22	Ngaruiya et al. (2021)	Kenya	To identify and explore the psychosocial considerations for the gerontechnology design for Kenyan geriatrics	Exploratory case study: Interviews $N = 8$ Age: 65–78 years Thematic analysis		Physical factors related to usability and user experience of older persons when using mobile phones. Psychosocial factors related to the emotional design experienced by older people when using mobile phones.
23	Wilson et al. (2021)	England, Scotland and Wales	To understand older adults' experiences of using social technology to connect with others	Qualitative exploratory: Semi-interviews $N = 20$ Age: 65+ Thematic analysis		Despite having access to technology for social connection, and using this technology regularly, multiple barriers impacted motivators and skills for use, namely perceived self-efficacy and fear, the culture of online communication, absence of social capital and physical functioning.
24	Jarvis et al. (2020)	South Africa	To investigate communication technology acceptance in older persons living in residential care	A cross-sectional survey $N = 277$ Age: 60+ years Structural equation model (SEM)	Senior technology acceptance model (STAM)	The acceptance of communication technology in this setting was low and predominantly influenced by attitudinal and technological context factors together with age and education.
25	Ha and Park (2020)	South Korea	To investigate the acceptance of technology among older Korean adults with multiple chronic health conditions and examine factors associated with technology acceptance	Quantitative: survey $N = 226$ (community-dwelling older adults) Age: 79.44 years Multiple linear regression model	Senior technology acceptance model (STAM)	Although older Korean adults with multiple chronic conditions displayed good technology acceptance, their age and education level predicted the level of acceptance.

Table 3 Quality appraisal for eligible studies

No.	Studies	Quality criteria for quantitative studies				
		Is the sampling strategy relevant to address the research question?	Is the sample representative of the target population?	Are the measurements appropriate?	Is the risk of nonresponse bias low?	Is the statistical analysis appropriate to answer the research question?
1	Chen and Chan (2013)	Yes	Yes	Yes	Yes	Yes
2	Halicka and Surel (2021)	Yes	No	Yes	Can't tell	Yes
3	Khan et al. (2021)	Yes	Yes	Yes	Yes	Yes
4	Özsungur (2022)	Yes	Yes	Yes	Can't tell	Yes
5	Arthanat et al (2019)	Yes	Yes	Yes	Yes	Yes
6	Ha and Park (2020)	Yes	Yes	Yes	Can't tell	Yes
7	Abdul Rahman et al (2021)	Yes	Yes	Yes	Yes	No
8	Tu and Liu (2021)	Yes	Yes	Yes	Yes	Yes
9	Jarvis et al (2020)	Yes	Yes	Yes	Can't tell	Yes
No.	Studies	Quality criteria for randomised control trials				
		Is randomisation appropriately performed?	Are the groups comparable at baseline?	Are there complete outcome data?	Are outcome assessors blinded to the intervention provided?	Did the participants adhere to the assigned intervention?
10	Lebron et al. (2015)	Yes	Yes	Yes	Can't tell	Yes
11	Portet et al (2013)	Yes	Can't tell	Yes	Can't tell	Yes
12	Cohen et al (2016)	Yes	Yes	Yes	No	Yes
No	Studies	Quality criteria for qualitative studies				
		Is the qualitative approach appropriate to answer the research question?	Are the qualitative data collection methods adequate to address the research question?	Are the findings adequately derived from the data?	Is the interpretation of results sufficiently substantiated by data?	Is there coherence between qualitative data sources, collection, analysis and interpretation?
13	Chen and Chan (2013)	Yes	Yes	Yes	Yes	Yes
14	Chen et al. (2021)	Yes	No	Yes	Yes	Yes
15	Reitsma et al. (2019)	Yes	Yes	Yes	Yes	Yes
16	Cajita et al. (2018)	Yes	Yes	Yes	Yes	Yes
17	Freiesleben et al. (2021)	Yes	No	Yes	No	Yes
18	Ngaruiya et al (2021)	Yes	Yes	Yes	No	No
19	Wilson et al (2021)	Yes	Yes	Yes	Yes	Yes
20	Cohen et al (2017)	Yes	No	Yes	Yes	No
21	Peek et al. (2016)	Yes	Yes	Yes	Yes	Yes

Table 3 (continued)

No	Studies	Quality criteria for qualitative studies				
		Is the qualitative approach appropriate to answer the research question?	Are the qualitative data collection methods adequate to address the research question?	Are the findings adequately derived from the data?	Is the interpretation of results sufficiently substantiated by data?	Is there coherence between qualitative data sources, collection, analysis and interpretation?
22	Turnbull et al. (2021)	Yes	Yes	Yes	Yes	Yes

No.	Studies	Quality criteria for mixed-method studies				
		Is there an adequate rationale for using a mixed method design to address the research question?	Are the different components of the study effectively integrated to answer the research question?	Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?
23	Huang et al. (2021)	Yes	Yes	Yes	Yes	Yes
24	Joseph et al. (2018)	Yes	Yes	Yes	No	No
25	Delbreil and Zvobgo (2013)	Yes	No	Yes	No	Yes

acceptance model ($n=5$), the senior technology acceptance model ($n=1$) and unified theory of acceptance and use of technology ($n=4$). Regarding the study design, most studies were either cross-sectional ($n=10$) or exploratory ($n=8$). Only a few studies adopted experimental ($n=4$) and mixed-method study designs ($n=3$). A descriptive summary of the reviewed articles is provided in Table 2.

Gerontechnology adoption by older adults and caregivers

This part of the review discusses the first research question about gerontechnology acceptance by older adults and caregivers. Findings of the thematic analysis revealed three primary themes: evaluation of gerontechnology, proxies of gerontechnology acceptance and barriers to gerontechnology acceptance. The results of each category are provided in the sections that follow.

Evaluation of gerontechnology

When older adults discussed gerontechnology, studies indicated more positive attitudes (e.g. Lebron et al. 2015; Turnbull et al. 2021; Wilson et al. 2021) than negative attitudes when they perceived the benefits of using gerontechnology. In some studies, gerontechnology received unfavourable attitudes when older adults had no explicit idea of the technology (Abdul Rahman et al. 2021). Beyond attitudes, the studies also emphasised that positive interest was tied to specific gerontechnologies. Gerontechnologies, which improve the overall health of older adults, were preferred when compared to those that were peculiar to some medical conditions of older adults. In this context, providing health information with the aid of digital devices was considered promising and acceptable (Turnbull et al. 2021) compared to other devices, such as fall detection devices (Abdul Rahman et al. 2021), intelligent wireless sensor systems (IWSS) among home-dwelling older (Cohen et al. 2016) or smart home voice (Portet et al. 2013), which may only apply to older adults who experience those peculiar medical conditions.

In contrast, Halicka and Surel (2021) observed that the most important gerontechnologies were those that dealt with older people's health and safety. Devices related to older adult care and social connectedness took third and fourth place, respectively, followed by mobility, recreational, and health informative devices. Housing and digital accessibility devices were the least important groupings. Some studies demonstrated caregivers' evaluation of gerontechnology, while others denoted a positive attitude towards gerontechnology to enhance the QoL of older adults (Chen and Chan 2013; Delbreil and Zvobgo 2013;

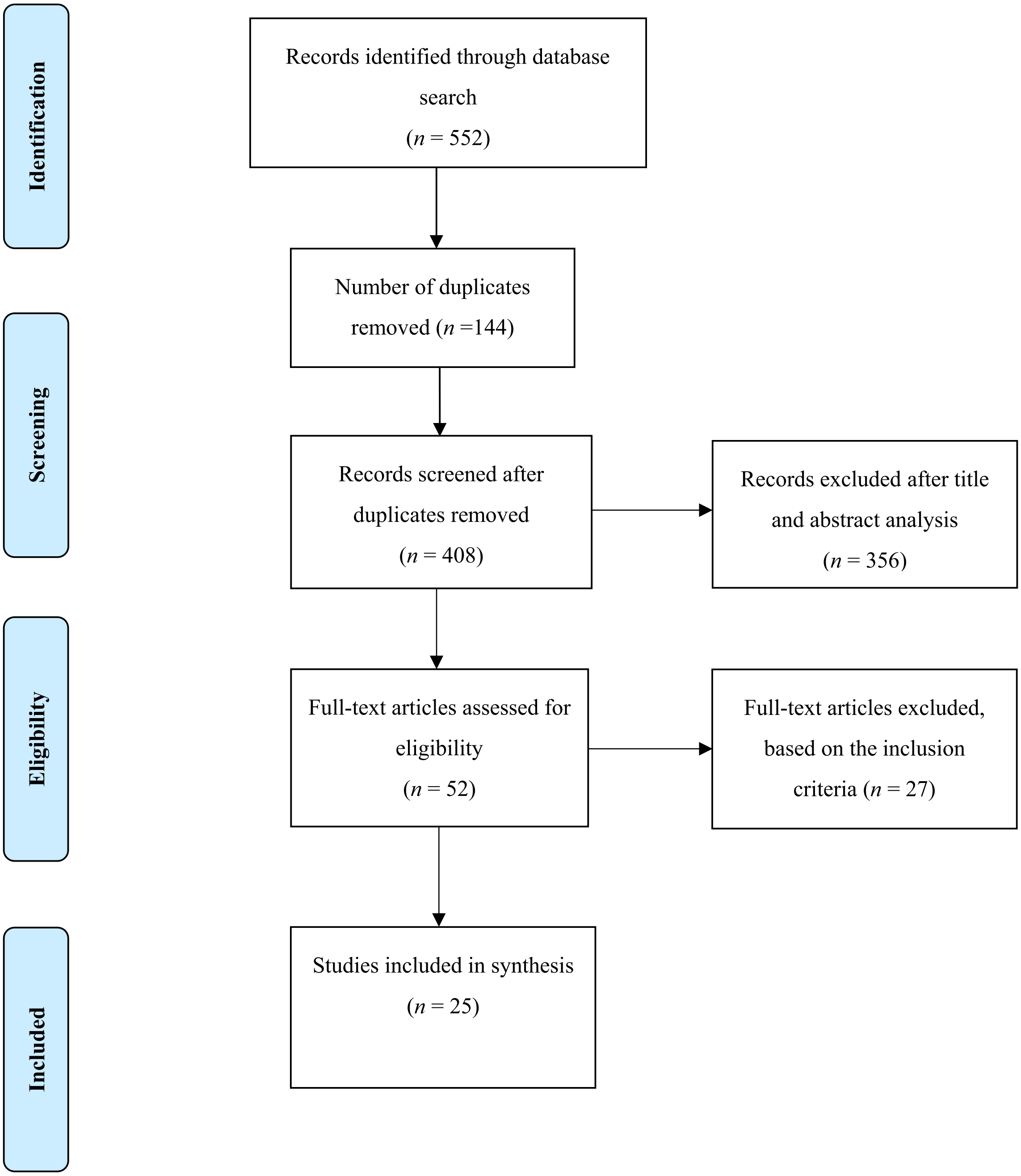

Fig. 1 Flowchart showing the search process

Portet et al. 2013) or reported caregivers' dissatisfaction with the performance and inappropriateness of the technologies (Cohen et al. 2017).

Predictors of gerontechnology acceptance

In this section, the following three main sub-themes were identified: technology usability, technology user-friendliness and social factors.

Technology usability

One critical motivation for gerontechnology acceptance was technology usability. For instance, studies found that older adults used technology for communication, cooking, supporting daily activities and entertainment (Delbreil and Zvobgo 2013; Huang et al. 2021; Portet et al. 2013; Menghi et al. 2017). Similarly, authors describe gerontechnology acceptance as a caveat to meeting the personal needs of older adults in several domains of life (e.g. Arthanat et al. 2019;

Jarvis et al. 2020; Reitsma et al. 2019). These studies are indicative that the need for good health, accomplishment, independence and peace of mind precipitates the usability of technology by older adults.

Other noteworthy studies have highlighted that older adults' thoughts on technology use were induced by their willingness to invest in technology (Peek et al. 2016) and frequency of use of the technology to increase the frequency of communication with their significant others (Wilson et al. 2021). Besides personal benefits, gerontechnology usability was inextricably tied to social benefits. The literature reports that the perceived usability of gerontechnology would be feasible if it would contribute to the creation of new jobs and bring measurable benefits to the QoL of human health (e.g. Halicka and Surel 2021; Wilson et al. 2021). Apart from older adults, studies report that caregivers' usefulness of gerontechnology was rated as significant in enhancing the health and safety of older adults (e.g. Cohen et al. 2016; Delbreil and Zvobgo 2013). As reported in the literature, caregivers' experiences of gerontechnology usability were linked with older adults' mental health and associated physical disabilities. In sum, the review emphasises that the perceived usability of gerontechnology could have personal and social benefits. In terms of social benefits, older adults stress the contribution of gerontechnology in maintaining their social networks, particularly with their families and children (Peek et al. 2016).

Technology user-friendliness

Another key finding connected to the boosters of gerontechnology adoption was user-friendliness. The findings in the review support the argument that perceived ease of use had a significant and positive influence on the usefulness of technology and that ease of use and usefulness predicted positive attitudes towards using gerontechnology (Halicka and Surel 2021). However, in some studies, the user-friendliness of gerontechnology was found not to culminate in the actual usage behaviour of older adults, even when it was expected that usage should be easy and effortless (Chen and Chan 2013).

In contrast to these studies, some studies claim that the user-friendliness of gerontechnology ensures safety and is necessary to guarantee usage behaviour (Delbreil and Zvobgo 2013). Instead, in the literature, some authors were concerned that older adults perceived personal proficiency in operating technology as a determinant of ease of use. For example, depending on the operational proficiency of older adults, entertainment devices, the internet, communication devices and microwave ovens were mentioned in the literature as unique gerontechnology devices that were either user friendly or unfriendly (e.g. Peek et al. 2016). In one pertinent study, perceived ease of use was tied to the ability of technology to connect older adults to significant others (Jarvis et al. 2020).

Social factors

In addition to user-friendliness, some studies claim that the availability of social support from significant others is indispensable in technology acceptance and usage (Chen and Chan 2014; Jarvis et al. 2020; Özsungur 2022; Peek et al. 2014). Tu and Liu (2021) added that older adults require proper guidance, assistance and resources from caregivers to use gerontechnology effectively. Beyond the scope of these studies, Chen and Chan (2014) linked older adults' technology adoption to attaining favourable social outcomes, for instance, the enhancement of one's image. This implies that using gerontechnology prevents older adults from being labelled outdated.

Barriers to gerontechnology acceptance

This section discusses six sub-themes that capture the barriers to gerontechnology acceptance. They encompass personal and behavioural factors, economic factors, technological factors, cultural and environmental factors and situational or dispositional factors. Details of the sub-themes are discussed below.

Personal and behavioural factors

From the analysis, negative self-evaluated beliefs inhibited gerontechnology acceptance behaviour (Freiesleben et al. 2021; Joseph et al. 2018). For instance, Chen and Chan (2013) found gerontechnology non-usage to be connected to low literacy levels, as it would require older adults to acquire specialised knowledge. The review also established that older adults with lower levels of self-efficacy and anxiety tend to be more likely to use gerontechnology and consider such technology useful and easy to use (Halicka and Surel 2021). Moreover, the authors explain that older adults have greater anxiety and believe they have little control over the technologies. It is evident that older adults feel more anxious and less competent; therefore, they are more resistant to using gerontechnology (Chen and Chan 2014; Jarvis et al. 2020; Wilson et al. 2021). As a result, older adults need assistance when they have difficulties. However, they may also be anxious and reluctant because they do not want to cause inconvenience to their caregivers (Chen and Chan 2013). Older adults have information anxiety caused by their physical health information, considering it to be undermining the tranquillity of their minds (Reitsma et al. 2019). Older adults' quest to be independent, safe, have personal contact and domestic needs (household chores, hobbies, and voluntary work) were personal indicators in favour of gerontechnology (Huang et al. 2021; Portet et al. 2013).

Beyond older adults' needs, studies also reiterated that caregivers are anxious that accepting gerontechnology would render older adults indolent (Portet et al. 2013; Reitsma et al. 2019). Arthanat et al. (2019) also identified marital status, home security and internet ownership as the personal predictors of gerontechnology unacceptance. Despite these, the review found that factors such as gender (mostly females), concerns about home security and a sense of independence contributed to gerontechnology adoption. The review also highlighted that cognitive and physical decline was observed to limit older adults' use of gerontechnology, especially in certain types of technologies, such as household appliances and mobile devices (Ha and Park 2020; Jarvis et al. 2020; Peek et al. 2016). Regarding personal factors, some studies explained that physical features, such as visibility, complexity, feedback, exploration, and recognition, are predominant factors in older adults' adoption of gerontechnology (Ngaruiya et al. 2021; Wilson et al. 2021). Pertaining to caregivers, the review found that discrepancies between patients' needs and gerontechnology devices discouraged acceptance (Freiesleben et al. 2021; Huang et al. 2021). It is important to emphasise that socio-demographic factors such as age, health and education predicted gerontechnology acceptance; however, in all, older adults' adoption intention was moderately low in the review.

Economic constraints

Another aspect of the findings is related to the economic constraints on gerontechnology non-usage. Though the role of promotional activities or advertising messages and visuals preceded gerontechnology acceptance (Freiesleben et al. 2021), the review's findings attributed the non-usage of gerontechnology to cost of the product or service (Chen and Chan 2013, 2014). That is, if the cost of the product or service, training or education fees, and maintenance costs exceed the acceptable range for older adults, users would refuse to use the technology (Peek et al. 2016). In addition, the study discovered that older adults preferred to buy gerontechnology products and services locally because they were cheaper rather than those available on the internet (Peek et al. 2014). Interestingly, the review indicates that older adults receive financial support from family members, implying that the responsibility for elderly care lies with the family rather than the government. Therefore, they may face greater financial constraints when using technology (Chen and Chan 2014).

Technological constraints

Gerontechnology properties related to size, language, weight, reliability, and language of others that older adults perceived as unfavourable affected adoption intention (Jarvis et al. 2020; Peek et al. 2016). Detailing technological constraints, Cohen et al. (2017) mentioned that caregivers' difficulty in managing alert messages from gerontechnology devices increased work demands, particularly for older patients with mental health problems, who were often unable to remember or explain the reason for their behavioural change. This resulted in either under- or overestimation of older patients' risks of declining health status, resulting in either irrelevant notifications or the absence of notifications in real cases of declining health status.

Cultural and environmental factors

Based on the analysis, the review explored environmental and cultural factors constraining gerontechnology acceptance. First, when discussing mobility aids and means of transport, Peek et al. (2016) mentioned that older adults were concerned about road safety, which led to their unacceptance of these types of technology. Second, the literature has found that culture and online communication constrain gerontechnology acceptance (Cohen et al. 2016). Wilson et al. (2021) observed that older adults felt that gerontechnologies, especially those with social benefits, were a useful tool to connect to others but that it did not replicate spending time with one another. Culturally, older people are concerned with their roles in contemporary society and how they can use technology to bridge the intergenerational gap (Ngaruiya et al. 2021). Chen and Chan (2013) found that acceptance and usage of gerontechnology were more difficult for older adults because they were not familiar with their generation compared to the younger generation.

Situational or dispositional factors

The thematic analysis also explored situational or dispositional factors in relation to gerontechnology usage. Regarding situational factors, an individual's current circumstance or situation beyond his or her control was found to impact gerontechnology acceptance (Peek et al. 2016). It has also been found that the use of one type of technology competes with the use of other types (Joseph et al. 2018; Peek et al. 2016). For example, Peek et al. (2016) highlighted that, for some types of technology, older adults' choice of a landline phone was because they were more familiar with it compared to that of a mobile phone—a technology for the present generation. Abdul Rahman et al. (2021) indicated that the situational barriers included lack of assistance, lack of time, limited exposure to modern technology and inaccessibility and influences of secondary resources. Unlike older adults, caregivers were concerned that most gerontechnology devices could not support caregiving in emergency situations (Freiesleben et al. 2021). In addition to situational constraints, some dispositional factors were also identified from the findings. Chen and Chan (2013) found forgetfulness to use devices as one of the dispositional barriers to gerontechnology. For example, the study mentions that most older adults cannot remember the passwords of their electronic devices.

Gerontechnology and the QoL of older adults

In this section, the review discusses the thematic findings regarding the impact of gerontechnology adoption on better elderly care and QoL. Two main themes were identified: a healthy lifestyle and social wellness.

Healthy lifestyle

Pertaining a healthy lifestyle, the results are ambivalent. The findings were indicative of the fact that gerontechnology adoption affects the QoL of older adults. For example, Delbreil and Zvobgo (2013) assert that caregivers' confidence in gerontechnology improves older adults' QoL and lightens the caregivers' burden. In support of this, Freiesleben et al. (2021) observed that caregivers held favourable views on locating technologies to increase older adults' QoL. Reitsma et al. (2019) also confirmed that older adults who used gerontechnology to monitor their health had an average active lifestyle, with all of them either walking or cycling regularly. Therefore, the healthy lifestyle of older adults in this instance could cause them to satisfy other life needs when compared with those who are less active. This study further supported the idea that, when provided with information about physical activity, older adults can validate their abilities and qualities and fulfil their need for accomplishment (Reitsma et al. 2019).

Although the impact of quality differs from one type of gerontechnology used to another, a study by Portet et al. (2013) emphasised that the acceptability of a smart home equipped with audio processing technology has enormous potential to ease everyday life for older adults. Moreover, in this study, most of the needs of elderly people were linked to better security at home. Conversely, while this arrangement was expected to produce an independent lifestyle, caregivers were concerned that it would render older people less independent by encouraging an idle lifestyle and further deteriorating their health conditions further (Freiesleben et al. 2021; Portet et al. 2013). Furthermore, findings suggest that using gerontechnology might essentially be a source of risk for older adults who may extensively be exposed to adverse health conditions or a loss of life (Halicka and Surel 2021).

Social wellness

It is evident from the findings that gerontechnology was used to enhance existing connections with, as opposed to withdrawal from, society, which has the potential to increase life satisfaction and reduce mental health issues (Wilson et al. 2021). In Wilson et al. (2021), access to and use of gerontechnology, such as digital devices and social media, were valued as tools for social connection. Surprisingly, older adults who were neither lonely nor isolated used technology to connect with others significantly more often than those who experienced loneliness, isolation, or both (Wilson et al. 2021). For older adults who were conservative and preferred face–face communication, Halicka and Surel (2021) mentioned that gerontechnology posed a threat to their social relations to a large extent. However, the review shows that the use of gerontechnology is evident specifically in online visual communication tools as a medium for connecting with friends and family when face-to-face communication is not possible (Wilson et al. 2021).

Discussion

First, this review has highlighted that older persons' and caregivers' attitudes towards gerontechnology are ambivalent. In contrast to many extant studies that conclude on positive attitudes towards gerontechnology usage (e.g. Cohen et al. 2016, 2017; Yow et al. 2018), analysis of the review recognises both positive and negative attitudes towards gerontechnology. Positive attitudes towards gerontechnology are related to the benefits of using gerontechnology, such as abating health, social and family challenges. Unfavourable or negative attitudes towards gerontechnology pertained to older adults' lack of explicit ideas about the technology, dissatisfaction with its performance and its inappropriateness.

This review has identified that older people's opinions regarding gerontechnology are important determinants of adoption intentions. This is more crucial, especially when positive attitudes towards gerontechnology may result in higher usage and negative attitudes resulting in lower usage (Chen and Chan 2013, 2014). Thus, efforts to change the negative opinions of older adults regarding gerontechnology should be given greater consideration. While this review underscores the indispensable role of positive attitudes towards gerontechnology adoption, some studies have argued that they may not lead to its usage (Kazanaviˇ and Lesauskait 2019; Lim et al. 2016). Furthermore, substantial number of studies have shown that users' opinions before and after using gerontechnology are diverse (Merkel and Kucharski 2019; Sundgren et al. 2020). Notably, some studies have demonstrated that the role of social influences on the intention and usage of gerontechnology is substantial in the initial stages of adoption. However, this weakens over time as users familiarise and gain proficiency with the technology (Peek et al. 2016). Similarly, other studies acknowledged that users have positive attitudes towards gerontechnology at the post-usage stage when their health condition improves after usage, although they might have had negative attitudes at the pre-usage stage. The improvement in attitudes towards gerontechnology from pre-usage to post-usage may stimulate continuous usage of the technology (Jansson and Kupiainen 2017; Peek et al. 2016). To facilitate the continued usage and acceptance of gerontechnology products and services, additional longitudinal research is required to better understand users' full gerontechnology adoption life cycle.

In the review, the self-efficacy and anxiety of older people are significant barriers to adoption of gerontechnology. The results are consistent with extant studies that demonstrate that individuals with lower levels of self-efficacy and higher levels of anxiety towards gerontechnology have a lower acceptance rate of the same (e.g. Latikka et al. 2019; Lee and Tak 2022). However, research indicates that the effects of self-efficacy and anxiety of older people on gerontechnology are more powerful when mediated by user-friendliness and the benefits of the technology (Chen and Chan 2013, 2014; Latikka et al. 2019; Williams and Rhodes, 2016). In contrast to these studies, some studies have argued that older adults' previous experience and frequency of use of a similar technology tend to increase levels of self-efficacy and reduce levels of anxiety (Kim et al. 2021; Peral-Peral et al. 2020). In general, the review suggests that there are significant differences in self-efficacy and anxiety when discussing technology in general compared to specific types of technology.

As reiterated in the review, financial resources obstruct the adoption of gerontechnology. Mostly, older adults and caregivers find it challenging to purchase and maintain gerontechnology products and services because they are often costly. Consistent with the exchange theory, various studies (e.g. Lee 2014; Lee and Tak 2022) are consistent with the argument that older adults and caregivers are constrained financially as they appraise the costs of technology vis-a-vis its prospective profits in adoption intention and usage. Furthermore, Chen and Chan (2013) found that since the burden for elderly care falls on the families of older people rather than the government, especially those with relatives in care homes, they may face greater financial constraints when it comes to using gerontechnology. However, some studies posit that, unlike caregivers, older adults are often late adopters. When a gerontechnology is introduced, it is labelled as highly innovative, complex, and highly priced; however, as the technology is used over time, it becomes accessible because it tends to be less innovative, simple and cheap (Arthanat et al. 2019; Lee and Kim 2017; Price et al. 2013). Therefore, it is imperative to say that incentives and subsidies provided by policymakers and stakeholders may improve the acceptance rate of gerontechnology.

While gerontechnology usability is critical in adoption intention, the review shows that technological factors pose various hurdles to overcome. Technological factors encapsulated in several design features make gerontechnology easier to control and manage. However, many design systems that have interfaces difficult to read, understand and control fail to comply with usability guidelines (Lee 2014). This is supported by studies conducted in Hong Kong and China, which found that older people do not even know the English alphabet well (Chen and Chan 2013, 2014), making it difficult for them to use electronic equipment with English interfaces. For caregivers, difficulty with technical characteristics resulted in either under- or overestimation of older patients' risks of declining health status (Frisardi and Imbimbo 2011). The review demonstrates that caregivers do not have complete knowledge of the technical features of gerontechnology, as corroborated in other studies (McHugh and Lawlor 2012; Melkas et al. 2020). Therefore, it is vital to consult caregivers while designing gerontechnology to understand their specific problems and address them comprehensively.

As previously stated, social capital networks are expedient in assisting older adults' efficient use of gerontechnology. This is substantiated by the fact that older adults with physical and cognitive decline, such as dementia, may be unable to use the gerontechnology (Guisado-Fernández et al. 2019; Kim et al. 2021) without support from social relationships. While the role of social capital in older adults' care for a health condition cannot be underestimated, it is essential to recognise that gerontechnology adoption and usage is an indication that older adults want to increase autonomy and compensate for age-related health deficiencies (Kohlbacher and Herstatt 2011).

The review demonstrates that gerontechnology acceptance by older adults and caregivers facilitates better elderly care and life quality. For older adults, gerontechnology acceptance and usage depend on the personal and social benefits of products and services. However, gerontechnology usage for caregivers is found to be contingent on the efficiency of the product or service, which can enhance the health and safety of older adults. The implication is that older adults and caregivers are more likely to adopt gerontechnology when they expect it to result in favourable outcomes. This raises the possibility that more optimistic users about any specified gerontechnology perceive it as more beneficial and easier to use compared to less favourable users (Godoe and Johansen 2012).

Moreover, these findings also support the notion that gerontechnology offers older adults, particularly cohorts of older persons in care homes, the opportunity to sustain their independence by ageing actively and ageing in place (Ollevier et al. 2020). This necessitates that social caregivers understand these new technology and the potential benefits for older adults' health promotion and assistance (Schmitter-Edgecombe et al. 2013). Thus, the studies examined in this review highlight the importance of professional training and development for social caregivers regarding the use of existing and emerging gerontechnologies to create more ecologically valid, impartial, and frequent measures of change when monitoring older people's healthy functioning.

Implications for further research agenda

Overall, both older workers and caregivers agree that a positive attitude towards gerontechnology is a means to enhance the QoL of older people. However, studies on the attitudes and perceptions of social caregivers and health professionals towards gerontechnology acceptance have received little attention so far. Therefore, future studies should investigate the factors of gerontechnology acceptance or unacceptance by social caregivers and health professionals. The paper highlights that the most important gerontechnology products and services are those that deal with older people's health and safety.

Further research can also investigate the structural factors that differ between these technologies and their stages of usage among older adults and social caregivers. More specifically, a longitudinal study is required on how changes in the factors identified in this review affect older adults' and social caregivers' attitudes and beliefs regarding the use of gerontechnology.

It is invariably reasonable to appreciate that various studies identified in the review proposed theoretical models to explain older people's adoption of gerontechnology. Factors identified in frameworks such as the technology adoption model (TAM), senior technology adoption model (STAM) and unified theory of acceptance and use of technology (UTAUT) were found to impact gerontechnology adoption by both older adults and caregivers. However, these models acknowledge that some factors may not be able to predict gerontechnology acceptance and usage. For instance, consistent with TAM, STAM and UTAUT, some studies in the review underscored the influence of attitudinal factors such as technology usability and user-friendliness in adoption. However, other studies found that personal, technological, and environmental factors were imperative in adoption and usage rather than attitudinal factors. This suggests the relevance of other factors that explain the unacceptance or acceptance of gerontechnology, regardless of the adoption intention of older people and social caregivers.

Thus, the review identified many mediating factors that explain the relationship between gerontechnology acceptance and the QoL of older adults. Hence, further studies employing quantitative methodology can investigate the moderating or mediating relationships between these factors and the strength of their relationships with each other. For example, a positive self-perception of ageing and satisfaction with life would increase the possibility of using technology. In return, using technology can also increase older users' well-being and self-evaluation. Future qualitative studies can deepen studies on older adults' and social caregivers' reasons for using or not using gerontechnology, regardless of their adoption intentions. In addition, more qualitative research is needed to better understand how older adults evaluate and decide between the various gerontechnology options available to them when faced with challenges in the domain of independent living. The paper also supports that it is important to study the use of technology by older adults', including understudied populations, such as the oldest-old and rural older adults, since these populations may have different health and technology needs.

Strengths and limitations

Our study has several strengths. First, this review offers a comprehensive evidence on gerontechnology acceptance and usage by focusing on the perspectives of both older persons and social caregivers, compared to many systematic reviews, which are predominantly themed on the older population. Second, the inclusion of studies that evaluate the effect of gerontechnology usage by older individuals and social caregivers contributes to scholarship by presenting systematic evidence that goes beyond gerontechnology usage intentions or adoption. In addition to theoretical evidence on gerontechnology intention or behaviour, evidence from this review informs policy or practice to ensure better elderly care and quality of life. Furthermore, the inclusion of both quantitative and qualitative study designs improves the quality of this review by removing any potential methodological bias and extending the scope and depth of evidence on the topic.

However, we acknowledge that our review has some limitations. First, we acknowledge that since this study was limited to publications in English language, there remains a possibility of missing other relevant studies and insights in some languages. In addition, the search strategy was exclusively restricted to peer-reviewed publications, excluding possibly relevant dissertations, conference presentations and book chapters. As we adopted a thematic approach in analysing the studies, we admit that there were no statistical or other quantitative techniques of analyses. Nonetheless, the thematic analysis goes beyond the narrative approach of mere descriptions and summary of the main features of included studies. Rather, the review explored the similarities and differences between studies, assessed their contributions to extant literature, and the practice or policy implications for future discourse on gerontechnology.

Conclusion

Through a systematic approach, this paper contributes to scholarship by extending knowledge of the experiences of both older adults and social caregivers regarding the acceptance and unacceptance of gerontechnology. This paper concludes that the impact of gerontechnology acceptance on both older adults and social caregivers is highly dependent on certain personal, socio-cultural, technological and physical factors. Furthermore, since older adults and social caregivers constitute two heterogeneous groups, a unitary or all-purpose policy approach for gerontechnology and a better QoL may be ineffective.

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Declarations

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ORIGINAL INVESTIGATION

Validation of a brief version of the Difficulties in Emotion Regulation Scale (DERS-16) with an older Norwegian population

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Abstract

Emotion regulation is proposed to have a salient role in optimal aging. However, currently used measures of emotion regulation have not been validated for older adults. Therefore, we evaluated the psychometric properties of the Difficulties in Emotion Regulation Scale—short form (DERS-16) in a large Norwegian sample consisting of individuals between 70 and 95 years (n = 2525). Tests of internal consistency, reliability, assessment of intra-domain correlations, and confirmatory factor analyses were performed. Construct validity was further investigated by assessing concurrent associations between DERS-16 and well-established measures of psychological disorders, psychological health, and well-being (five-item version of Geriatric Depression Scale, Geriatric Anxiety Inventory—short form, and OECD guidelines on measuring subjective well-being). All subscales derived from the instrument showed adequate internal consistency. Furthermore, we obtained a theoretically consistent factor structure, in which a bifactor model combining a general emotion regulation factor and five additional domain-specific facet-factors had superior model fit. As expected, difficulties in emotion regulation correlated positively with symptoms of depression and anxiety, and negatively with psychological health and well-being. Associations were generally of moderate strength. We can thus conclude that the DERS-16 demonstrates excellent psychometric properties when used in samples with older adults and may safely be employed in studies of emotion regulation difficulties in the older segment of our population.

Keywords Emotion regulation · Validation · Psychometric properties · DERS-16

Introduction

The way people relate to and regulate their emotions is associated with psychological health. A common definition of emotion regulation is "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross 1998, 2015). Empirical evidence points out emotion regulation as a general transdiagnostic factor that may explain the development and maintenance of psychological disorders (Aldao et al. 2010). Numerous self-report questionnaires have been designed to assess emotion regulation (John and Eng 2014). However, most of these questionnaires have been designed using samples with younger adults. The validity of emotion regulation assessment with older adults is therefore unclear.

One of the most frequently used measures of emotion regulation is the Difficulties in Emotion Regulation Scale (DERS-36; Gratz and Roemer (2004)). The DERS-36 is a 36-item questionnaire designed to measure emotion regulation abilities. Results from studies that explore the psychometric properties, and the factorial structure of the DERS-36 are not conclusive (Lee et al. 2016; Osborne et al. 2017). Additionally, attempts have been made to design shorter

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versions of the DERS-36, to reduce the administration time and the burden for research participants and patients. Subsequently, shorter forms of the DERS-36 based on improved psychometric properties have been developed. One of these is the DERS-16 (Bjureberg et al. 2016), which omits one of the original subscales (emotional awareness) and is shortened down to 16 items.

The DERS-16 measures emotion regulation difficulties across five dimensions: (1) emotional clarity and understanding; (2) acceptance of emotions; (3) engaging in goal-directed behavior when experiencing emotions; (4) refraining from impulsive behaviors when experiencing emotions, and (5) access to effective and situationally appropriate strategies to regulate emotions. Several attempts have been made to investigate the psychometric properties and factor structure using Confirmatory Factor Analyses (CFA), but the results are inconsistent. Studies have demonstrated acceptable fit when examining the factor structure of the DERS-16 using a five-factor model, both in university students (Shahabi et al. 2018; Yiğit and Guzey Yiğit 2019) and hospitalized patients with severe psychiatric disorders (Charak et al. 2019). In contrast, poor or marginal fit indices for the five-factor model was found in studies that used samples that were large and community-based (n > 700) (Miguel et al. 2017; Sörman et al., 2022), and outpatients with psychosis (Lawlor et al. 2021). Finally, two studies found satisfactory fit using a five-factor model when omitting two items from the strategy-factor in their analyses, hence testing a 14-item version of the DERS-16 (Lawlor et al. 2021; Westerlund and Santtila 2018).

Concerning other models, Shahabi et al (2018) tested a second-order model including the five factors in addition to a higher-order emotion regulation difficulties factor. However, the model showed poor fit. More recently, several studies have evaluated a bifactor solution of the DERS-16, with five factors in addition to a general emotion regulation difficulties factor. Sörman et al. (2022) found good and superior fit in comparison to the five-factor solution. Similar results have been found in studies using clinical samples with eating disorders, including adult women (Nordgren et al. 2019) and adolescent girls (Monell et al. 2022). This is in line with factor-analytic investigations with the DERS-36, where best fit is typically demonstrated using a bifactor solution in comparison to five-factor and second-order models (Hallion et al. 2018; Osborne et al. 2017).

Regarding construct validity of the DERS-16, studies show promising results, as self-reported difficulties in emotion regulation correlate with symptoms and severity of depression (Burton et al. 2022; Skutch et al. 2019) and anxiety (Shahabi et al. 2018; Sörman et al. 2022). In sum, former factor-analytic investigations show somewhat mixed results, of which heterogeneity in terms of types of statistical models and sample characteristics are common.

Another concern regarding studies based on the DERS-16, is the lack of older adults in the study samples. Although five studies included smaller sub-samples of older adults (Charak et al. 2019; Lawlor et al. 2021; Miguel et al. 2017; Sörman et al. 2022; Westerlund and Santtila 2018), the exact distribution of age groups in these studies are unclear, and most studies do not consider age as a possible contributor to the results. An exception is Miguel et al. (2017) who included a sample with individuals ranging in age from 18 to 70 years and found a negative correlation between age and DERS-16. That is, the older the individuals, the lesser self-reported emotion regulation difficulties. In line with Miguel and colleagues, Westerlund and Santtila (2018) found that younger individuals (< 40 years old) reported significantly more difficulties with emotion regulation compared with older individuals (> 40 years old). However, their study included a small sample of older adults (n = 59), raising questions about the validity of this finding.

Overall, the lack of older adults in validation studies utilizing the DERS-16 raises concerns regarding the validity of the instrument specifically for this age group. Studies suggest that age is an important moderator in terms of emotional processing. For example, laboratory investigations show that older individuals recognize negative emotions less accurate than younger adults (Mill et al. 2009). Also, older individuals choose different emotion regulation strategies than younger individuals when experiencing negative emotions. For instance, one study showed that older individuals exhibited a greater preference for choosing distraction as a strategy for regulating their emotions compared to younger adults when exposed to negative-valanced images. This preference was further linked to higher levels of well-being among the older adult sample (Scheibe et al. 2015). Moreover, studies have suggested that the experience of negative affect decreases as a function of age (Furnham and Cheng 2019). One study demonstrated that older individuals reported fewer negative emotions during an unpleasant social interaction compared to their younger counterparts. This was further supported by lower levels of psychophysiological arousal among the older group (Luong and Charles 2014). Additionally, older individuals experience less negative and more positive affect in daily life (Hay and Diehl 2011) along with more stability in emotional states (Brassen et al. 2011). Finally, older adults attend to and remember positive stimuli and exhibit less attention to negative stimuli compared to younger adults (Reed et al. 2014). Based on such findings, it has been hypothesized that emotion regulation difficulties decrease as an effect of age, partly because of changes in personal goals when time left in life is perceived as limited (Carstensen et al. 1999). In support of this hypothesis, studies with heterogeneous age groups report that self-reported emotion regulation difficulties as measured by the DERS-36 decreases with age (Giromini et al. 2017;

Orgeta 2009). Against this backdrop, it appears imperative to test whether the assessments of self-reported emotion regulation that we use in clinical and empirical work are valid also in older populations.

The aim of the present study was to examine the internal structure of scores from the DERS-16 by analyses of internal consistency and confirmatory factor analyses (CFA) in a sample of individuals who were 70 years or older, and testing four factor-analytic models: (1) a unidimensional model based on the assumption of a general emotion regulation difficulties factor; (2) a five-factor model; (3) a hierarchical model and (4) a bi-factorial model consisting of a general emotion regulation difficulties factor together with all five factors was assessed. Based on prior studies, we hypothesized that the single-factor solution would have the poorest fit, while the proposed factor models with five distinct emotion regulation facets and the higher-order model would be confirmed with acceptable fit indices. Based on prior results from studies with the DERS-36 (Hallion et al. 2018; Osborne et al. 2017) and DERS-16 (Monell et al. 2022; Nordgren et al. 2019; Sörman et al. 2022), we predicted that the bifactor solution would demonstrate superior fit compared to the other models.

The second aim of the study was to examine construct validity of the DERS-16 with relevant external correlates. For example, difficulties in self-reported emotion regulation has been shown to be associated with major depressive disorder (Joormann and Stanton 2016; Visted et al. 2018) and anxiety disorders (Cisler and Olatunji 2012). Similarly, other studies have found positive correlations between symptoms of depression and anxiety and the DERS-16 (Bjureberg et al. 2016; Shahabi et al. 2018; Yiğit and Guzey Yiğit 2019). However, no prior studies have investigated the construct validity of psychological health using measures validated specifically for older individuals. We hypothesized to find positive relationships between self-reported emotion regulation difficulties and measures of depression and anxiety, and negative relationships between self-reported emotion regulation difficulties and well-being.

Method

Participants and procedures

A representative sample of 81,170 individuals from among 224,000 adult inhabitants in the City of Bergen in Western Norway were invited in April 2020 to participate in a study surveying the impact of lockdown on daily life and health during the COVID-19 pandemic. The individuals invited to participate were drawn from the Contact and Reservation Registry through the Norwegian Digitalization Agency. In total, 29,535 individuals consented to participate in the first wave of the study. Out of these, 3917 first wave responders were over 69 years old. For the present validation study, all 3917 home-dwelling seniors (age > 69 years) were invited to fill out an online questionnaire package involving psychological health and well-being.

The ethics committee Regional Ethics Committee Western Norway approved the study (Reference: 131560). The study was conducted according to the guidelines of the Declaration of Helsinki. All participants consented before participation.

Measures

Difficulties in Emotion Regulation Scale-16 item version (DERS-16) (Bjureberg et al. 2016). The DERS-16 consist of 16 items that assess the following facets of emotion regulation difficulties: (1) nonacceptance of negative emotions (three items, labelled NONACCEPT); (2) inability to engage in goal-directed behaviors when experiencing negative emotions (three items, labelled GOALS); (3) difficulties controlling impulsive behaviors when experiencing negative emotions (three items, labelled IMPULSE); (4) limited access to emotion regulation strategies (five items, labelled STRATEGIES); and (5) lack of emotional clarity (two items, labelled CLARITY). The items are rated on a 5-point Likert-scale (from 1: almost never to 5: almost always). The total score (DERS-TOTAL) is derived by summing all individual item responses, and subscale scores are derived by summing up all item responses within each subscale. Higher scores reflect greater levels of emotion regulation difficulties. The DERS-36 has been translated into Norwegian (Dundas et al. 2013).

The five-item version of Geriatric Depression Scale (GDS-5) (Hoyl et al. 1999). The GDS-5 was used to measure symptoms of depression. The participants respond on a two-point rating scale (0–1; e.g. "Do you often feel helpless?" and "Do you feel pretty worthless the way you are now?"). Higher scores (maximum 5) reflect greater depressive symptoms. The GDS-5 has been translated into Norwegian, and validated for use with Norwegian participants (Eriksen et al. 2019).

The short form of the Geriatric Anxiety Inventory (GAI-SF; (Byrne and Pachana 2011) was used to measure symptoms of anxiety. It consists of five items (e.g., "I worry a lot of the time" and "I often feel nervous"), requiring a yes (agree) or no (disagree) answer. Responses are summed and higher total score reflect greater anxiety. The GAI-SF has been translated and validated to be used in Norway (Molde et al. 2017).

Subjective well-being was measured using two items from the OECD Guidelines on measuring Subjective Well-being (OECD 2013). Participants respond on a scale from 0 to 10 (0: not at all satisfied/not at all worthwhile, 10: completely satisfied/completely worthwhile) on the following two items: (1) Overall, how satisfied are you with life? (2) Overall, to what extent do you feel the things you do in your life are worthwhile? Higher scores reflect higher well-being.

Statistical analyses

Preliminary analyses and reliability

Frequency and descriptive analyses on background variables, mental health, and well-being were conducted on both included and excluded participants. T-test analyses on indices of mental health and well-being were performed to assess possible disparities between included and excluded participants. Descriptive analyses were performed with means and standard deviations for each item of the DERS-16. Moreover, skewness and kurtosis, means, standard deviations and Cronbach's alpha values for each subscale was computed. In this study we adhered to the recommended spectrum (skewness < 3 and kurtosis < 10) (Kline 2016). We calculated Pearson correlation coefficients for all subscales. Preliminary analyses and correlation coefficients were calculated using IBM STATISTICS SPSS version 28.

Factor analysis and model fit

Four confirmatory factor analyses (CFA) were carried out based on structural equation modelling (SEM): (1) a single-factor, unidimensional "Emotion Regulation Difficulties" solution; (2) a five-factor facet solution; (3) a hierarchical model with a higher-order general factor and five second order facet factors, and finally; (4) a bifactor model, including the five facet factors in addition to a general emotion regulation difficulties factor at the same level. The fit indices used to assess model fit were comparative fit index (CFI), Tucker Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). We used the recommendations of Hu and Bentler (1999) in terms of the interpretation of the fit indices: values of > 0.95 on CFI and TLI and values of < 0.06 on RMSEA was considered as acceptable fit indices. The CFA analyses were performed using IBM STATISTICS AMOS version 27.

Associations with external correlates

Bivariate correlations were computed between all facets of the DERS-16, and indices of depression (GDS-5), anxiety (GAI-SF), and subjective well-being (OECD) were used to assess associations with relevant external variables. To assess the explained variance of the DERS-16 in the external variables, we calculated R^2 ($r * r$) for strongest obtained correlations.

Results

Recruitment and preliminary analyses

Of the total 3917 participants that were invited, 914 responders did not answer or did not want to participate. Of the 3003 resulting participants, 478 respondents did not complete the DERS-16 or had missing data on DERS-16 and were omitted from further analyses. Thus, 2525 were included in this study (65% response rate). See Table 1 for demographic, mental health, and well-being characteristics of the included participants. Overall, the included sample reported low levels of depression and anxiety, and relatively high levels of well-being. The characteristics of the 478 respondents that

Table 1 Demographic and background characteristics of participants (n = 2525)

	n	%
Gender		
Male	1356	54
Female	1169	46
Age		
70–74	1271	51
75–79	750	30
80–84	309	12
> 85	176	7
Domestic status†		
Living alone	1007	42
Living with others	1336	58
Usage of health services prior month		
Familiy doctor	13	1
Nursing service or home care	16	1
Hospital services	8	> 1
COVID-19 related variables		
In quarantine prior month	141	6
COVID-19 infection prior month	63	3
Mental health and well-being indices		M (SD)
Depression (GDS-5)	2455	0.79 (1.02)
Anxiety (GAI-SF)	2478	0.57 (1.19)
Well-being (OECD)	2507	15.28 (3.73)

GDS-5, Five item Geriatric Depression Scale; GAI-SF, Geriatric Anxiety Inventory short form; OECD, OECD Guidelines on measuring Subjective Well-being

†Total n was 2373 (missing data from 152 participants)

Table 2 Means and standard deviations for each item of the DERS-16

Factor	Item no	Item	M	SD
Clarity	1	I have difficulty making sense out of my feelings	1.36	0.56
	2	I am confused about how I feel	1.18	0.43
Goals	3	When I am upset, I have difficulty getting work done	1.56	0.69
	7	When I am upset, I have difficulty focusing on other things	1.61	0.72
	15	When I am upset, I have difficulty thinking about anything else	1.69	0.81
Impulse	4	When I am upset, I become out of control	1.32	0.58
	8	When I am upset, I feel out of control	1.23	0.52
	11	When I am upset, I have difficulty controlling my behaviors	1.21	0.48
Nonaccept	9	When I am upset, I feel ashamed with myself for feeling that way	1.34	0.61
	10	When I am upset, I feel like I am weak	1.27	0.55
	13	When I am upset, I become irritated with myself for feeling that way	1.57	0.73
Strategies	5	When I am upset, I believe that I will remain that way for a long time	1.17	0.54
	6	When I am upset, I believe that I'll end up feeling very depressed	1.14	0.44
	12	When I am upset, I believe that there is nothing I can do to make myself feel better	1.26	0.57
	14	When I am upset, I start to feel very bad about myself	1.42	0.67
	16	When I am upset, my emotions feel overwhelming	1.43	0.71

were excluded from analyses are presented in Additional file 1: Table S1. Independent samples T-tests revealed no significant differences between the excluded group and the included group in terms of anxiety ($t(303) = -1.56$, $p = 0.12$) or well-being ($t(369) = 1.50$, $p = 0.14$). However, the excluded group had elevated depression levels compared to the included sample ($t(293) = -2.03$, $p = 0.04$).

The means and standard deviations for all items are presented in Table 2.

Reliability

The range of skewness of the DERS-16 was 1.3–2.5, and 2.4–7.3 for kurtosis. Internal consistency was acceptable, with Cronbach´s alpha values ranging from 0.66 to 0.79 on subscales and 0.92 for the total scale. See Table 3 for correlations and Table 4 for descriptive statistics, distribution, and internal consistency values.

Table 4 Means, distribution and internal consistency of the DERS-16

	Mean	SD	Skewness	Kurtosis	α
Clarity	2.53	0.86	2.17	7.11	0.66
Goals	4.86	1.87	1.29	2.41	0.79
Impulse	3.75	1.31	2.51	8.79	0.78
Strategies	6.44	2.18	2.34	7.31	0.79
Nonaccept	4.18	1.56	2.01	5.88	0.76
Total	21.76	6.48	1.82	4.70	0.92

α, Cronbach's alpha. The mean values of each subscale of the DERS-16 were computed by summing responses within each subscale

Confirmatory factor analyses

First, the unidimensional model indicated poor fit (RMSEA = 0.10; CFI = 0.85; TLI = 0.83). The five-factor facet model had fair fit (RMSEA = 0.08; CFI = 0.92; TLI = 0.90).

Table 3 Person correlation coeffecients between five factors of the DERS-16

	Clarity	Goals	Impulse	Strategies	Nonaccept
Clarity	–				
Goals	0.49	–			
Impulse	0.48	0.66	–		
Strategies	0.56	0.70	0.65	–	
Nonaccept	0.51	0.52	0.52	0.65	–
Total	0.68	0.87	0.80	0.90	0.80

All Pearson correlations $p < .001$

Table 5 Model fit indices for different factor models of the DERS-16. RMSEA presented with 95% confidence interval

	χ^2	*df*	*p* value	RMSEA	CFI	TLI
Single factor model (unidimentional)	2873.52	104	> 0.000	0.10	0.85	0.83
Five factor model	1587.43	94	> 0.000	0.08	0.92	0.90
Higher order model	1691.00	99	> 0.000	0.08	0.91	0.90
Bifactor model	546.10	78	> 0.000	0.05	0.97	0.96

The higher-order or hierarchical model showed a similar fit to the five-factor facet model (RMSEA = 0.08; CFI = 0.91; TLI = 0.90). Finally, when assessing the five-factor facet model with the addition of a general factor (bi-factor model), we found clearly superior fit compared to the other models (RMSEA = 0.05; CFI = 0.97; TLI = 0.96). See Table 5 for fit indices for all confirmatory factor analyses.

The bi-factor model is graphically represented with standardized factor loadings in Fig. 1. In this model, the five facet factors CLARITY, GOALS, IMPULSE, STRATEGIES and NONACCEPT load on every item of each factor, alongside the general emotion regulation difficulties factor (TOTAL-factor, represented in Fig. 1 as DERS).

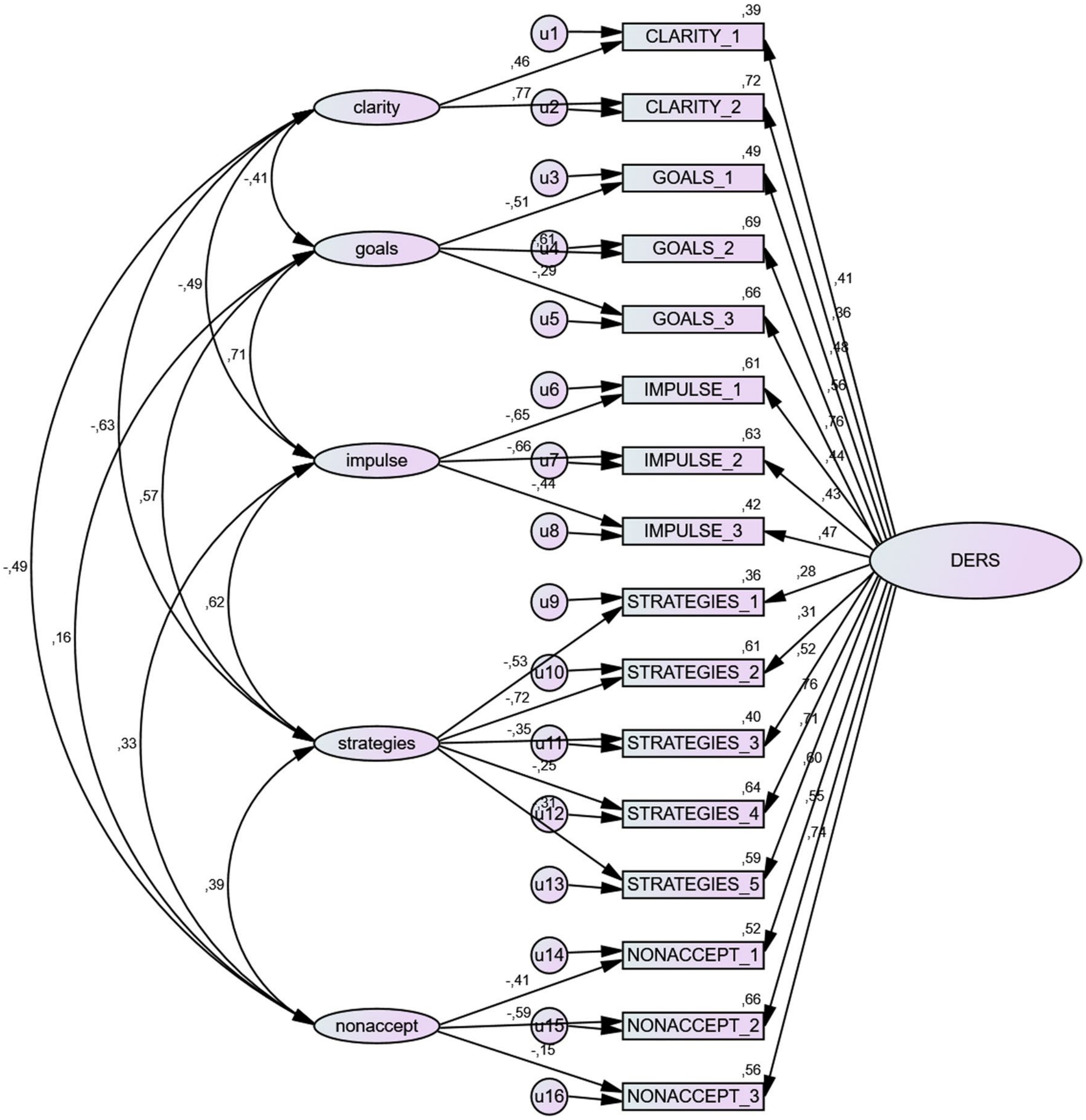

Fig. 1 Bifactor model of DERS-16 items with standardized factor loadings

Table 6 Correlations with other variables

	GDS-5	GAI-SF	OECD
DERS-total	0.37***	0.49***	− 0.39***
DERS-clarity	0.31***	0.41***	− 0.30***
DERS-goals	0.29***	0.40***	− 0.34***
DERS-impulse	0.29***	0.35***	− 0.31***
DERS-nonaccept	0.26***	0.34***	− 0.25***
DERS-strategies	0.37***	0.49***	− 0.37***

GDS-5, Five item Geriatric Depression Scale; GAI-SF, Geriatric Anxiety Inventory short form; OECD, OECD Guidelines on measuring Subjective Well-being

***$p < .001$

Associations with external correlates

The correlations between all DERS-16 scales and depression (GDS-5), anxiety (GAI-SF) and well-being (OECD) are presented in Table 6. As expected, the associations between self-reported emotion regulation difficulties, depression, and anxiety were positive and generally of moderate strength (Cohen 1988). Moreover, the associations between self-reported emotion regulation difficulties and well-being were negative, and mostly of moderate strength. The strongest correlations across the three convergent construct-variables were found for the DERS-TOTAL (explaining 14%, 24%, and 15% of the variance in depression, anxiety, and well-being, respectively) and the subscale STRATEGIES (explaining 14%, 24% and 14% of the variance in depression, anxiety, and well-being respectively).

Discussion

The DERS-16 is a promising questionnaire for measuring emotion regulation difficulties in research and clinical settings. However, no prior studies have validated the use of the DERS-16 in samples of older adults. Hence, we investigated the psychometric properties of the DERS-16 in a large sample of older individuals. Overall, our results suggest that the DERS-16 has acceptable psychometric properties when applied with older adults. Moreover, DERS-16 showed good construct validity, as difficulties with self-reported emotion regulation was substantially and positively correlated with symptoms of depression and anxiety, and equally substantially, but negatively correlated with well-being.

When considering the scores on DERS-16 of our sample, they were considerably lower (mean total score (M) = 21.76) compared to previous investigations using younger community samples, including Bjureberg et al. (2016; M = 42.90 and 33.57) Miguel et al. (2017; M = 44.57), Shahabi et al. (2018; M = 32.92), Sörman et al (2022; M = 29.13) and Yiğit and Guzey Yiğit (2019; M = 38.71). This lends support to previous findings that aging is associated with changes in emotional experience, and that increasing age is associated with decreased difficulties in emotion regulation (Giromini et al. 2017; Miguel et al. 2017; Westerlund and Santtila 2018). The lower self-reported difficulties in emotion regulation could possibly also account for the fact that older individuals typically report higher well-being and life satisfaction compared to younger adults (Carstensen et al. 2011). Taken together, our finding of lower self-reported difficulties in emotion regulation in older adults show that DERS-16 scores should be corrected for age to avoid underestimation of older individuals' difficulties with emotion regulation (Giromini et al. 2017). This was well demonstrated in a study that included older individuals with generalized anxiety disorder that showed lower levels of self-reported emotion regulation difficulties (measured with the DERS-36) compared to younger adults who met the same diagnostic criteria (Staples and Mohlman 2012).

The analyses of skewness, kurtosis and Cronbach's alpha showed that the DERS-16 demonstrated acceptable degrees of reliability (Kline 2016). In terms of internal consistency, all subscales except CLARITY had values over 0.75. The CLARITY subscale had an alpha of 0.66. It is likely that this is due to the fact that this scale consist of only two items, and lower number of items on a scale commonly result in lower Cronbach's alphas (Tavakol and Dennick 2011).

The results from our confirmatory factor analyses were comparable with prior findings. In line with previous results, the five-factor model demonstrated similar fit indices (Miguel et al. 2017; Sörman et al. 2022). However, we did not replicate previous findings that showed superior fit indices for the five-factor model (Shahabi et al. 2018; Westerlund and Santtila 2018; Yiğit and Guzey Yiğit 2019). One possible explanation for the mixed results may be characteristics of the included samples across studies. The studies that found acceptable factor analytic fit indices for the five-factor solution had smaller sample sizes (n = 201 and n = 316) and recruited younger adults that were university students. The studies that did not find support for the five-factor model had larger samples (n = 725 and n = 843) and had a community sample with a wider age range. Larger and more representative samples may therefore have affected the results, which may also account for the finding in the current study. We did, in line with recent investigations find superior fit for the bifactor model (Monell et al. 2022; Nordgren et al. 2019; Sörman et al. 2022). This is also consistent with findings that used the original DERS-36 (Hallion et al. 2018; Osborne et al. 2017). The main defining feature of a good fitting bi-factor model is that it lends credence to the existence of an overarching global level factor that cuts across facet domains, while simultaneously validating any theoretically distinct lower-level facet scores. It thus mirrors the typical structure of instruments that operates with both an overall score and separate subscale scores, as do the DERS-16. Essentially, our CFAs thus indicate that both the total score of the DERS-16 and the five subscale scores are structurally valid with older individuals.

The results also support the external validity of the DERS-16, as we found significant correlations with symptoms of depression, anxiety, and well-being. This is also in line with other investigations which found similar correlation coefficients between the DERS-16 and measures of depression and anxiety (Bjureberg et al. 2016; Shahabi et al. 2018; Yiğit and Guzey Yiğit 2019).

Although the current study provided evidence for the psychometric validity of the DERS-16 in a sample of older adults, it has several limitations that need to be addressed in future research. First, the study was conducted during the COVID-19 pandemic, during which the population faced several restrictions such as reduced contact with others and demands for social distancing. However, only a small proportion of our sample was directly affected by COVID-19, either through direct infection or isolation in quarantine. Nonetheless, the prolonged threat of infection and increased isolation may have resulted in increased stress, which in turn could have affected the scores of the DERS-16. Second, as the study was conducted in Norway the generalizability of the results to other cultures may be limited. Thus, to add a comparative perspective to our study, similar investigations should be conducted across countries and cultures. Similarly, our sample reported low rates of depressive and anxiety symptoms, along with high rates of well-being. Therefore, future investigations should include older individuals within different clinical populations. Higher scores in clinical populations in comparison to healthy older individuals would further increase the validity of the DERS-16, and in addition clarify whether the clinical cut-off values should be lowered when considering self-reported emotion regulation difficulties in older individuals. Second, all measures in the current study were based on self-report questionnaires, which could be associated with biases such as social desirability and fabrication. Meanwhile, this study also has several strengths; it is based on a large sample randomly pulled from the general population of older adults, with a relatively large age span. Furthermore, the study has systematically used instruments that have been validated for use by older individuals.

In conclusion, this study was conducted with a large sample of older adults and provides evidence that DERS-16 has satisfactory psychometric properties when employed with older individuals. The DERS-16 exhibits acceptable factor-analytic fit indices and demonstrates adequate construct validity, given that the questionnaire correlates with measures of psychological health and well-being. This study indicates that age should be considered when examining emotion regulation. Further research is necessary in other cultures and among various subgroups of older individuals, including clinical populations.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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METHODOLOGY

Life history data from the gateway to global ageing data platform: resources for studying life courses across Europe

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Abstract

Research from a range of disciplines highlights the need to adopt a life course perspective that considers earlier life courses to explain outcomes in later life (e.g. later life health, cognitive ageing or retirement behaviour). This includes a more comprehensive assessment of earlier life courses over time and of how they are shaped by societal and political contexts. But quantitative data with detailed information on life courses that allow to address these questions are rare. Or, in case the data are available, the data are rather difficult to handle and appears to be underused. This contribution introduces the harmonized life history data from the gateway to global ageing data platform from two European Surveys, SHARE and ELSA, with data from 30 European countries. Besides providing some details on the collection of life history data in the two surveys, we also describe the way how raw data were rearranged in a user-friendly state sequence format and additionally give some examples based on the resulting data. This illustrates the potential of collected life history data from SHARE and ELSA, clearly going beyond the description of single aspects of the life course. By providing harmonized data of two prominent studies on ageing in Europe in a user-friendly format, the gateway to global ageing data platform provides a unique data source that is easily accessible for research, and permits to study life course and their links to later life in a cross-national perspective.

Keywords Life course · Life history data · SHARE · ELSA · Sequence data

Background

Understanding how individual life courses unfold and how they may influence later life (e.g. health, economic situation, labour market participation) are central topics of various disciplines involved in ageing research, including sociology, epidemiology and psychology (Kuh et al. 2014). The interest, hereby, is not only to know whether a person was once exposed to a specific factor in a life domain, for example, if she/he worked under specific working conditions, but also to study entire trajectories, with information on the timing, the duration and the sequential character of different exposures over time, as well as the interlink of these aspects with other life domains (e.g. work-family trajectories). Another interest, hereby, is to investigate if historical, societal and political contexts shape these histories, for example, if country differences of histories exists that can be linked to different national policies. Both ideas correspond to a life course perspective and have gained increasing importance over the last decades across disciplines (Bernardi et al. 2019; Elder et al. 2003). Specifically, this concerns the idea of a holistic perspective on entire histories and the necessity to study histories in the light of their social and political contexts in which they unfold.

Quantitative data to address these topics, though, require detailed cross-national information for an extended time frame that can be linked with information on later life. This type of data is still relatively rare, and prospective cohort studies with long observation periods only partially help to overcome this shortcoming. Reasons are because some

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of the cohorts (especially birth cohort studies) have yet to reach older ages, or because the richness of prospective data with its information on histories is restricted to the number of waves of data collection (and the life stages covered in the data). Also, data from cohort studies are often not comparable between countries, thus preventing cross-national comparisons. An attempt to overcome these limitations is to supplement the data collection of ongoing cohort studies on ageing by retrospective interviews that additionally collect life history data. In these interviews, participants are asked about their lives before entering the study, for example, entire employment histories the respondent previously had.

An increasing number of studies conduct such life history interviews, including two significant studies of ageing in Europe ageing: the English Longitudinal Study of Ageing (ELSA) (Steptoe et al. 2013), and the Survey of Health, Ageing and Retirement in Europe (SHARE) (Börsch-Supan et al. 2013a). Both studies are part of the international family of Health and Retirement studies around the world, which are all developed in close coordination, with a focus on harmonizing research methods and study designs to allow for cross-national comparisons. Importantly, both studies not simply collect life history data through structured questions as part of their face-to-face interview. Instead, based on advances in research on autobiographical memories (for an overview see: Smith et al. 2021), the collection of data occurs with the help of a graphical representation of the life course (or a "calendar"). This calendar is visible to participants on a computer screen in the interview and consists of a two-dimensional grid, where the x-axis describes the temporal dimension (e.g. years), and the y-axis different domains of the life course (e.g. children, employment or housing). When filling this calendar during the interview, respondents have the possibilities to cross-reference between different histories (e.g. job when first child was born), as well as major "landmark events" are provided (e.g. year of moon landing) that help to memorize the life course. Surely, recall bias remains an issue, and some information (e.g. attitudes and beliefs questions) are difficult to be asked retrospectively. But there is widespread consensus that calendar interviews contribute to better quality and more accurate retrospective information (Axinn et al. 1999; Belli 1998; Belli et al. 2007; Blane 1996; Drasch & Matthes 2011; Freedman et al. 1988), for example, when asking about sociodemographic conditions or employment histories (Baumgarten et al. 1983; Wahrendorf et al. 2019). Also, compared with prospective data collection (where question wording and order in the interview may change across waves of data collection), retrospective data make sure that information (referring to different time points) is equally assessed.

Life history data have now been collected for nearly 100,000 respondents across Europe as part of SHARE and ELSA. Thereby, the domains or different topical areas covered across the life course range from family life and partnership relationships, housing histories and geographical mobility, to employment histories (including paid work and home or family work) to health histories with information on major periods of poor health or disability. This provides remarkable opportunities for comparative life courses research, specifically, for studying previous life courses in a cross-country perspective including the association between life course factors (e.g. patterns of family formation) and various later life outcomes (e.g. health, later life cognitive functioning, retirement behaviour, financial situation). However, albeit the data are freely available for research purposes, the richness and full potential of the data are still not fully exploited. One important reason may be the difficulty associated with learning multiple surveys, and—specifically in case of life history data—the complex data structure resulting from life history interviews (see below for details). This structure requires extensive data management in each survey to provide information on entire histories, that allow to fully exploit the longitudinal nature of the data.

For these reasons, the gateway to global ageing data (sponsored by the National Institute on Aging) was developed as a platform to make data more accessible to researchers and to facilitate cross-country analyses among surveys of ageing, especially those using the Health and Retirement Study (HRS) and its international sibling studies around the globe. One major achievement of the platform, hereby, is to provide harmonized datasets from participating surveys, accompanied by extensive documentations of questionnaires and the provision of all codes to create these harmonized data (Lee et al. 2021). Such harmonized data have now also been developed for the life history data from SHARE and ELSA, and—in contrast to the raw data provided by the single surveys—were released in a user-friendly sequence data format (see below for details).

In this article, we introduce the harmonized life history data from SHARE and ELSA provided by the gateway to global ageing data platform, and give some illustrative examples of resulting data to show its potential for life courses research.

Life history data in SHARE and ELSA

ELSA began in 2002 in England (not covering the entire UK), and SHARE in 2004, with ongoing waves of data collection in two-year intervals and new respondents (so-called "refreshers") being added subsequently to maintain population representation in both surveys. The two studies rely on nationally representative samples of individuals aged 50 and older (based on probability household samples where respondents and partners are interviewed). This corresponds to a target population of persons born in 1952 or earlier for ELSA and in 1954 or earlier for SHARE (in the first waves, respectively). While SHARE started in 12 countries (11 European countries and Israel), new countries joined SHARE in the subsequent years, with 29 participating countries since study onset. For detailed data resource profiles of ELSA, see (Steptoe et al. 2013), and for SHARE (Börsch-Supan et al. 2013a).

In addition to regular waves which focus on current life circumstances of participants at moment of data collection, both surveys also had life history interviews. In ELSA, this was firstly conducted between March and October 2007 (in addition to the core interview in wave 3), and in SHARE between autumn 2008 and summer 2009 (as a separate life history interview in place of a core interview, often also referred to as “SHARELIFE”) (Börsch-Supan et al. 2013b). In addition, wave 7 of SHARE repeated the life history survey for all respondents (and countries) who were not part of wave 3. More details can be found in the respective methodological volumes of SHARE (Bergmann et al. 2019; Schröder 2011) and ELSA (Ward et al. 2009). A number of completed life history interviews in the two studies, including mean age and sex distribution for each country, are presented in Table 1. In sum, comparable life history data exist

Table 1 Completed life history interviews for the harmonized data from the gateway to global ageing data, incl. mean age and sex distribution

Survey	Country	Wave 3				Wave 7				Total
		No	Age	Sex %		No	Age	Sex %		
			(Mean)	Male	Female		(Mean)	Male	Female	No
ELSA	England	7855	(66.7)	46.7	53.3	–	–	–	–	7855
SHARE	Austria	994	(66.2)	45.0	55.0	2693	(66.8)	46.3	53.7	3687
	Germany	1918	(66.2)	45.7	54.3	2982	(66.7)	46.7	53.3	4900
	Sweden	1961	(66.4)	47.3	52.7	2129	(67.0)	48.1	51.9	4090
	Netherlands	2258	(64.9)	47.2	52.8	–	–	–	–	2258
	Spain	2271	(66.6)	45.8	54.2	3424	(67.4)	46.3	53.7	5695
	Italy	2528	(66.3)	45.2	54.8	3000	(66.7)	45.8	54.2	5528
	France	2500	(66.2)	45.1	54.9	2186	(66.6)	45.6	54.4	4686
	Denmark	2144	(65.1)	47.2	52.8	1961	(66.1)	47.9	52.1	4105
	Greece	3090	(66.4)	46.4	53.6	1160	(67.1)	45.9	54.2	4250
	Switzerland	1324	(65.6)	46.3	53.7	1648	(66.4)	47.4	52.6	2972
	Belgium	2865	(65.9)	46.0	54.0	3333	(66.5)	46.8	53.2	6198
	Israel	–	–	–	–	2131	(65.3)	46.4	53.6	2131
	Czechia	1816	(64.4)	44.9	55.1	3292	(65.9)	45.6	54.4	5108
	Poland	1939	(63.8)	43.5	56.5	3559	(65.1)	44.1	55.9	5498
	Ireland	855	(65.9)	48.0	52.0	–	–	–	–	855
	Luxembourg	–	–	–	–	1250	(65.2)	48.5	51.5	1250
	Hungary	–	–	–	–	1538	(66.7)	42.4	57.6	1538
	Portugal	–	–	–	–	1282	(68.2)	44.4	55.6	1282
	Slovenia	–	–	–	–	3691	(66.0)	46.3	53.7	3691
	Estonia	–	–	–	–	5115	(66.7)	40.1	60.0	5115
	Croatia	–	–	–	–	2408	(66.1)	44.5	55.5	2408
	Lithuania	–	–	–	–	2035	(65.9)	39.7	60.3	2035
	Bulgaria	–	–	–	–	1998	(66.0)	44.4	55.6	1998
	Cyprus	–	–	–	–	1233	(65.4)	47.8	52.2	1233
	Finland	–	–	–	–	2007	(66.3)	46.4	53.6	2007
	Latvia	–	–	–	–	1734	(66.4)	39.0	61.0	1734
	Malta	–	–	–	–	1261	(65.8)	47.6	52.4	1261
	Romania	–	–	–	–	2114	(66.1)	44.4	55.6	2114
	Slovakia	–	–	–	–	2077	(64.4)	44.3	55.7	2077
Total		36,318				63,241				99,559

ELSA = English Longitudinal Study on Ageing; SHARE = Survey of Health, Ageing and Retirement in Europe

Values for mean age and sex proportions are based on weighted data and use latest version of SHARE (version B.3) and ELSA (version A.2) of the Gateway to Global Aging Data platform for 99,559 respondents from 30 countries across Europe, where most histories were conducted in wave 7 of SHARE.

Data structure and domains covered

As part of the life history survey respondents provided information for five domains: employment, partnership, children, health and accommodation. As an example, in the case of employment histories, all respondents gave information on each paid job they had till the moment of the interview and details for periods when they were not in paid employment (e.g. gap between two jobs). For each of these job spells (or spells when not working), the data contain information on the year when the respective spell started and ended, and variables that specify the spell (e.g. in self-employment, doing home or family work, or retired). The same type of information was collected for accommodation spells or for partnerships. Based on this "spell data format", though, it is quite complicated for non-experienced researcher to derive simple statistics, for example, to know what the exact employment situation of a person was at age 40. For some respondents, this information may be stored in the second job spell—and for others the information may be given in the provided details for the period when not working between the second and the third job. Technically, this requires extensive data management where the provided spell information of each individual (with differing numbers of spells between individuals) is used to ascertain a specific state at a given age (based on a defined list of possible states). Further readings with additional information on spell data, its management and analyses can be found elsewhere (Blanchard et al. 2014; Kröger 2015; Ritschard & Studer 2018).

Therefore, to facilitate the use of life history data, the gateway provides harmonized life history data in a state sequence format, where—for each domain covered in the interview—data are rearranged in a less complex and more intuitive state sequence format. This means that the datasets contain a discrete state variable for each age covered in the life history interview to describe the state at a particular age (e.g. the work situation at the age of 20, 21, 22, 23, 24, etc.). As an example, the variable "WORKSTATE25" captures the employment situation at age 25, and the variable "WORKSTATE50" the employment situation at age 50. As a consequence, for each individual who completed a life history interview, this provides information on whole sequences, with information on successive states throughout the life course. Table 2 illustrates the information evolving from these data using employment histories between age 15 and 65 as an example (covering 51 years). Each history is presented as a sequence of letters where the letter represents a specific employment situation.

The first two sequences belong to persons who started to work full-time after full-time education at the age of 19, either in full-time employment (person 1) or as self-employment (person 2), and were both constantly working till entering retirement, with comparatively early retirement of the second person. The remaining examples belong to persons who started working somewhat later after full-time education, and either had a long period of home or family work that was followed by part-time work (person 3), or repeated unemployment interruptions (person 4).

Taken together, the state sequence format directly allows to describe the circumstance at a specific age (without need of extensive data management). And this format is also the standard format for sequence analyses (Halpin 2017; Ritschard and Studer 2018; Studer 2013). Sequence analyses allow a comprehensive analyses of whole sequences of respondents. This ranges from the creation of summary measures of entire histories, such as years spent in a specific state (e.g. in paid work) or the identification of specific pattern of interest (e.g. reemployment after long period of unemployment), to techniques that allow to regroup similar histories into typologies.

Full details on the procedures to re-arrange the data and on the derived harmonized states for each of the five histories in the two surveys are available online in the respective codebooks of the two studies (Wahrendorf et al. 2023a, 2023b). These also contain details on the variables used in the raw datasets, on the naming conventions of the created variables, and how it was ensured that identical concepts and questions were used when harmonizing the data. An overview of the resulting histories and the derived harmonized states for each of the five histories is provided in Table 3.

Table 2 Examples of employment sequences from age 15 to 65

Employment sequences
EEEEWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWRRRRR
EEEESSSSSSSSSSSSSSSSSSSSSSSSSSRRRRRRRRRRRRRRRRRRRRR
EEEEEEEEEEWWWHHHHHHHHHHHHwwwwwwwwwwwwwwwwwwwwRRRRRR
EEEEEEEEEWWUUUWWWWUWWWWWUwwwwwwwwWWWWWWWWWWWWRRRRRR

E = "Full-time education", W = "Employed full-time", w = "Employed part-time", S = "Self-employed", U = "Unemployed", H = "Home/family work", R = "Retired", O = "Other"

Table 3 Domains of the harmonized histories

Domain	Annual information from age 15 to age 80 on…
Work	Different main work states, including paid work, unpaid work and states when not working (up to 8 categories)
Partnership	Whether respondent lived with a partner (irrespective of marital status)
Children	Total number of children (regardless of age of children), and total number of children below age 18 (counting biological and adopted children in both cases)
Housing	Different housing states, including private (owner or tenant), non-private housing, living abroad or still living in parental home (5 categories)
Health	Whether had period of ill health or disability (not specifying type of illness)

Access to data and documentation via the gateway

To access the data, registered users can either download the generated datasets or the programs that will generate the harmonized dataset from the study's raw data files. Specifically, for ELSA the created harmonized dataset can be downloaded from the UK data repository (without need to run the creation code). For SHARE, users need to download the raw data from the SHARE Research data centre and run the creation code in Stata that is available on the gateway. All necessary information, sources or links to respective data sources are provided on the gateway. The generated dataset also contains an ID-variable that allow to merge life history data with other datasets of the respective study, for example, with health data from the remaining waves of data collection. Furthermore, the data contain study-specific sampling weights for respondents of the life history interviews (referring to moment of data collection), together with stratum and cluster variables that account for complex survey design.

Some illustrative results

In the following, we give two simple examples of the collected life history data (for illustrative purposes without intention of an in-depth analyses of the addressed topic). All figures are based on the latest release of the gateway (based on SHARE version B.3 & ELSA version A.2) and have been produced with Stata. We apply weights to produce appropriate population estimates, and also account for different sample sizes of each country when estimating proportions across countries.

Figure 1 presents the observed distribution of eight different employment states of the harmonized employment histories between age 15 and 65 years, separately for men and women across both surveys. We clearly see how the proportions of some states vary across the life course, for example, that the proportion of respondents who were in full-time education is highest at the beginning of the observation period and quickly declines thereafter. Also, there are differences between men and women, with higher labour market participation (mostly full-time employment) for men compared with women. Another finding is that there is almost no home or family work for men, and that women spent a large amount of their employment histories in home or family work. Whether the average time (measured in years) spent in home or family work for women (again for the period between age 15 and 65) varies by country is shown in Fig. 2. With average scores above 25 years, highest values are found in the Mediterranean countries Spain, Greece, Malta and Cypress, together with Ireland and the Netherlands. In contrast, values are clearly lower in the Nordic countries Denmark, Sweden and Finland as well as Hungary and Slovakia, but especially in the three Baltic countries (Estonia, Latvia and Lithuania) together with Bulgaria and the Czech Republic (with less than 5 years). These results clearly suggest that employment histories vary between men and women, and also indicate how women's situation in the paid labour market and the gender division of labour are very different across Europe. This has potentially important impact on later economic situations and health of older persons [for an example linking employment histories with later health or cognitive functioning see (Wahrendorf et al. 2021) or (Ice et al. 2020)]. And possibly these patterns are related to different social and labour market policies, including childcare regulations or different family policies. The two figures give two simple examples for potential sex and country differences in employment histories that are probably linked to the wider sociopolitical contexts.

Discussion

The presented harmonized life history data of SHARE and ELSA from the gateway to global ageing data platform provides remarkable opportunities for studying and comparing previous life course across Europe, as well to study their links with later life outcomes. Besides being delivered in a harmonized format (and thus allowing for cross-national comparisons), one key feature of the data is that they are delivered in a user-friendly state sequence format that make data more accessible for the research community and allows an in-depth analyses of entire histories. On a conceptual

Fig. 1 Chronogram of employment histories by sex, based on annual data of the employment situation between age 15 and 65 (15,939 men and 20,379 women). Note: Values are based on weighted data that (also accounting for different sample sizes of each country and use wave 3 data of the latest Version of SHARE (Version B.3) and ELSA (Version A.2) of the Gateway to Global Aging Data platform

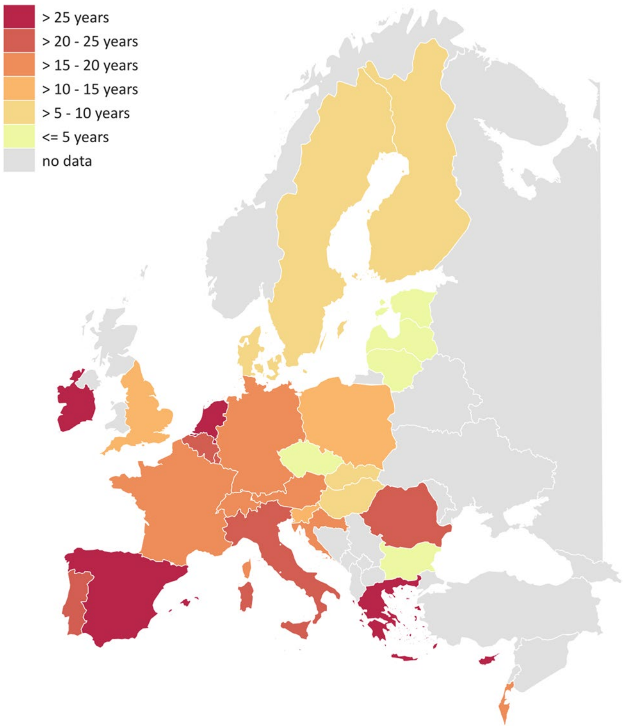

Fig. 2 Average years spent in home/family work as main employment situation between age 15 and age 65 for women, based on employment histories of 26,215 women (aged 65 or older). *Note*: Values are based on on weighted data and use wave 3 and wave 7 data of latest Version of SHARE (Version B.3) and ELSA (Version A.2) of the Gateway to Global Aging Data platform

level, this means that the data may facilitate researchers to address one core idea of the life course perspective when studying life course in Europe (Bernardi et al. 2019; Elder et al. 2003), namely, the necessity of studying histories as a whole. Importantly, while the two presented studies are two significant studies of ageing in Europe a, an additional life history dataset is already available from the China Health and Retirement Longitudinal Study (CHARLS) (Wahrendorf et al. 2022), and in progress from HRS in the US. Also, it is worth noting at this point that SHARE and ELSA also ask specific questions about childhood conditions (i.e. childhood health and socioeconomic conditions at age 10). These childhood data are also incorporated into the Harmonized datasets of the gateway, and—albeit referring to a single time point only—is surely of interest for life course researcher interested in consequences of early-life conditions.

Some limitations of the harmonized data, though, must be named: First, when harmonizing life history data, it is inevitable that some details are not used. As an example, some researchers may be interested in intra-generational social mobility processes when studying employment histories. Yet, while SHARE collected information on the occupation respondents had (first digit of the ISCO code), ELSA did not ask for this aspect. In case of interest, users may therefore modify and adapt the provided do-files of SHARE to their own purposes. Second, when creating the state sequence data, some decisions are needed, for example, to decide which state is prioritized in the unlikely case that respondents reported both paid employment and a period of not working. For these details, we refer people to the codebook, where respective strategies are clearly described. Third, in the case of health history, the available information (i.e. period of ill health or not) must be considered as rather limited, specifically if researchers are interested in single diseases and the age of diagnoses (e.g. cardiovascular diseases or symptoms of depression). In that case we recommend to use data from core waves where different diseases and their age at onset are assessed, thus allowing to investigate life time prevalence of specific diseases or the age when a disease was diagnosed. Fourth, because of legal regulations, the gateway cannot directly release the harmonized data files on its website, and therefore, needs to refer to other sources. Future users, though, may profit from a gateway data enclave that is in progress, where users will be able to access data from a virtual gateway without need to go through the respective provider of survey data.

In conclusion, albeit life history data are increasingly available in ongoing studies on ageing, the extent to which the potential is used is still very restricted. By providing harmonized data of two prominent studies on ageing in Europe in a user-friendly format, we hope this facilitates its use and stimulates research in the field.

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Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Increasing retirement ages in Denmark: Do changes in gender, education, employment status and health matter?

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Abstract

Recent studies report significant increases in retirement ages over the past two to three decades in most countries in the Organization for Economic Co-operation and Development—increases that research has attributed mainly to changes in the legislative frameworks for retirement in these countries. Using unique data from the Danish Longitudinal Study of Ageing, this study investigates whether and, if so to what extent, changes to the workforce in terms of gender, education, employment status (employed or self-employed) and health contribute to explaining differences in retirement ages between the cohorts born in 1935 and 1950. The retirement window of these cohorts stretches from the early 1990s to the late 2010s—a period characterized by substantial changes to workforce. On average, retirement ages increased by two years from the 1935 cohort to the 1950 cohort. However, due to changes in the investigated factors having offsetting effects, the net effect of such changes on retirement ages was minor. Thus, while increasing levels of education and better health among older workers contributed to increasing retirement ages, increasing female labour force participation and fewer self-employed workers had the opposite effect. In absolute terms, the total compositional and behavioural influence on retirement ages of changes in terms of employment status (− 0.35 years) was almost as large as the total changes in terms of education (0.44 years). Thus, future studies investigating long-term changes in retirement ages would benefit from including changes in employment status (self-employed or wage earner) as an explanatory factor.

Keywords Retirement age · Cohort study · Blinder–Oaxaca decomposition · Education, employment status · Denmark

Introduction

Population ageing throughout Western societies has raised concerns about increasing costs for old-age pensions and decreasing tax revenues (OECD 2019). In response, to boost labour force participation among older adults, many countries have increased statutory retirement ages and have restricted early-retirement opportunities (Mclaughlin and Neumark 2018). In addition to these changes in retirement legislation, a number of factors—including increasing educational levels, improved health among older workers and fewer physically demanding jobs (driven by technological change and a growing service sector)—may have contributed to the upward trend in retirement ages (OECD 2017a). Indeed, the last three decades have been characterized by increasing labour market participation rates among older adults in most countries in the Organization for Economic Co-operation and Development (OECD), including Denmark (OECD 2017b; Boissonneault et al. 2020; Bingley et al. 2021; Turek et al. 2022).

Research investigating the causes of the increases in retirement ages in OECD countries suggests that changes in retirement legislation have been an important driver (Boissonneault et al. 2020; Börsch-Supan and Coile 2018; Coile et al. 2018; Deeg et al. 2021; Geppert et al. 2019). Parallel to changes in retirement legislation, the gender, educational and occupational composition of the workforce has changed substantially (Albæk et al. 2022). The composition of the workforce is important for increasing retirement ages for the following two reasons. First, retirement ages are directly associated with workers' characteristics, such as gender, education and health (Munnell 2015; OECD 2021). Second, changes in retirement behaviour (driven e.g. by legislative changes) may not be evenly distributed across socio-economic, demographic, educational and occupational groups

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(Coile et al. 2018; Radl 2013; Trentini 2020). For example, increases in retirement ages have mainly taken place among the highly educated (OECD 2017a; Rutledge 2018) and among people with high occupational status (Leinonen et al. 2020; Qvist 2020), and have in general been more pronounced for women than for men (OECD.Stat 2021).

While ample scholarly work has investigated causes of variation in exit ages both between individuals (Fisher et al. 2016; Scharn et al. 2018; Wang and Shultz 2010) and across countries (Börsch-Supan and Coile 2018; Larsen and Pedersen 2017), fewer studies have examined causes of variation in exit ages over time. Moreover, although research has established that changes in retirement legislation have constituted an important driver of increasing retirement ages (Börsch-Supan and Coile 2018; Geppert et al. 2019; Boissonneault et al. 2020), less is known about how retirement age is affected in the long term by the changes that have occurred in the old-age workforce.

This study investigates changes in retirement across cohorts (i.e. changes in retirement age over time). A recent systematic review of long-term changes in retirement ages (covering the period 2000–2019) identified 19 studies on this topic (Boissonneault et al. 2020). Among these studies, only three concerned demographic characteristics (including education). No study assessed the influence of increasing health or changes in employment status on retirement age.

This study thus contributes to the retirement literature by investigating whether and, if so to what extent, the increase in average retirement ages can be attributed to changes in the Danish workforce in terms of gender, education, employment status (shares of self-employed vs. wage earners) and health. We compare the cohorts born in 1935 and 1950, whose retirement window stretches from the early 1990s to late 2010s—a period characterized by substantial changes to retirement legislation as well as to the workforce.

In Denmark, changes in the retirement legislation primarily aimed at restricting early retirement opportunities (Larsen and Pedersen 2017). In particular, the *Voluntary Early Retirement Program* (VERP), which offered high replacement rates for low-wage workers, was subject to several reforms to reduce its attractiveness (Bingley et al. 2004). While the VERP initially aimed at offering early retirement to workers with physically demanding occupations, it gradually became a popular path to early retirement for broad segments of the population (Jørgensen 2009). To lower expenditures on the VERP, the statutory retirement age was actually *lowered* from 67 to 65 in 2004 (Larsen and Pedersen 2017). Thus, contrary to most OECD countries, the incentives for retiring after age 65 were attenuated from 2004 to 2019 in Denmark. Additional file 1: Online resource A provides a detailed overview of the legislative changes for the cohorts under study.

Changes to the workforce since the 1935 cohort entered the labour market (i.e. from the 1950s and onwards) include the outsourcing of labour-intensive production and technological development, leading to increased demand for highly skilled labour (Skaksen 2019) and to increases in average levels of education (Jacobsen 2004; Larsen et al. 2016). Consequently, since the 1950s, more highly educated white-collar workers have entered the Danish labour market while the share of unskilled blue-collar workers has decreased (Larsen and Pedersen 2017). At the same time, the gender distribution in the workforce has shifted as more women have entered the labour market (Statistics Denmark 2015) and the proportion of workers in good health has increased significantly (Siren and Larsen 2018).

This study is the first to investigate the potential impact of long-term changes in the share of self-employed workers in the workforce on the development of retirement ages. The share of self-employed workers has fallen dramatically in Denmark since the 1980s, and in 2019, only 6% of the workforce were self-employed, making it the lowest share in Europe. Potential explanations for this development include a shrinking agricultural sector and a growing public sector (Holstein 2021). While studies show a positive association between self-employment and retirement age at the individual level (Nolan and Barrett 2019; Anxo et al. 2019), the compositional and behavioural long-term influence of changes in self-employment on retirement ages has not previously been investigated. Given the dramatic fall in the share of self-employed workers, Denmark constitutes an important case for studying this association.

We use Blinder–Oaxaca decomposition to investigate changes in retirement ages across cohorts. This approach has the advantage of allowing for the decomposition of the increase in retirement age across cohorts into a “compositional”, a “behavioural” and an “interaction” component, where the first refers to changes in the characteristics of the workforce, the second refers to changes in retirement behaviour of the workforce and the third refers to interaction effects between compositional and behavioural changes (Jann 2008; Etezady et al. 2021). In other words, this analysis tells us to what extent the increase in retirement ages across cohorts are due to older workers being different (in terms of gender, education, employment status and health), acting differently or a combination of these factors.

Expected impact of changes in characteristics

This study focuses on the cross-cohort impact of changes in terms of education, gender, employment status and health on increasing retirement ages. Drawing on retirement literature, we discuss the expected impact of each factor in the following paragraphs.

Education

A number of studies have established a positive association between education and retirement age (e.g. Robroek et al. 2015; Turek et al. 2022). We therefore hypothesize a positive contribution to retirement ages from the increase in the shares of highly educated workers across cohorts (hypothesis H1a).

However, as relatively larger proportions of the workforce have obtained more education, the selection mechanisms into high-skilled occupations may have become softer. Changes in retirement legislation—which mainly aimed at limiting early retirement opportunities—may have amplified this potential gradual weakening of the skill-selection mechanism by boosting retirement ages among low-skilled workers (Bingley et al. 2019). We therefore expect the positive association between education and retirement age to have weakened over time (i.e. to be smaller for the 1950 than for the 1935 cohort) (hypothesis H1b).

Due to the offsetting influence of compositional and behavioural factors, we cannot form an a priori expectation as regard the total effect of changes in education on retirement ages.

Gender

The increase in the share of female workers over time has likely influenced average retirement ages negatively, as women in general retire earlier than men (Axelrad and Mcnamara 2017; De Preter et al. 2013a, b) (hypothesis H2a). Moreover, weakening of the selection mechanism may have influenced the behaviour of female workers negatively, as employed women in the 1935 cohort were probably a more strongly positively selected group in terms of labour market attachment than employed women in the 1950 cohort. Hence, we expect the negative association between being female and retirement age to have increased over time (i.e. to be stronger for the 1950 than for the 1935 cohort) (hypothesis H2b). As we expect both compositional and behavioural effects in terms of gender to be negative, the total contribution of cross-cohort changes on retirement age is also expected to be negative (hypothesis H2c).

Employment status

As self-employed workers generally retire later than wage earners (Nolan and Barrett 2019; Anxo et al. 2019), we expect the decrease in the share of self-employed workers across cohorts to have contributed negatively to retirement ages (hypothesis H3a). However, self-employed workers in the 1950 cohort were probably a more strongly selected group than self-employed workers in the 1935 cohort. If so, the positive association between self-employment and retirement age will be stronger for the 1950 than for the 1935 cohort (hypothesis H3b). Due to the offsetting influence of compositional and behavioural factors, we cannot form an a priori expectation as regard the total effect of changes in employment status on retirement ages.

Health

Due to a positive association between good health and later retirement (De Preter et al. 2013a; Blundell et al. 2023), we expect the increasing shares of healthy workers across cohorts to have contributed positively to retirement ages (hypothesis H4a). Moreover, changes in retirement legislation have led to increasing incentives to prolong working lives—and workers in good health are more likely to have responded positively to such incentives (Mclaughlin and Neumark 2018). Therefore, we also expect an increasingly positive association between good health and retirement age across cohorts (hypotheses H4b). Consequently, the total effect of health and retirement age is also expected to be positive (hypothesis H4c).

The preceding paragraphs argue that the influence of changes across cohorts in terms of gender, education, employment status and health on retirement ages may be both positive and negative. Thus, the aggregated net effect of these changes on retirement ages remains an empirical question.

Data and methods

Sample

Our analysis builds on data from the Danish Longitudinal Study of Ageing (DLSA), a representative on-going longitudinal study of living conditions among older adults in Denmark, collected every five years since 1997 (Kjær et al. 2019). The data include several topics relevant to this study, including age at retirement, self-reported health and employment status during most of a person's working life. The data include every fifth birth cohort from 1920 to 1960. In this study, we focus on individuals born in 1935 and 1950. We include individuals in the analysis who were in employment at age 50.

We mainly include survey data for these cohorts collected the year when respondents turned 67 years old, i.e. in 2002 and 2017. We choose to focus on data collected at age 67 for two reasons. First, most respondents have retired permanently from the labour market at age 67. Hence, by choosing this age, we can largely include information on actual (rather than expected or imputed) retirement age. Second, as most respondents retire in their 60 s, age 67 is, for most respondents, the earliest possible post-retirement data collection point.

However, retirement may have occurred substantially earlier (i.e. from age 50 and onwards), or may occur substantially later, than age 67. We therefore mainly include information on factors that are unlikely to change after age 50 in the analysis, including gender, education and employment status for most of one's working life.

We combine the DLSA with information from the Danish administrative education registries, which include individual-level data on highest level of education for the entire population. Our final sample includes 2644 observations.

Our analysis compares the changes in characteristics and behaviour across the 1935- and the 1950-cohort. Thus, differences in attrition due to mortality or non-response across the two cohorts may influence results. However, 83% of 50-year-olds in the 1935-chort were still alive at age 67 whereas the corresponding figure in the 1950-cohort was 88% (Statistics Denmark 2023). Thus, differences in mortality across the two cohorts were minor.

Response rates in the DLSA have fallen over time and were 88% and 77% at age 67 in the 1935-and 1950-cohort, respectively. To investigate if this increasing attrition due to non-response may influence results, we compared the distribution of gender and education (available in registries) in the original sample and among respondents for the two cohorts. These analyses revealed no significant differences in the gender and educational distributions. While we cannot conduct a similar comparison for the survey-based variables, our comparison of key registry-based information suggests that our sample is representative for the general population for both cohorts.

Variables

We use self-reported and imputed data to define our dependent variable, *age at retirement*. For those who had retired at or before age 67, we use the self-reported retirement age. For those retired people who did not report a retirement age, we impute retirement ages (restricted to the interval 50–67 years). Not all respondents had retired at age 67. Omitting these respondents would introduce bias, in particular as a larger proportion of respondents were still employed at age 67 in the 1950- than in the 1935-cohort (19.5 vs. 10.8%). For people in employment at age 67, we rely on expected retirement ages. While expected retirement ages overall have been found to be informative for actual retirement ages, there is a tendency towards respondents' retiring earlier than expected (Kézdi and Shapiro 2023). However, we expect this tendency to be less pronounced in our data than in previous studies, as we only include expected retirement ages for those respondents who were still employed at age 67, whereas the literature on retirement expectations and realisations generally concerns workers that are younger than the statutory retirement age (see Kézdi and Shapiro (2023) and references therein). For those who did not report an expected retirement age, we impute retirement ages (restricted to the interval 67–80 years). In total, we impute retirement ages for 6% of the sample. A graph of the distribution of the dependent variable for the two cohorts appear in Additional file 1: Online resource B. While retirement to some degree is concentrated at pension accessibility ages, most people retire in their early- to mid-60 s, whereas few retire earlier or later. Thus, we argue that retirement ages are approximately normally distributed in both cohorts.

Gender is coded as either female or male.

The registry-based information on *education* is coded to form four levels: basic education, vocational education, short- or medium-cycle higher education (2–3 years), long-cycle higher education (at least 4 years).

The DLSA contains information on respondents' employment status—e.g. whether respondents were white- or blue-collar workers or self-employed for most of their working lives. However, due to a strong correlation between skill-level (white- or blue-collar worker) and education, we define *employment status* based on self-reported information on whether respondents were self-employed or wage earners for most of their working lives.

Constructing a measure for *health* around the time of retirement is challenging, given that retirement ages have increased across cohorts (and health is correlated with age) and that the health care system has improved (making the usage of register-based health information problematic). We therefore use self-reported health at age 62 as a proxy for health around the time of retirement (using self-reported health at age 67 may introduce reversed causality, as most respondents have retired prior to that age). We impute health information for the 22% of the sample that were not interviewed at age 62 (or who had missing information on health). The health measure includes two levels: good (very good or good self-reported health) or bad (intermediate, bad or very bad self-reported health) (we do not use the full scale because few respondents reported bad or very bad health).

Analytical approach

To investigate to what extent long-term changes to the workforce can explain increases in retirement ages we first descriptively analyse the development in workforce composition in terms of education, gender, employment status and health as well as changes in average retirement ages across cohorts in terms of these characteristics. Second, we use the Blinder–Oaxaca decomposition technique to examine if—and if so the extent to which—changes in gender, education, employment status and health across cohorts can explain the changes in retirement ages.

Following Jann (2008) and Etezady et al. (2021), we decompose the change in average retirement ages from the 1935 to the 1950 cohort into three terms, a "compositional", a "behavioural" and an "interaction" component:

$$\Delta\overline{Y} = \left(\overline{X}_{1935} - \overline{X}_{1950}\right)'\beta_{1950} + \overline{X}_{1950}'\left(\beta_{1935} - \beta_{1950}\right) + \left(\overline{X}_{1935} - \overline{X}_{1950}\right)'\left(\beta_{1935} - \beta_{1950}\right)$$

The first term refers to changes in the characteristics of the workforce given retirement behaviour of the 1950 cohort ("compositional changes"), the second term refers to changes in the retirement behaviour given characteristics of the 1950 cohort ("behavioural changes") and the third term refers to interaction effects between compositional and behavioural changes.

To avoid the choice of base category influencing behavioural results for categorical (dummy) variables, we express coefficients as deviations from the grand mean (Jann 2008).

Handling missing data

We apply the Multiple Imputation of Chained Equations (MICE) procedure (Azur et al. 2011) to impute missing data on (a) retirement ages for retirees with missing information on this variable, (b) retirement ages for people in employment at age 67 with missing information on expected retirement age, and (c) self-reported health at age 62. We impute the missing values by regressing them one by one on information on gender, employment status (self-employed vs. wage earner), education, self-reported health at age 67 and year. Each cycle of one-by-one regressions on all other variables constitutes an iteration. By the end of the first iteration, the missing values on all the survey variables have been imputed. We perform 25 iterations, as previous research has shown that the number of imputations should be at least as large as the fraction of incomplete cases in the data (Bodner 2008; White et al. 2010). By 25 imputations, the data have sufficiently stabilized, such that the order in which variables are imputed no longer matters (Raghunathan et al. 2016). The imputed values after 25 iterations, combined with the observed data, constitute one imputed dataset. We repeat this procedure 25 times to generate 25 imputed datasets in total, and then use Rubin's rule to combine the estimates from each of the 25 datasets to obtain the final results from the imputed data (Rubin 2004).

Table 1 Distribution on key variables by cohort

	1935 cohort	1950 cohort	Change 1950–1935
Retirement age (years) (Standard deviation)	61.4 (0.14)	63.5 (0.12)	2.08
Woman (%)	47.0	51.5	4.6
Self-employed (%)	18.8	9.9	– 9.0
Education (%):			
Basic education	47.2	22.1	– 25.0
Vocational education	32.5	41.4	8.9
Higher education (≤ 3 years)	16.1	29.2	13.1
Higher education (4 + years)	4.3	7.3	3.0
Good health at age 62 (%)	74.5	79.0	4.5
Observations	1035	1609	

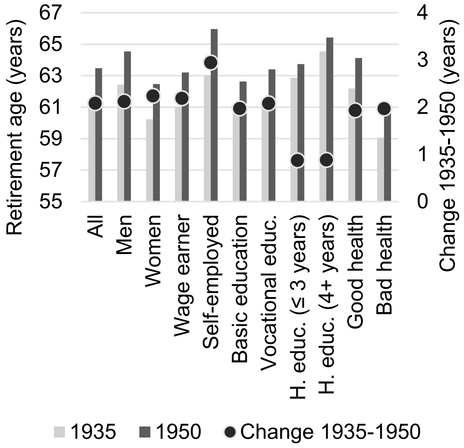

Fig. 1 The development in average retirement ages across cohorts by socio-economic group (years)

Results

Descriptive findings

Table 1 presents the distribution of the study sample on key variables by cohort. On average, retirement ages increased from 61.4 years in the 1935 cohort to 63.5 years in the 1950 cohort, i.e. by 2.1 years. The table clarifies substantial compositional differences across the cohorts in our study. While the share of female, healthy and highly educated workers increased, the share of self-employed and low-skilled workers decreased substantially. In particular, the share of self-employed workers fell by almost 50% from the 1935 to the 1955 cohort.

Figure 1 presents average retirement ages by socio-demographic characteristics, as well as the change in average retirement ages from the 1935 to the 1950 cohort (secondary axis). While average retirement ages vary across socio-demographic groups, the change in retirement age across cohorts has, in general, been parallel between cohorts. For instance, while men retire approximately two years later than women do, this pattern has not changed across cohorts (average retirement ages have increased by approximately two years for both genders). We find the same parallel development for people in good vs. bad health. People in good health retire approximately three years later than people in bad health do, but regardless of health status, retirement ages grew by two years across the two cohorts.

However, we do not see this parallelism in terms of education and employment status. First, while there is an educational gradient in average retirement ages, the development across the two cohorts has been substantially slower among highly educated workers (approximately 0.9 years) than among workers with basic or vocational education (approximately 2 years). Changes in Danish retirement legislation aiming to reduce early retirement may explain these differences. Thus, in Denmark, in contrast to other high-income countries (OECD 2017a; Rutledge 2018; Bingley et al. 2019), workers with low levels of education have changed their retirement behaviour more than more highly educated workers.

Second, the self-employed workers stand out as the only group with higher-than-average retirement ages for both cohorts *and* a substantial (3 years) development across cohorts.

Decomposition analysis

In Table 2, we study to what extent changes in terms of gender, education, employment status and health across cohorts can explain changes in retirement ages. Table 2 decomposes the increase in retirement ages from the 1935 cohort to the 1950 cohort into a compositional, a behavioural and an interaction component. The analysis also includes a constant term, which we assume mainly includes unobserved behavioural differences. In a decomposition analysis, the summation of all terms equals the total gap and therefore, a term cannot be set to zero due to low statistical significance (Etezady et al. 2021). Thus, standard errors are omitted from Table 2, but appear in Additional file 1: Online resource C.

Of the 2.1-year increase in retirement ages (from 61.4 years in the 1935 cohort to 63.5 years in the 1950 cohort), 0.21 years can be attributed to compositional changes. This rather limited influence is due to the changes in workforce composition offsetting each other. As hypothesized, relative increases in the shares of highly educated workers and workers in good health have influenced average retirement ages positively (by 0.35 + 0.12 = 0.47 years, or 5.6 months) (H1a, H4a), whereas changes in gender and employment status (i.e. relatively more female and fewer self-employed workers) have influenced retirement ages negatively (by − 0.08 − 0.19 = − 0.27 years, or − 3.2 months) (H2a, H3a).

Table 2 Decomposition analysis of increases in retirement ages from the 1935 cohort to the 1950 cohort. Changes in years in the composition-, behaviour- and interaction-term

	Composition	Behaviour	Interaction	Total
Average retirement age:				
1935 cohort: 61.40 years				
1950 cohort: 63.48 years				
Total change	0.21	2.05	− 0.18	2.08
Gender	− 0.08	0.00	0.00	− 0.08
Men	− 0.04	0.03	0.00	− 0.02
Women	− 0.04	− 0.02	0.00	− 0.06
Employment status	− 0.19	− 0.13	− 0.04	− 0.35
Wage earner	− 0.09	− 0.16	− 0.02	− 0.27
Self-employed	− 0.09	0.04	− 0.02	− 0.07
Education	0.35	0.23	− 0.14	0.44
Basic education	0.30	0.20	− 0.11	0.40
Vocational education	− 0.08	0.12	0.03	0.08
Higher education (≤ 3 years)	0.08	− 0.07	− 0.06	− 0.05
Higher education (4 + years)	0.04	− 0.01	− 0.01	0.02
Health	0.12	0.02	0.00	0.15
Good self-rated health	0.06	0.03	0.00	0.10
Bad self-rated health	0.06	− 0.01	0.00	0.05
Constant		1.91		
N				2644

The second column of Table 2 shows the impact of cross-cohort changes in behaviour on retirement age. Coefficients are expressed as deviations from the grand mean to avoid the choice of base category influencing behavioural results (Jann 2008). Therefore, the results related to behavioural changes tell us if the *difference* in behaviour within groups (e.g. the change in retirement ages that can be explained by differences in retirement behaviour between men and women) has increased or decreased across cohorts. However, the results do not tell us if that difference is mainly driven by a behavioural change, e.g. among men or among women. To clarify which groups mainly contribute to the observed changes in retirement behaviour, we present predicted retirement ages by characteristic and cohort in Additional file 1: Online resource D.

The estimates regarding behavioural changes, in-line with the descriptive findings, support the hypothesized patterns of a weakening association between educational level and late retirement (H1b), an intensifying negative association between being female and late retirement (H2b) and an intensifying positive association between being self-employed (H3b) and healthy (H4b) and late retirement.

The third column of Table 2 shows the contribution from the interaction between compositional and behavioural changes on retirement age. The total contribution from this term is negative and relatively small (− 0.18). The main part of this contribution comes from workers with basic education (− 0.14). This finding is due to the positive contribution from the relatively large increase in the retirement age for low-skilled workers largely being counterbalanced by this group becoming smaller over time.

Across compositional, behavioural and interaction effects, the total contribution of increasing levels of education is 0.44 years, whereas better health contributed positively by 0.15 years (H4c) to increasing retirement ages. The total contribution due to changes in the share of female workers (H2c) and self-employed workers both influenced retirement ages negatively, by − 0.08 and − 0.35 years, respectively. Thus, due to offsetting effects, changes across cohorts in gender, education, employment status and health explain only 0.16 years of the total 2.1-year increase in retirement ages. The increase in retirement ages is mainly due to behavioural changes that we cannot attribute to the investigated characteristics and that are captured by the constant term (1.91 years). Consequently, the increase in retirement ages from the 1935 to the 1950 cohort is mainly due to unobserved factors, including changes in retirement legislation (Boissonneault et al. 2020; Börsch-Supan and Coile 2018; Coile et al. 2018; OECD 2017b), that we cannot control for in our analysis.

Discussion

This study analysed changes in retirement ages for the cohorts born in 1935 and 1950 across a retirement window stretching from the early 1990s to the late 2010s. Across cohorts, the composition of the labour force changed substantially, as increasing shares of highly educated and female workers entered the labour market, while the share of self-employed workers dropped considerably. While we recognize that changes in retirement legislation were important drivers of increasing retirement ages, this study contributes to the literature by examining the importance of changes in gender, education, employment status and health.

In particular, this study contributes by investigating the impact of changes in terms of employment status—i.e. changes in the shares and behaviour of wage earners and self-employed workers—on retirement ages. In total, the change in retirement ages attributed to changes in employment status amounts to − 0.35 years. Thus, changes in employment status across cohorts were, in absolute terms, more important for the development in retirement ages in Denmark than the corresponding changes in gender (− 0.08 years) and health (0.15 years) and almost as large as the changes in education (0.44 years). This study thus establishes the importance of including changes in employment status when explaining the long-term development in retirement ages.

While substantial changes to the workforce have taken place in the period examined here, these changes influence retirement ages both positively (e.g. increasing educational levels, and better health) and negatively (e.g. more female workers and fewer self-employed workers). Moreover, positive behavioural changes mainly took place among self-employed and low-skilled workers. However, these behavioural changes had little influence on aggregated retirement ages due to the negative compositional development (i.e. these groups becoming smaller over time). Thus, the net total effect of changes in gender, education, employment status and health on retirement ages has been limited.

In contrast to previous studies (OECD 2017a; Rutledge 2018), we find that increases in retirement ages have mainly taken place among low-skilled workers. In the retirement window under study, legislative changes in Denmark primarily aimed at restricting early retirement opportunities. Our study, in accordance with previous work, thus indicates that changes in retirement legislation are an important driver of increasing retirement ages (Boissonneault et al. 2020; Börsch-Supan and Coile 2018; Coile et al. 2018; OECD 2017b).

In addition, structural, demographical, technological and socio-cultural trends related to retirement behaviour may contribute to explaining increasing retirement ages across cohorts (de Wind et al. 2015; Browne et al. 2019). Fewer mentally and physically straining occupations, an increase in the demand for older workers due to demographic change and strong economic development during most of the retirement window under study are other factors that may have contributed to increasing retirement ages (DØRS 2021).

This study has three limitations that readers should consider when interpreting the findings. First, we only have access to expected or imputed retirement ages for people retiring past age 67, which prevents the precise estimation of the association between changes to the workforce and increases in retirement ages for this group. Second, we have limited information about respondents at the exact time of retirement. We have circumvented this problem by basing our analysis on variables that are unlikely to change as respondents' approach retirement (education, gender and employment status for most of one's working life). For health, we use health at age 62 as a proxy for health at the age of retirement. However, the precision of the proxy may vary across cohorts and hence, we may not accurately capture the true influence of changes in health on retirement ages. In addition, we cannot control for the labour force participation of respondents' spouses, which has been found to influence retirement behaviour—in particular among men (Coile 2004, 2019; Schirle, 2008). Third, we cannot directly measure the influence of changes in the legislation regarding early retirement. Nevertheless, this study provides important and novel insights into the influence of compositional and behavioural changes—in particular in terms of employment status—on retirement ages.

Conclusions

Over the last two to three decades, the demographic transition towards increasing shares of older adults has led to restrictions in retirement policies and increasing retirement ages across a wide range of countries (Bingley et al. 2019; Boissonneault et al. 2020; Turek et al. 2022). Parallel to legislative changes, significant changes to the workforce have occurred. Consequently, the workforce retiring in the early 1990s differed markedly from the workforce retiring in the late 2010s in terms of gender, education, employment status and health. This study analysed to what extent these changes to the workforce contribute to explaining the increase in retirement ages in Denmark over the past two to three decades. While our results show that changes in these factors had little *aggregated* impact on the increase in retirement ages, this limited impact was mainly due to them having offsetting effects. Therefore, our findings still have important implications for the future development in retirement ages—internationally as well as in Denmark.

For instance, the proportion of 60–70-year-olds with good health and educational resources can be expected to increase in the coming years, as the proportion of older people with physically demanding jobs decreases. Moreover, increasing numbers of workers have recently taken up self-employment following increasing unemployment rates due to the COVID-19 crisis (Statistics Denmark 2021; Nearside 2022; Utz et al. 2022). The demographic development and the associated labour shortages may contribute to continued high demand for older workers (OECD 2022). In addition, increasing retirement ages and other policy changes will likely influence retirement ages of future cohorts positively. All these factors point towards retirement ages that will increase in the future.

By contrast, increasing labour force participation among women is likely to put downward pressure on retirement ages in many countries. In addition, the "new" self-employed workers, who may have chosen self-employment to avoid COVID-19-related unemployment (i.e. out of necessity), may differ from previous generations of self-employed workers, who may have chosen self-employment more by desire. Thus, the association between being self-employed and late retirement might weaken in the future. Moreover, recent research demonstrate that not all workers are equally able to postpone retirement (Lain et al. 2019; Quinby and Wettstein 2021). In Denmark, this recognition has led to the introduction of a new early retirement program—"early pension"—that allows workers with a minimum work history of at least 42–44 years to retire one to three years before the statutory retirement age—and it is possible that other countries will follow suit. As the net-effect of these policy, compositional and structural changes is unknown, future research should continuously follow the development in retirement ages. Our results show that accounting for changes in employment status is an important explanatory factor when doing so.

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Author contributions AA contributed to conceptualization (equal); methodology (equal); writing—original draft (lead); and writing—review and editing (equal).ML contributed to conceptualization (equal); methodology (equal); formal analysis (lead); writing—review and editing (equal); and project administration (lead).

Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

The Current and Retrospective Cognitive Reserve (2CR) survey and its relationship with cognitive and mood measures

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Abstract

Cognitive Reserve (CR) is often assessed with surveys spanning demographic, lifestyle, and socio-behavioral variables. The role of both past and current life experiences on CR has, however, rarely been examined. We developed the Current and Retrospective Cognitive Reserve (2CR) survey to assess classical CR proxies (socio-economic status, engagement in leisure and social activities) and other dimensions of potential importance (family engagement, religious/spiritual activity) both currently (CRc; in later adulthood) and retrospectively (CRr; as recalled from younger adulthood). We administered the 2CR, measures of general cognitive functioning, working memory (WM), crystallized—vocabulary— and fluid—reasoning—intelligence, and depressive symptoms (DS) to 235 community-dwelling Italian adults (ages 55–90 years). We used exploratory and confirmatory factor analyses to examine the 2CR latent structure, and we estimated correlations of its dimensions with cognitive abilities and DS. Analyses confirmed a three-level factor structure with two global CR factors (CRc and CRr) at the top level, dimensional CR factors (socio-economic status, family engagement, leisure activity, social engagement, and religious/spiritual activity) at mid-level and observed items at the lowest level. Item-factor representations partially differed across CRc and CRr. Both CRc and CRr were positively correlated with measures of intelligence, WM and DS, but associations of measures of intelligence were stronger for CRr, whereas associations of WM and DS were slightly stronger for CRc. The 2CR can be considered a reliable survey for assessing CR proxies within a multidimensional, "life stage-dependent" framework insofar as CRc are CRr closely related but also differently associated with intelligence, WM, and DS.

Keywords Cognitive reserve · Cognitive functioning · Working memory · Depression · Factor analysis

Introduction

Different compensating factors can counteract/delay cognitive losses linked to the normal aging process and/or to neurodegenerative disorders. One such factor is reserve capacity, i.e., the ability to preserve functionally appropriate behaviors despite the presence of age- and/or pathology-related changes in neurocognitive status. The Cognitive Reserve (CR) model conceives CR as a dynamic and active process, whereby the differential recruitment of cognitive strategies/neural networks underlying task performance allows individuals to cope better with brain damage (Stern 2009). The operationalization of CR is, however, complex, since it cannot be measured directly (Cosentino and Stern 2013). Therefore, CR is usually assessed using proxies based on indicators of lifestyle behaviors and activities that, if "adopted", serve to protect or augment it.

Commonly used CR proxies include education level, occupational attainment, and engagement in intellectually

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stimulating leisure activities (Opdebeeck et al. 2016; Stern 2009; 2019). These proxies are thought to reflect a cognitively "enriched" environment, which confer resilience to the neuropathology detrimental effects on functional behaviors and clinical outcomes (Reuter-Lorenz and Park 2014). There is, for example, substantial evidence to show that higher education, along with higher occupational status and engagement in leisure and mental activities, lowers the risk for developing dementia (Opdebeeck et al. 2015; Valenzuela and Sachdev 2006) and can counteract age-related worsening in cognitive abilities and everyday functioning (Ihle et al. 2019).

These CR proxies are frequently examined in isolation and most often limited to education. However, a single indicator is unlikely to capture the full CR dimensionality (Cosentino and Stern 2013). Additionally, assessment with a single indicator does not allow for the statistical differentiation of reliable vs. unreliable sources of variance. Therefore, multi-item surveys thought to reflect the different dimensions of CR have been developed and are increasingly used. These typically include various lifestyle and socio-behavioral items, which are aggregated to provide a global CR score and/or scores for more specific CR dimensions (e.g., leisure engagement encompassing time spent performing intellectually, socially, and/or physically stimulating leisure activities/hobbies; Nucci et al. 2012). However, these inventories do not account for the likelihood that such CR proxies vary across different life course periods (Stern et al. 2019).

To better capture the dynamic nature of CR, it is imperative to assess both overall and domain-specific activities and experiences as they manifest in later life (i.e., as currently assessed in older adults) and also as they have been accumulated over the lifespan (i.e., as retrospectively assessed). To our knowledge, of the extant multidimensional CR surveys, only three assessed CR proxies at different life stages: the Cognitive Reserve Scale [CRS] by Leon et al. (2014) and the Lifetime of Experiences Questionnaire [LEQ] by Valenzuela and Sachdev (2007)—or at specific ages: the Lifetime Cognitive Activity Scale [LCAS] by Wilson et al. (2013).

Notably, the LCAS and CRS do not solicit the classical (and arguably fundamental) CR proxies of education level and occupational status. Moreover, despite a range of intellectually, socially, and physically stimulating activities reflected across these surveys, none include measures of family/relational support or engagement in spiritual/religious activities. Communication and contact with family members and close friends have been shown to contribute both to emotional wellbeing and cognitive functioning in older adults (Ihle et al. 2021; Kelly et al. 2017), and thus to successful/healthy aging (Rowe and Kahn 1998). Moreover, the physical and psychological health of a person's marital/domestic partner are known to impact both emotional and cognitive outcomes in adulthood (Xu et al. 2016). Spiritual/religious engagement often spans both personal and social dimensions and has been suggested to influence CR as a strengthening factor within the successful aging framework (Hosseini et al. 2019).

Finally, these inventories usually provide a single global score for CR. To our knowledge, no CR survey has thoroughly examined the latent representation/structure of specific CR dimensions within and across current vs. retrospective life stages. By extension, dimensional CR factors assessed at different life stages have not been validated against objective measures of cognitive performance (e.g., working memory, fluid abilities) or closely related affective measures (e.g., depressive symptoms) known to be sensitive to age- and pathology-related declines. This matters because current vs. retrospective CR, and specific dimensions thereof, may be differentially related to such outcomes (Ihle et al. 2021; Rosen et al. 2002).

Here, we present and evaluate a new CR survey, the Current and Retrospective Cognitive Reserve (2CR), aimed at capturing CR as a multidimensional and non-static construct by comprehensively assessing classical and novel CR proxies with respect both to participants' current status at the time of assessment (CRc) and retrospectively (i.e., as recalled to have occurred in younger adulthood; CRr). The 2CR comprises groups of items related to classical socio-demographics (e.g., educational and occupational attainment, financial status). It also assesses the frequency of engagement in a varied typology of stimulating activities, here organized into leisure activity (encompassing recreational exercise, creative expression, and intellectual stimulation) and social engagement (e.g., volunteering, club membership, public events). Moreover, it is the first to include items related to family engagement (including partnership quality) and spiritual/religious engagement.

We examined CR structure as captured by the survey using confirmatory factor models, testing a three-level latent representation of CR (which was informed by results from a prior exploratory pilot study; see Additional file 1). Specifically, we modeled two global current and retrospective CR factors (CRc and CRr) at the top level, with CR dimensional factors (i.e., socio-economic status, leisure activity, social engagement, family engagement and spiritual/religious engagement) at the intermediate level, and finally with items/parcels at the observed/base level.

We further estimated associations of the global and dimensional CR factors with objective cognitive measures, i.e., general cognitive status, vocabulary and reasoning—for crystallized and fluid intelligence, respectively—and a measure of working memory previously shown to be sensitive to normative aging (Borella et al. 2008). Furthermore, since cognitive impairment and depression are often comorbid in later life (e.g., da Costa Lane Valiengo et al. 2016), we also examined here, for the first time,

Table 1 Characteristics of the sample

Characteristic	Summary statistic
Total participants	$N = 235$
Women	$n = 128$ (54.5%)
Age in years	$M = 68.3$, $SD = 8.8$, range = 55.0–90.0
Years of education	$M = 10.2$, $SD = 4.1$, range = 4.0–20.0
Partnered (= yes)	$n = 199$ (84.7%)
Children	$M = 1.8$, $SD = 1.0$, range = 0–5
Occupational category	
Manual, unqualified	$n = 47$
Manual, qualified	$n = 78$
Non-manual, qualified	$n = 65$
Professional, degreed	$n = 26$
Director or manager	$n = 19$
Cognition and depression measures	
MMSE adjusted for age, education (general cognitive functioning)	$M = 28.4$, $SD = 1.2$, NA = 20
WAIS Vocabulary (crystallized intelligence)	$M = 41.6$, $SD = 10.9$, NA = 0
Raven's total correct (fluid intelligence)	$M = 31.4$, $SD = 10.0$, NA = 1
LST - words recalled (working memory)	$M = 11.1$, $SD = 3.3$, NA = 11
GDS (depressive symptoms)	$M = 2.0$, $SD = 1.6$, NA = 0

MMSE = Mini-Mental State Examination. WAIS = Wechsler Adult Intelligence Scale. LST = Listening Span Task. GDS = Yesavage Geriatric Depression Scale. NA = number of missing observations. There were no missing data for sociodemographic variables

associations of currently and retrospectively assessed CR factors (global and dimensional) with depressive symptoms (DS).

In general, we expected that the structural factor analyses would support our three-level model, with reliable loadings of survey items onto domain-specific CR factors, and strong domain-specific CR factor loadings onto global CR factors. Moreover, we anticipated moderately positive correlations between current and retrospective factors. Note that results from our pilot study indicated partially differential item representation for the CRc and CRr dimensional factor. This was expected given that goals and resources change across the adult lifespan (Ebner et al. 2006) and is reflect in the factor model underlying the currently tested version of the 2CR.

We further expected modest but significant positive correlations between the CR factors and objective cognitive measures, in line with previous evidence (Opdebeeck et al. 2016) and indicative of broad-domain convergent validity. Because depression impacts mental health outcomes (da Costa Lane Valiengo et al. 2016) and might result in an "impoverished environment" in terms of mental and social stimulation, and given evidence that interactions with loved ones and participation in leisure, social, and religious activities may lower depression risk (Dezutter et al. 2006; Handing et al. 2022), we expected significant negative correlations between the CR factors and DS.

Methods

Participants

The sample consisted of 235 individuals over 55 years of age (see Table 1). They were all volunteers, community-dwellers of various Italian cities. None of the participants had a history of psychiatric or neurological disorders, or cognitive difficulties [participants' Mini-Mental State Examination (Folstein et al. 1975) scores ≥ 27]. None met the criteria for clinical depression [participants' Geriatric Depression Scale (Yesavage et al. 1983) scores ≤ 5]. The study was approved by the local ethical committee for psychological research.

Materials

Current and Retrospective Cognitive Reserve survey (2CR)

The first version of the 2CR included items of key importance from existing CR questionnaires and from an extensive review of literature on healthy aging and cognition. This initial survey (2CR pilot) was administered to a sample of 342 community-dwelling older adults. These pilot data were then factor analyzed and cross-validated against measures of cognitive performance and health status (see Additional file 1). Guided by these—pilot—study results, we developed the current version of the 2CR (Additional file 2), which we administered to a new, independent sample of older participants (described above).

In addition to basic socio-demographic variables (age, sex), the survey comprises items spanning five dimensions of experience: socio-economic status, leisure activity, social engagement, spiritual/religious practice, and family engagement. Except for family engagement, these dimensions were assessed with respect both to current status (i.e., late adulthood/older adulthood) and retrospective status (youth or younger adulthood). We developed the 2CR to be flexible with respect to the age range implied by "retrospective," i.e., to support different research goals with respect to developmental comparison. For the current study, retrospective referred to younger adulthood, i.e., ages 20–35/40 years[1]. As noted, family engagement was assessed only with respect to current status. This was because associated variables (partnership quality items, e.g., cognitive and emotional status of one's spouse) would not be applicable if "retrospective" were operationalized as referring to late adolescence.

All response-level items were scaled 0–4, except for educational level, which was scaled from 1 to 7 to cover all of the major educational attainment levels provided by the Italian education and training system (higher scores = higher level of education completed). For the items assessing the engagement in leisure, social, and spiritual/religious activities, participants were asked to rate their frequency of engagement with each of the activities choosing the following options: never, seldom (yearly), sometimes (monthly), often (weekly), always (daily).

The structure of the 2CR corresponds to a three-level factor model, with general current and retrospective CR (CRc and CRr) at the top level, i.e., at level-3, the above-described CR dimensions as latent constructs at level-2, and observed items at level-1. All level-1 items except for indicators of socio-economic status were obtained as composite scores (parceled as means for this analysis) of sets of two or more items (see Fig. 1 for a diagram of the full model, with composite items further described in the corresponding figure caption and in the scoring sheet for the 2CR in Appendix A).

Listening Span Test (LST; Borella et al. 2008)

It consists of sets containing increasing numbers (from 2 to 6) of short sentences. Participants were instructed to listen to each sentence, judge whether it was true or false, and retain its last word. At the end of each set, participants were asked to recall the last word of each sentence. The total number of correctly recalled words was used as a measure of WM performance (maximum score = 20).

Wechsler adult intelligence scale revised—vocabulary subtest (Weschler 1981)

A list of 35 words was presented, and participants were asked to provide either their meaning or a synonym. Answers to the 35 items were scored according to the manual. The dependent variable was the sum score for all items (maximum score = 70).

Raven's progressive matrices (Raven's; Raven et al. 1977)

Participants were presented with 60 matrices. The matrices were similar to a puzzle with a piece missing from the bottom right corner. The participants had to choose which of the 6 pieces presented best completed the figure and to complete the test within a 20-min time constraint. The total number of correct solutions was used as a measure of fluid intelligence.

Procedure

All participants completed one in-person individual session with an experimenter, lasting about 90 min (with a 5–10-min mid-session break). After obtaining participants' consent, the order of the tasks/questionnaire was: the MMSE, the 2CR, the Verbal intelligence, the Raven's, the LST, and the GDS.

Analyses

We conducted confirmatory factor analyses of the survey data using Mplus statistical software (Muthén and Muthén 2017) with full information maximum likelihood (FIML) estimation and treating response items as continuous variables. We fit three models, beginning with the "full" three-level model (Fig. 1). This model included observed response items at level-1 (a mix of individual item scores and composite/item parcel scores). The level-1 items in turn loaded onto level-2 "dimensional" CR factors, which included five current domains (leisure activity, social engagement, religious activity, socio-economic status, and family engagement) and four retrospective domains (again, family engagement was not assessed retrospectively). Finally, the dimensional level-2 factors loaded onto global CRc and CRr factors at level-3.

Note that, according to the factor-item structure that emerged from the pilot study, relations between some observed activities and dimensional CR factors differed across retrospective vs. current life periods; e.g.,

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[1] Note that the survey allows for the age range associated with retrospective status to be specified by the experimenter at the time of administration, e.g., contingent on research goals and sample demographics.

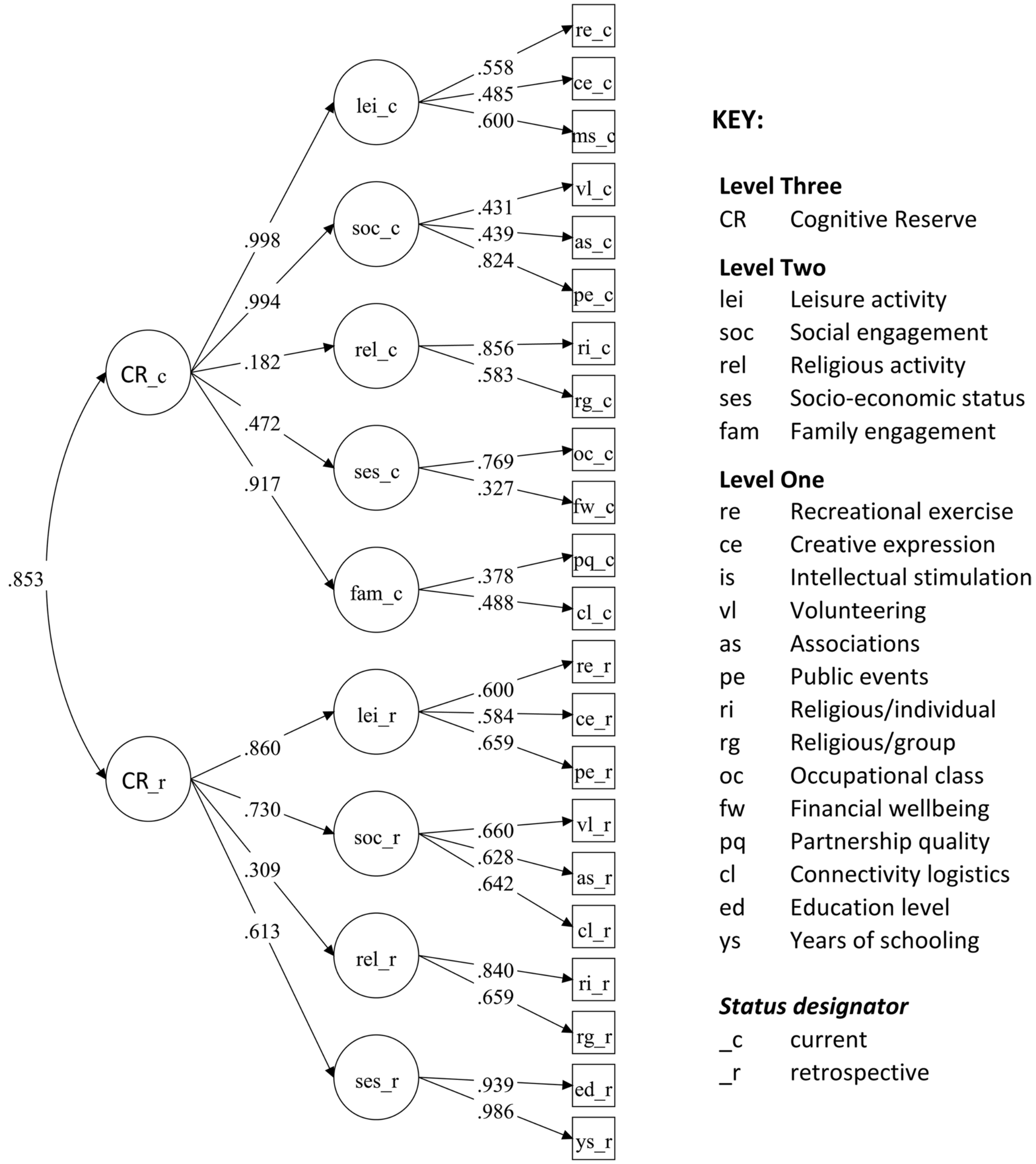

Fig. 1 Diagram of the three-level latent structure of the final 2CR survey. *Note*. Standardized factor loadings estimates (shown on directional pathways) were obtained from a three-level factor model, with global CRc and CRr factors at the top level, dimensional CR factors at mid-level, and observed items at the lowest level. Most level one (observed response) items were calculated as composite scores, averaging across response items as follows: recreational exercise (swimming, gym, dance); creative expression (writing, painting, playing music); intellectual stimulation (reading, puzzles, chess); volunteering (at hospitals, schools, charitable organizations); associations (clubs, political groups, professional groups); public events (theatre/concerts, museums, conferences); religious/spirituality-individual (prayer, meditation); religious/spirituality-group (participation in religious rites/ceremonies, church community events); partnership quality (partner's accessibility, health, mood, mental health); connectivity logistics (driving and computer use related to family/social purposes). Unique item variances and covariances are not shown to allow for a clearer visual presentation of associations between items/factors. Global CRc and CRr factors were correlated at $r = 0.853$, $p < 0.001$

Table 2 2CR structural equation model fit statistics

Model	Parameters	χ^2 (*df*)	CFI	RMSEA	[95%CI]	SRMR	AIC
1. Three-level (CRc, CRr)	88	355 (187)	0.913	0.062	[0.052, 0.072]	0.067	12,606
2. Three-level (CRc + r)[†]	87	369 (188)	0.906	0.064	[0.054, 0.074]	0.068	12,619
3. Two-level (dimensional factors only)	110	312 (165)	0.924	0.062	[0.051, 0.072]	0.061	12,607

CFI = comparative fit index. RMSEA = root mean square error of approximation. SRMR = standardized root mean square residual. AIC = Akaike Information Criterion

[†] Non-positive definite residual covariance matrix (theta)

connectivity logistics loaded onto social engagement retrospectively, whereas connectivity logistics loaded onto family engagement currently (see Fig. 1).

As for socio-economic status, most people finish formal schooling in adolescence or early adulthood, and education contributes strongly to subsequent occupational experiences (Wilson et al. 2013). Occupational attainment is indeed highly correlated with educational achievement and it -in and of itself- represents a form of lifelong education (an individual's occupation may provide opportunities for cognitive stimulation and new learning) (Scarmeas and Stern 2004). Therefore, we used education to represent retrospective SES, while occupational attainment, along with financial wellbeing, to represent current SES. With respect to retrospective SES, we included both educational level (highest level of education achieved) and years of formal schooling as indicators. As a construct, education level is prone to variation across different types of high schools and/or universities (which may also differ in quality) within and across different countries, potentially influencing scoring equivalence across contexts. Years of schooling better expresses variation in the number of years taken to obtain a given degree, thereby better reflecting differences in normative vs. delayed/accelerated learning. Though related, these two indexes therefore represent two different dimensions of educational attainment, and considering both would allow one to better capture—quantitative and qualitative—sources of educational benefits as a proxy of CR (see Lawrence et al. 2016; McDowell et al. 2007).

In a second model, we only included a single global CR general factor at level three for comparison purposes (i.e., to see if the dimensional factors would collapse onto a single, overarching CR dimension). Finally, we estimated associations between the global and dimensional CR factors and measures of cognitive performance and depressive symptoms. Note that unique variances for level-1 items that were identical save for the distinction of current vs. retrospective were allowed to correlate to account for shared method variance.

Results

Model fit statistics for the confirmatory factor analyses are provided in Table 2.

Overall fit was acceptable across all models based on established cutoff criteria (Hu and Bentler 1999). However, the residual covariance matrix (theta) was non-positive definite for the three-level model with a single global CR factor. A formal test of change in model fit across the three-level models ($\Delta\chi^2 = 14$, $df = 1$, $p < 0.001$) further confirmed selection of the model with two global CR factors (CRc, CRr) over the model with a single global CR factor. Standardized item/factor loadings for the three-level CRc and CRr model are shown in Fig. 1 (additional parameter estimates are provided in Supplemental Materials 2). Standardized loadings (λ) were all strong (≥ 0.400) with a few exceptions. For level-1 items, current financial wellbeing (reverse-coded financial hardship) and family engagement had moderate loadings ($\lambda = 0.327$ and $\lambda = 0.378$, respectively) onto the corresponding level-2 items. For level-2 items, current and retrospective religious activity loaded weakly/moderately onto the corresponding global CR factors ($\lambda = 0.182$ and $\lambda = 0.309$, respectively). Global current and retrospective cognitive reserve factors were strongly positively correlated ($r = 0.853$).

Convergent and discriminant validity

Table 3 shows the correlations of the 2CR global and dimensional factors with variables of interest. With respect to the demographic measures, chronological age was weakly negatively correlated with current leisure activity and social engagement and was weakly negatively correlated with retrospective leisure activity, SES (education), and global CR. Chronological age was moderately negatively associated with current family engagement. Men had weakly/moderately lower religious activity, currently and retrospectively, than women. Men had weakly/moderately higher current SES (occupation) and family engagement, and weakly/moderately higher retrospective social engagement and CR, than women.

Table 3 Correlations of 2CR factors with cognitive performance and depressive symptoms

Covariates	Dimensional CR factors									Global CR factors	
	LEI_c	SOC_c	REL_c	SES_c	FAM_c	LEI_r	SOC_r	REL_r	SES_r	CR_c	CR_r
Age	−0.164	−0.250	*0.141*	*−0.003*	−0.390	−0.190	*−0.145*	*0.058*	−0.312	*−0.222*	−0.307
Male†	*−0.057*	*0.005*	−0.323	0.336	0.316	*0.196*	0.220	−0.307	*0.144*	*0.067*	*0.218*
MMSE (general cognitive functioning)	*−0.099*	*−0.025*	−0.264	*−0.011*	*0.196*	*−0.111*	*0.093*	*−0.030*	*0.073*	*−0.024*	*0.029*
WAIS Vocabulary (crystallized intelligence)	0.376	0.468	*0.054*	0.622	0.221	0.391	0.262	*0.078*	0.600	0.481	0.562
Raven's (fluid intelligence)	0.367	0.370	−0.182	0.353	0.376	0.389	0.222	*−0.105*	0.513	0.409	0.498
LST (working memory)	0.369	0.458	*0.015*	0.530	0.362	0.350	*0.136*	*−0.050*	0.452	0.481	0.435
GDS (depressive symptoms)	−0.278	−0.272	*−0.104*	−0.316	−0.595	−0.219	*−0.139*	*−0.121*	−0.135	−0.369	−0.232

Factor abbreviations are defined in Table 1. Factors' suffix "_c" refers to current, and suffix "_r" refers to retrospective. Correlations between covariates and dimensional CR factors were estimated in a first-order factor model (i.e., without global CR factors). MMSE = Mini-Mental State Examination, adjusted for age and education level. WAIS vocabulary subtest. Raven's = Raven's progressive matrices, total correct. LST = listening span task (working memory), words correctly recalled. GDS = Yesavage Geriatric Depression Scale. Non-significant ($p > .05$) correlations are shown *italicized*. The listed covariates were added to models 1 and 3 (Table 2), respectively. This allowed us to calculate correlations of these measures with the global CR factors (model 1) and with the dimensional CR factors (model 3)

†Point-biserial correlations

Associations with cognitive performance measures

Global CRc and CRr factors were not significantly related to MMSE, but both showed moderately strong positive associations with vocabulary (*r* = 0.481 and *r* = 0.562, respectively), reasoning (*r* = 0.409 and *r* = 0.498), and WM (*r* = 0.481 and *r* = 0.435).

Of the dimensional CR factors, current and retrospective leisure activity, current social engagement, and current and retrospective SES were moderately positively associated with vocabulary (*r* = 0.376–0.622), reasoning (*r* = 0.353–0.513), and WM (*r* = 0.350–0.530). Current family engagement was weakly positively associated with vocabulary (*r* = 0.221) and moderately positively associated with reasoning (*r* = 0.376) and WM (*r* = 0.362). Current religious activity was weakly negatively associated with MMSE scores (*r* = -0.264) and with reasoning (*r* = -0.182). Retrospective religious activity was not significantly associated with any of the cognitive performance measures.

Associations with depressive symptoms

Of the global CR factors, CRc was moderately negatively associated with depressive symptoms (*r* = − 0.369), and CRr was weakly negatively associated with DS (*r* = − 0.232). Of the dimensional CR factors, current family engagement was most strongly negatively associated with DS (*r* = − 0.595). Current and retrospective leisure activity, current social engagement, and current and retrospective SES were weakly negatively correlated with GDS (*r* = − 0.135–0.316).

Discussion

We developed the 2CR survey to characterize the dynamic nature of (classical and new) CR proxies in two main life stage periods, i.e., currently (as typically assessed) and retrospectively. We evaluated its factor structure, and results supported a three-level representation of CR, with distinct, global current and retrospective CR factors (CRc and CRr) at level-three, dimensional CR factors at level-two, and with observed items and composite scores at level-one. This depth of representation is, to our knowledge, novel among CR surveys considering different life stages. Global and dimensional CR factors were further examined in relation to objective measures of cognitive ability and, for the first time, depressive symptoms.

Survey structure and item-factor representation

Associations between global (level three) and domain-specific (level two) CR factors

With respect to the 2CR latent structure (Fig. 1), except for family engagement (which, as noted in the Methods, we did not assess retrospectively), the global/domain-specific CR structural sub-models were identical for current and retrospective variables. Loading strengths of the domain-specific CR factors onto the global CR factors were highly consistent, with leisure activity and social engagement most strongly representative of each global factor. Along with socio-economic status, leisure and social domains are not only related to successful/active aging (Rowe and Khan 1998), but they are also well-established socio-behavioral CR proxies (Opdebeeck et al. 2016; Stern et al. 2019), so their salient loadings are reassuring. In contrast, religious/spiritual activity was only weakly associated with both global CR factors, an unexpected result. It may be that religious/spiritual activity is more closely linked to other psychological aspects (e.g., fear of dying; Fortner et al. 2000) than to cognitive protective factors generally. Family engagement also loaded strongly onto CRc, a result consistent with recent evidence on the importance of family (and especially partnership quality) for individual psychological well-being and cognitive functioning in later adulthood (Handing et al. 2022; Kelly et al. 2017).

Associations between domain-specific CR factors and observed variables

In contrast to the higher-order (global/domain-specific) CR factor structure, associations between the domain-specific CR factors (level two) and observed/composite items (level one) were mostly asymmetrical across current vs. retrospective variables. As explained in the Methods, asymmetries related to SES and family engagement were inherent to the nature of the domains themselves (e.g., occupational class and partnership/marital status are not relevant when assessing retrospective status as pertaining to late adolescence). Such item-factor structural asymmetries were determined from the pilot study factor analyses (Supplemental Materials 1). For example, connectivity logistics (driving, telecommunications usage) were more closely related to family engagement in the current period (older age), but to general social engagement retrospectively. Similarly, participation in public events was related to social engagement in later adulthood, but to leisure activities in earlier adulthood. These qualitative asymmetries were thus effectively "baked into" the survey in its present form and as administered to the current sample of participants. The results (model fits, factor loadings) from the structural factor analyses applied to these data largely support this structure.

Associations with cognitive performance

Differential associations were observed between the CR factors (global and dimensional) and cognitive performance measures. Both CRc and CRr were significantly positively correlated with vocabulary and reasoning (measures of crystallized and fluid intelligence), consistent with prior evidence (Opdebeeck et al. 2016). However, associations with these measures were more pronounced with respect to CRr. Both CRc and CRr were similarly both positively associated with WM, but in this case, the association was slightly stronger for CRc. Differences in intelligence, and corresponding differences in educational attainment and behavior-related risk factors for cognitive decline, manifest at an early age and carry forward across the lifespan (Lövdén et al. 2020). In contrast, WM deficits, on average, become increasingly evident in later adulthood, at which time they may begin to interfere with and account for self-care behaviors and social support structures (Borella et al. 2008, 2017). Such developmental patterns are consistent with the observed differential associations of CRc and CRr with objective measures of intelligence and memory.

Neither CRc nor CRr correlated with general cognitive status (MMSE). Basic assessments of cognitive status (e.g., awareness of the day and date) are commonly used to evaluate neurological functioning during clinical intake, but these comparatively coarse measures may lack sensitivity to CR dimensions that track across a more varied range of individual ability (Arcara et al. 2017). Associations between dimensional CR factors and objective cognitive performance were most pronounced with respect to SES (current and retrospective). Especially salient relations were observed between SES (current and retrospective) and crystallized intelligence, confirming that an "enriched" learning environment, in terms of educational and occupational stimuli and opportunities, may promote/sustain crystallized intelligence (Cheng and Furnham 2019).

There were also differentiated relations between leisure activity (current and retrospective), social engagement (current), and family engagement (current) dimensional CR factors and the objective cognitive measures. Notably, whereas leisure activity, social engagement (current), and SES CR factors were most strongly linked to crystallized intelligence (which remains relatively stable across the adult lifespan), family engagement was more strongly linked with reasoning and WM. This result is consistent with studies showing WM and fluid abilities as playing important roles for engaging in social activities and close interpersonal relations (Kelly et al. 2017). Reciprocally, there is also evidence linking better socio-relational functioning (as a precursor) to reduced age-related loss in fluid abilities (as outcomes), with cognitive reserve playing a mediating role (Ihle et al. 2021).

Current religious activity was negatively (albeit weakly) associated with MMSE scores and with reasoning, whereas retrospective religious activity was not significantly associated with any of the cognitive performance measures. Although this result was not anticipated, prior studies have similarly shown that religiosity is negatively correlated with fluid reasoning abilities (Daws and Hampshire 2017). This result may reflect how such religious/spiritual activities were assessed on the 2CR, and it may also reflect the specific population from whom the current data were obtained. These are certainly considerations for evaluating such associations in different cultural contexts and age groups in future studies using the 2CR, for which religious/spiritual practice may have a protective effect. Indeed, religious/spiritual practice may differentially manifest as a function of age across cultural settings, e.g., because some cultures may afford more opportunities for (or place stronger expectations on) older adults to be religiously observant.

Associations with depressive symptoms

As expected, moderately strong negative correlations were observed between DS and global CRc, family engagement, and current SES. DS were also weakly negatively associated with leisure activity (current and retrospective), social engagement (current), SES (retrospective), and CRr. The result that family engagement was most strongly associated with reduced DS is consistent with recent studies showing that social isolation, particularly related to increased physical distance from loved ones (consistent with our indicators for family engagement) is a potent risk factor for depression in older adults (Handing et al. 2022). Increased social selectivity (smaller social networks, more narrowly prescribed social activities) during adulthood may serve to ensure more positive social exchanges (Carstensen 1995; Luong et al. 2011) but may also place increased value on such social support for maintaining emotional wellbeing in later life.

Limitations

An important limitation of this study related to sample selection is that study participants were on average cognitively well-functioning, which may further explain the lack of association between 2CR and MMSE scores, and without clinically diagnostic DS. We also lacked neuroimaging data, which would have allowed us to further test CR as a moderator of associations between brain status and cognitive performance. These issues should be examined in future studies to show that better CR, as evaluated on the 2CR survey, better predicts overall functioning in participants with clinically meaningful levels of brain injury and/or dementia.

The survey itself also has some potential limitations. For the pilot study, family engagement indicators also included number of family members (a count of spouse/children/grandchildren); however, we omitted this indicator in the current 2CR model (Fig. 1) due to variable/data characteristics.[2] We did, however, retain the original items (marital status, number of children and grandchildren) on the final survey for use by others should they desire further validation. We also conducted a follow-up sensitivity analysis including this variable (as a continuous outcome), but the model failed to converge.

In assessing communication, we focused on purpose rather than modality. We therefore combined computer, tablet, and phone use in a single item, as they can all be used for the same goal of communicating with others. Generational differences in device usage patterns may to some extent account for the asymmetry in how this communication item loaded onto current vs. retrospective CR factors, but we believe the 2CR model and survey structure does capture important differences of communication purposes (more broadly social for youth/younger adults, more family-focused for older adults, coherent with Carstensen's 1995, lifespan theory of socioemotional selectivity; English and Carstensen 2014) and have therefore chosen to retain this as a single item.

Retrospective SES was indicated by two items (education level and years of schooling). Due to the very strong correlation ($r = 0.92$) between these items, we subsequently tested two models wherein retrospective SES was operationalized as either of these observed (singular) education variables rather than as a factor loading on both. However, both models failed to converge. In follow-up checks, we identified 27% of participants as displaying a discrepancy between years of schooling and education level, with approximately 55% of those individuals showing deferred attainment (e.g., due to repeating grade levels, dropping out, or simply due to differences across educational systems). The remainder evinced precociousness (early advancement). In the end, we retained SES as a factor indicated by both education variables (a) for enhanced reliability given the latent-variable definition and (b) for potentially improved validity by accounting for the above-noted discrepancies across education measures.

Finally, we included a variety of common daily life leisure activities known to prompt CR, but these lists were necessarily non-exhaustive. For example, with respect to recreational exercise, three items loaded most strongly (going to the gym, dance, swimming/water aerobics). Notably, these activities concurrently promote aerobic and motor-coordination skill development, and they may also promote social interaction. Such multifaceted exercises may be key to supporting cognitive and mental health in later life (Verghese et al. 2003).

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[2] Counts of family members were highly skewed, requiring statistical treatment as a categorical variable. For the revised survey used here, we sought to treat all response variables as continuous rather than categorical variables (a) to facilitate model specification/convergence and (b) to support FIML estimation, which accommodates missing data.

That said, researchers using this survey in the future may wish to consider other recreational exercise activities (e.g., walking, cycling)—as well as additional items related to creative expression and "intellectual stimulation." We therefore have included open-ended response options for each of these survey questions.

Conclusions

Overall, these findings highlight the life stage-dependent nature of CR, which likely shifts both qualitatively and quantitatively as adults adapt and develop in response to changing demands, goals, and priorities across the lifespan (Ebner et al. 2006). Though CRc and CRr were strongly positively correlated, comparison of model fit clearly favored a solution with two separate global CR factors, compared to a single CR factor, and this was further supported by differential associations of CRc vs. CRr with the objective measures of cognitive performance. It follows that it is important to evaluate CR as a multidimensional and dynamic construct with respect both to the individual's status at the time/life period of assessment and also in relation to earlier life activities, as reflected in the 2CR survey.

An important dimension of CR not included in other currently available CR inventories is family engagement (encompassing partnership quality), which we found to be significantly positively associated with reasoning and WM performance and negatively associated with DS. This is an especially salient outcome given that family engagement (and partnership quality) has rarely been examined as a CR dimension and given that both cognitive impairment and depression have represented primary concerns for mental health within the older adult population (World Health Organization 2017). Physical proximity to loved ones is likely an essential protective factor for mental health and everyday functioning in later adulthood (Carr and Utz 2020; Handing et al. 2022), so it follows that this dimension merits inclusion as a dimension of CR.

The relationship between CR and cognitive processes central in aging (WM, reasoning and crystallized intelligence) were also confirmed, with evidence of differential associations across CRc (memory was comparatively salient) and CRr (intelligence was comparatively salient), consistent with previous findings across the adult lifespan (e.g.,). Further, we showed for the first time that depressive symptoms were significantly negatively associated with dimensional and global CR factors.

In conclusion, this study shows our new 2CR survey to be a psychometrically sound measure of CR, sensitive not only to differentiated life experiences in early vs. later adulthood, but also to their associations with current cognitive and psychological outcomes in adulthood and older age. The 2CR will likely be useful in clinical practice and could easily be extended also as a form of semi-structured interview regarding individuals' past and current lifestyle habits. The 2CR may further prove useful for applied research to develop strategies/solutions (social policies, assessment/monitoring, training programs) targeting cost-effective lifestyle factors for improved mental health and quality of life in later adulthood.

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Authors' contributions E. Borella designed the study, supervised the data collection, and contributed written content. P. Ghisletta provided guidance and feedback for statistical analysis and interpretation. E. Carbone supervised data collection and provided written content. S. Aichele performed the statistical analyses and contributed interpretation and written content. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study, the analytic methods, and study materials are available from the corresponding authors upon request.

Declarations

Competing interest The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential competing interest.

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ORIGINAL INVESTIGATION

Changes in retirement plans in the English older population during the COVID-19 pandemic: The roles of health factors and financial insecurity

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Abstract

Over the course of 2020 and 2021, the COVID-19 pandemic disrupted lives globally. In the UK, unemployment rate continued to increase during and post-lockdown periods, and job security and financial wellbeing deteriorated. It is important to understand whether individual decisions related to retirement plans have changed systematically as a result of the pandemic, especially among older adults who experienced greater rates of pandemic unemployment. Using the English Longitudinal Study of Ageing, this article examines changes in retirement plans of older adults during the COVID-19 pandemic and estimates the impact of health and financial circumstances on these changes. In June/July 2020, 5% of 2095 participants reported planning earlier retirement, while 9% reported planning later retirement. We found that poor self-rated health and financial insecurity were associated with intentions to postpone retirement. Additional risk of later retirement associated with poor health was detected among those experiencing financial insecurity. In November/December 2020, 7% of 1845 participants reported planning earlier retirement, while 12% reported planning later retirement. We found that poor health was predictive of a lower relative risk of later retirement, while depressive symptomatology and financial insecurity predicted a higher relative risk of later retirement. The findings imply a contextual role of health factors in, and a persistent influence of financial insecurity on, retirement planning in the older population.

Keywords COVID-19 pandemic · English Longitudinal Study of Ageing · Retirement planning · Mental health · Self-rated health · Financial insecurity

Introduction

Over the course of 2020 and 2021, the COVID-19 pandemic disrupted lives globally, with fear and uncertainties surrounding the novel coronavirus and its mutations, lockdown restrictions and social distancing policies. Older adults constituted a vulnerable population during this period, that is, they were more likely to develop serious conditions and experience higher mortality if infected—many were required to shield or stay at home, leading to social isolation and poor mental health (Di Gessa and Price 2022). It was reported that as the unemployment rate kept increasing during and post-lockdown periods, job security and financial wellbeing deteriorated in the UK (Cheng et al. 2021; Brown et al. 2022). What has been less discussed, however, is the impact of the pandemic on older workers, even though there is evidence for greater rates of pandemic unemployment among older than among younger workers (Bui et al. 2020). There was also a depression of pension values due to the market downturn, which would have affected older workers close to retirement age (Sutcliffe 2020; Pew Charitable Trusts 2021). Those financially affected by the pandemic have also been shown to be less likely to save and annuitise (Hurwitz et al. 2021).

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From a policy and planning perspective, it is important to understand whether individual decisions related to retirement plans have changed systematically as a result of the pandemic. The literature has shown that retirement plans are significantly influenced by personal (including health) and financial factors (Quinn 1977; Taylor and Shore 1995; Delpachitra and Beal 2002; Scharn et al. 2018), both of which have been substantially altered by the pandemic. Moreover, the pandemic presented unique challenges compared with past recessions: for instance, working longer to compensate for the decline in retirement savings may have been less viable, given older adults' need to shield or stay at home (Bui et al. 2020). Ageism may have also been a greater problem than it was previously, considering the increasing need for digital skills and reliance on remote working (Pit et al. 2021). However, few studies have documented whether and how older workers have changed their retirement plans during this crisis and the impact of health and financial circumstances on these changes (Davis 2021; Kaur 2021). Moreover, the intersectionality between health factors and financial circumstances has not yet been revealed in the context of the pandemic.

Using the English Longitudinal Study of Ageing (ELSA), a nationally representative study on older adults aged 52 years and above in private households in England, evidence is provided on how health factors and financial insecurity during the COVID-19 pandemic have affected retirement plans. Older adults were observed at two peak time points of the pandemic—June/July 2020 and November/December 2020, with a 74% response rate—thereby allowing an examination of whether the impact of these factors remained stable over time, and a longitudinal analysis that accounts for individual unobserved heterogeneity. In addition, interaction effects of health factors and financial insecurity on changes in retirement plans are investigated in this article.

Theoretical framework

In studying factors influencing retirement plans or decisions, the push–pull theory, which distinguishes between 'push' and 'pull' routes of influence on retirement, is one of the most important and widely discussed theories. People are 'pushed' to quit their job due to negative factors that constrain them from working (Shultz et al. 1998; Oksanen and Virtanen 2012; De Preter et al. 2013), such as poor health, poor working conditions, caring responsibilities, and so on (Olesen et al. 2012; Oakman and Wells 2013; Qvist 2021). They can also be 'pulled' towards retirement (Oksanen and Virtanen 2012), due to positive factors encouraging earlier retirement, including leisure expectations and pension wealth, among others (Blöndal and Scarpetta 1999; Munnell et al. 2004).

Health factors have been widely investigated as predictors of retirement (Mein et al. 2000; Munnell et al. 2004; Topa et al. 2009; Olesen et al. 2012; Scharn et al. 2018). Poor physical and mental health are usually considered push factors of retirement behaviours and plans (Taylor and Shore 1995; Von Bonsdorff et al. 2010; Olesen et al. 2012). Theoretically, poor health affects both people's ability and desire to work. People with poor physical or mental health may experience a loss of control over their work (Topa et al. 2009), affecting their productivity and ability to do full-time work, thus forcing them into retirement. Moreover, restricted ability to work promotes people's self-efficacy of retirement—their self-perceived capability to carry out retirement successfully (Hoffmann and Plotkina 2021)—which contributes to retirement intentions (Taylor and Shore 1995). Meanwhile, a positive attitude and orientation towards leisure activities drive people to quit the labour market, as suggested by Beehr's model (Beehr 1986). Therefore, hypotheses 1 and 2 are constructed accordingly:

> Hypothesis 1. People in poor health are more likely to retire earlier, or less likely to retire later.
> Hypothesis 2. People with psychological distress are more likely to retire earlier, or less likely to retire later.

The impact of financial insecurity on retirement plans is less straightforward. On the one hand, financial security acts as a pull factor of earlier retirement. A higher level of financial security is associated with earlier retirement (Taylor and Shore 1995), which conversely implies that financial insecurity or stress tends to retain people in employment (Mein et al. 2000). On the other hand, financial insecurity has a detrimental influence on health factors. Studies have shown that during the COVID-19 pandemic, financial insecurity or concerns led to the deterioration of mental health worldwide (Wilson et al. 2020; Cheng et al. 2021; De Miquel et al. 2022). Following an adaptation of the model proposed by Homaie Rad et al. (2017), there exists a trade-off between the direct effect of financial insecurity on retirement and the indirect effect via health factors. When the positive utility of financial security is larger than the negative utility of poor physical or mental health, later retirement plans may be made. In the context of the COVID-19 pandemic, it is conjectured that people's perceptions of their financial situation may be more volatile and influential on retirement planning than the changes in health for two reasons. First, there was a relatively large fall in employment level among the older population in the UK, compared with their younger counterparts (Powell et al. 2022). Second, older adults have been shown to be more resilient to anxiety, depression, and other stress-related disorders seen among younger populations during the early stages of the pandemic (Vahia et al. 2020). Therefore, the direct effect of financial insecurity may be larger in magnitude than their indirect effect, leading to hypothesis 3:

> Hypothesis 3. People with financial insecurity are more likely to retire later, or less likely to retire earlier.

Data and methods

The English Longitudinal Study of Ageing (ELSA) is an ongoing panel study representing men and women aged 50 + who reside in private households in England. The study began in 2002 (Wave 1), with responses from 12,099 individuals comprising core members (those representative of the English population aged 50+) and their partners. Every two years, sample participants are interviewed on their health, social, psychological, cognitive, and economic circumstances; in addition, every four years, nurse visits are conducted for the collection of biological samples and anthropometric measurements. The most recent sweep of the study was Wave 9, with data collection spanning June 2018 and July 2019. The sample was also refreshed at Waves 3, 4, 6, 7 and 9, to ensure the sample remains nationally representative (Steptoe et al. 2013).

Sample

The ELSA COVID-19 Substudy, administered between June 3 and July 26, 2020 (Wave 1) and again between November 4 and December 20, 2020 (Wave 2), was also used. The Wave 1 (Wave 2) survey was issued to 9525 (9150) eligible members, with 7040 (6794) interviews completed, achieving a 74% response rate. In both waves, the survey was administered online (83%) or by telephone interview for those who were not able to respond online (17%). As our analysis relied on some key information collected prior to the pandemic, our sample comprised only core members who were also observed in ELSA Wave 9 ($n = 5583$ in COVID-19 Wave 1, $n = 5148$ in COVID-19 Wave 2) (Addario et al. 2020). In addition, participants who reported themselves to be retired, permanently sick or disabled, or looking after their home or family were excluded from our sample, which resulted in a considerable drop in sample size. The final weighted working sample consisted of 1354 interviews in Wave 1 and 1201 interviews in Wave 2 with non-missing information on the key variables (detailed below), with the weights adjusting for non-response in the corresponding COVID-19 Wave, contingent on response in ELSA Wave 9.

Outcome variable

In both waves of COVID-19 Substudy, participants were asked, “Has the age at which you expect to retire from paid work changed as a result of the coronavirus outbreak?”, with response options “Yes, I now plan to retire earlier”, “Yes, I now plan to retire later”, and “No”. Three groups of changes in retirement plans were constructed accordingly.

Key exposures

The focus of this study was on two main areas of exposure during the COVID-19 pandemic: financial insecurity and health. For financial insecurity, participants were asked to rate on a five-point scale, how worried they were, if at all, about their future financial situation. This variable was dichotomised to indicate financial insecurity (i.e., somewhat, very, or extremely worried, vs. not at all or not very worried). They were also asked to rate on a five-point scale, how their current financial situation compared to before the coronavirus outbreak. This variable was collapsed into three categories, namely (a little or much) better off, about the same, and (a little or much) worse off.

As for health, participants were asked to rate on a five-point scale, how they would say their health was in the past month. This variable was dichotomised to indicate poor self-rated general health (i.e., fair or poor, vs. excellent, very good, or good). The measurement of mental health was based on eight items from the Center for Epidemiologic Studies Depression (CES-D) scale, which measured participants’ depressive symptoms in the week prior to interview (Beekman et al. 1997). Participants were categorised as experiencing depressive symptomology if they responded positively to four or more symptoms (Zaninotto et al. 2022).

Covariates

The statistical analysis adjusted for pertinent pre-pandemic covariates taken from information collected in Wave 9. This included gender, age, ethnicity (white vs. otherwise), partnership status (married or cohabiting, vs. otherwise), whether they have dependent children, and whether they live in an urban or rural area. Past health information was also considered, namely whether they reported a limiting long-term illness and depressive symptomology, the latter captured with the same measure used in COVID-19 Waves 1 and 2.

For economic conditions, only pre-pandemic adjustments were available, including participants’ education (degree vs. otherwise), social class (managerial, administrative, and professional occupations; vs. intermediate occupations, small employers, and own account workers; vs. lower supervisory, technical, semi-routine, and routine occupations), neighbourhood deprivation levels (captured using Index of Multiple Deprivation quintiles), experience of financial difficulties (not managing very well financially, or have some or severe financial difficulties; vs. getting by alright financially, or managing quite or very well financially), home ownership status, and wealth levels.

From the COVID-19 Waves, covariates included whether they had private pensions from which they had not yet started receiving or drawing an income, and whether they were working at the time of interview (i.e., currently working; vs. on paid or unpaid leave from employment including furlough, or self-employed but not currently working), as well as whether participants had any experience of COVID-19, including having tested positive for COVID-19 (themselves, a household member, or someone close to them outside their household), stayed in hospital for treatment due to COVID-19 (themselves or a household member) or died from COVID-19 (a household member or someone close to them outside their household).

Analytical strategy

Multinomial logistic specifications of changes in retirement plans (using "no change" as reference) were estimated separately for COVID-19 Waves 1 and 2. In our longitudinal analysis, a random-effect model was estimated to account for unobserved individual heterogeneity (weighted to account for non-response in the COVID-19 waves, contingent on response in ELSA Wave 9), and a likelihood-ratio test informed the use of an independent covariance structure (cf. unstructured covariance). Exponentiated coefficient estimates were interpreted as relative risk ratios (RRRs). To rule out potential selection bias associated with sample exclusion, inverse probability weighting (IPW) was applied to cross-sectional multinomial logistic regressions, in a selectivity analysis. All analyses were conducted using Stata 17.0.

Results

Descriptive statistics

In June/July 2020, among older adults in the labour force (i.e., employed, on paid or unpaid leave from employment, or self-employed and working or not working), around 4.9% were planning to retire earlier due to the pandemic, 8.8% were planning to retire later, with the remainder (86.3%) reporting no change in their expected age at retirement. By November/December 2020, 7.3% were reportedly planning to retire earlier due to the pandemic, and 11.8% were planning to retire later. Characteristics of participants by these changes in retirement plans in June/July and November/December 2020 are shown in Supplementary Tables A1 and A2, respectively.

In general, compared with older adults reporting no change in retirement plans, those planning to retire earlier were less likely to be worried about their future financial situation, whereas those planning to retire later were more likely to be worried about their future financial situation. Those who in June/July 2020 reported a plan to retire later were also more likely to being financially worse off as a consequence of the pandemic. By November/December 2020, those who reported planning to retire earlier were also more likely to be in poor health, whereas those planning to retire later were more likely to have depressive symptomology (Figs. 1 and 2).

Looking at demographic characteristics observed in 2018/19 (ELSA Wave 9), compared with older adults who reported no change in retirement plans due to the pandemic, those reporting in June/July 2020 a plan to retire earlier were more likely to be partnered. In November/December 2020, those reporting a plan to retire earlier were more likely to live in an urban area and to experience depressive symptomology. Little difference in demographic characteristics, such as sex, age, education, and household composition, was observed between those planning to retire later and those reporting no change in plans, across both COVID-19 periods.

As for pre-pandemic economic conditions, older adults reporting in June/July 2020 a plan to retire earlier were wealthier, and more likely to live in a better (i.e., less deprived) neighbourhood, own their own home and have a private pension, compared with those reporting no change in plans. In contrast, older adults planning to retire later were more likely to live in a more deprived neighbourhood. Less of a difference was observed in pre-pandemic economic conditions by retirement plans reported in November/December 2020, except that those planning to retire earlier were, notably, economically better off.

Cross-sectional analysis

Results from the separate multinomial logistic regressions for the COVID-19 waves are presented in Table 1—figures are relative risk ratios (RRRs), or risks in relation to the reference of no change in retirement plans.

Health

After adjusting for covariates, older adults reporting poor health were relatively more likely to plan to retire later over not changing their plans, compared to those reporting better health, but this was only evident when interviewed in

Table 1 Cross-sectional multinomial logistic regressions

Ref: no change	Covid Wave 1 (Jun/Jul 2020)				Covid Wave 2 (Nov/Dec 2020)			
	Retiring earlier		Retiring later		Retiring earlier		Retiring later	
Main exposure								
Poor self-rated health	1.043	(0.491)	1.953*	(0.606)	0.687	(0.302)	0.513	(0.183)
Depressive symptomatology	0.860	(0.363)	1.293	(0.406)	1.386	(0.583)	1.862*	(0.472)
Worried about future financial situation	0.794	(0.273)	2.154**	(0.598)	0.556	(0.200)	2.003**	(0.521)
Controls from 2018/19								
Male	0.811	(0.244)	1.621	(0.404)	0.928	(0.262)	1.452	(0.340)
Age	1.034	(0.028)	1.021	(0.024)	0.987	(0.025)	1.017	(0.026)
Non-white	1.790	(0.955)	1.812	(0.723)	3.982**	(2.064)	1.368	(0.583)
Partnered	2.538*	(0.973)	0.877	(0.245)	1.197	(0.381)	1.041	(0.301)
Have children in benefit unit	0.840	(0.375)	1.431	(0.516)	0.791	(0.341)	1.320	(0.408)
Live in rural area	0.634	(0.230)	0.898	(0.257)	0.451*	(0.164)	1.598	(0.407)
Limiting, long-term illness	0.866	(0.368)	0.604	(0.243)	0.989	(0.410)	0.555	(0.208)
Depressive symptomology	1.124	(0.664)	1.140	(0.497)	0.284	(0.248)	1.960	(0.793)
Degree [NVQ4-5]	0.960	(0.299)	1.578	(0.431)	0.640	(0.208)	1.297	(0.354)
Social class								
Managerial, administrative, professional								
Intermediate	0.992	(0.507)	0.904	(0.367)	0.604	(0.289)	0.672	(0.260)
Routine/manual	0.745	(0.332)	1.079	(0.432)	0.965	(0.403)	1.196	(0.420)
Other/incomplete info	1.256	(0.459)	1.244	(0.453)	0.673	(0.256)	1.114	(0.351)
Index of Multiple Deprivation								
Quintile 1 (least deprived)								
Quintile 2	0.824	(0.295)	1.014	(0.363)	1.132	(0.420)	1.088	(0.332)
Quintile 3	0.296**	(0.135)	1.010	(0.408)	0.699	(0.288)	0.805	(0.272)
Quintile 4	0.524	(0.222)	1.887	(0.736)	0.535	(0.225)	1.081	(0.404)
Quintile 5 (most deprived)	0.424	(0.269)	0.417	(0.219)	0.743	(0.404)	0.748	(0.401)
Financial difficulties	0.859	(0.575)	0.914	(0.358)	0.294	(0.253)	0.511	(0.195)
Own home	2.049*	(0.644)	1.232	(0.349)	1.849*	(0.579)	0.776	(0.204)
Log wealth	0.984	(0.043)	1.011	(0.025)	1.036	(0.071)	0.999	(0.026)
Controls from 2020								
Have private pension	2.263*	(0.718)	1.560	(0.428)	1.366	(0.385)	1.284	(0.315)
Currently working	1.672	(0.835)	0.828	(0.293)	0.280**	(0.120)	1.270	(0.531)
Financial condition due to COVID								
Better off	1.271	(0.476)	1.646	(0.643)	1.504	(0.528)	2.088*	(0.652)
Same (ref.)								
Worse off	2.072*	(0.749)	3.163**	(0.927)	1.731	(0.616)	3.399**	(0.940)
Covid exposure	1.290	(0.423)	1.014	(0.314)	1.143	(0.304)	0.831	(0.205)
N	1354				1201			

Figures are relative-risk ratios. $*p < 0.05$, $**p < 0.01$

June/July 2020 (RRR: 1.953). Hypothesis 1 was rejected. By November/December, older adults reporting depressive symptomology were more likely to plan to retire later over not changing their plans (RRR: 1.862). Hypothesis 2 was rejected.

Financial insecurity

Consistent with the descriptive statistics, regression estimates showed that financial insecurity was significantly predictive of plans to retire later due to the pandemic, even after adjusting for pre-pandemic financial difficulties: the RRR in June/July 2020 was 2.154. Therefore, on average, the relative risk of planning to retire later over not changing retirement plans among those who were worried about their future financial situation, was around twice as high as this relative risk among those who were not worried. This influence was more likely to be directly related to the pandemic rather than general effects. Moreover, this estimated relationship remained significant in November/December 2020, where the RRR was 2.003. Hypothesis 3 cannot be rejected.

Covariates

Notably, in June/July 2020, older adults who were married or cohabiting, lived in a less deprived neighbourhood, owned their home and had private pension, were relatively more likely to report planning to retire earlier over not changing their retirement plans, compared with their respective counterparts. In contrast, by November/December 2020, predictive characteristics were identifying as non-white, living in an urban area, owning their own home and not working at the time of interview (i.e., paid/unpaid leave from employment, or self-employed but not currently working). No significant association was found between social class and changes in retirement plans, possibly due to the inclusion of home ownership and individual wealth which captured lifetime accumulated wealth. Across both COVID-19 Waves, older adults with depressive symptomology in 2018/19 were more likely to report planning to retire later over not changing plans, than those who did not experience these symptoms previously. Experience of COVID-19 was not predictive of changes in retirement plans at either COVID-19 Wave.

Results from a selectivity analysis applying inverse probability weighting to these cross-sectional multinomial logistic regressions were consistent, with similar magnitudes (see Supplementary Table A3).

Interaction effects of health and financial insecurity

Given the significant roles of the exposure variables, particularly for the relative risk of planning to retire later over not changing retirement plans (hereafter simply referred to as 'relative risk' in the rest of this subsection), Table 2 provides further estimations from interacting financial insecurity with each of the other exposures of interest, while still controlling for all other covariates as in Table 1.

After including the (nonsignificant, positive) interaction term between financial insecurity and depressive symptomology, both their main effects were no longer predictive of this relative risk, across both time points. This was also partly the case for self-rated health: in June/July 2020, both the main effects of financial insecurity and health were no longer significant after the inclusion of their interaction term which was, in turn, strongly predictive of a higher relative

Table 2 Multinomial logistic regressions with interactions

Ref: no change	Covid Wave 1 (Jun/Jul 2020)								Covid Wave 2 (Nov/Dec 2020)							
	Retiring earlier				Retiring later				Retiring earlier				Retiring later			
(A) Self-rated health																
Financial insecurity	0.794	(0.273)	0.744	(0.271)	2.154**	(0.598)	1.633	(0.527)	0.556	(0.200)	0.547	(0.213)	2.003**	(0.521)	2.030**	(0.529)
Poor health	1.043	(0.491)	0.846	(0.478)	1.953*	(0.606)	0.433	(0.273)	0.687	(0.302)	0.662	(0.334)	0.513	(0.183)	0.567	(0.363)
Interaction[a]			1.566	(1.388)			6.898**	(4.701)			1.103	(0.947)			0.876	(0.633)
(B) Depressive symp.																
Financial insecurity	0.794	(0.273)	0.928	(0.344)	2.154**	(0.598)	1.846*	(0.566)	0.556	(0.200)	0.604	(0.256)	2.003**	(0.521)	1.760	(0.511)
Depressive symp.	0.860	(0.363)	1.231	(0.635)	1.293	(0.406)	0.603	(0.452)	1.386	(0.583)	1.521	(0.692)	1.862*	(0.472)	1.349	(0.643)
Interaction[b]			0.404	(0.348)			2.721	(2.478)			0.781	(0.558)			1.608	(0.916)

All panels represent different regressions. Each regression includes the same set of controls and modifiers as in Table 1. $*p<0.05$, $**p<0.01$

[a] Interaction term between financial insecurity and poor health.

[b] Interaction term between financial insecurity and depressive symptomatology

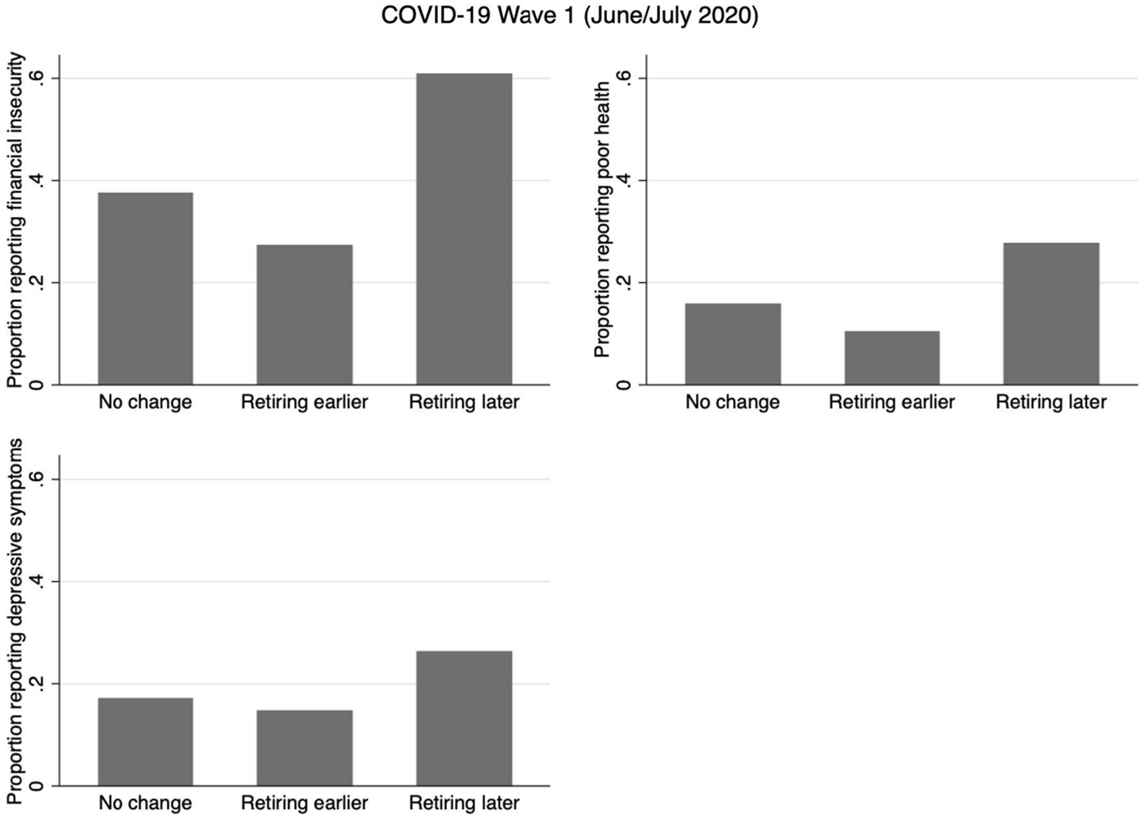

Fig. 1 Prevalence of financial insecurity, poor health, and depressive symptomology, by changes in retirement plans, in COVID-19 Wave 1

risk. The RRR estimate of 6.898 suggests that the relative risk was higher by nearly seven times among those experiencing both financial insecurity and poor self-rated health, than among those experiencing neither. By November/December, this interaction term was no longer significant, and the main effect of financial insecurity remained significant. Results were consistent when inverse probability weighting was applied, reported in Supplementary Table A4.

Longitudinal analysis

Table 3 provides results from estimating the multinomial logit regression in a panel setup for the two COVID-19 waves, thereby accounting for unobserved heterogeneity at the individual level. Results from a likelihood-ratio test validated the assumption of zero covariance.

Consistent with the cross-sectional estimates at both time points in Table 1, neither health nor financial insecurity were significantly predictive of the relative risk of planning to retire earlier over not changing retirement plans. Significant relationships were observed between financial insecurity and the relative risk of planning to retire later over not changing retirement plans (RRR: 3.315). However, self-rated health was no longer predictive of this relative risk.

Consistent with Table 1, the demographic and economic covariates captured from 2018/19 (ELSA Wave 9) played a larger role for the relative risk of planning to retire earlier over not changing retirement plans, than for the relative risk of planning to retire later. Identifying as non-white, living in an urban area, having no past depressive symptomology, living in a less deprived area, having their own home, having private pension, and not currently working, were predictive of a higher relative risk of planning to retire earlier over not changing retirement plans. On the other hand, only having past depressive symptomology predicted a higher relative risk of planning to retire later.

In the interaction analysis between financial insecurity with each of the other exposures of interest (Supplementary Table A5), very little impact of the interaction terms was observed; instead, persistent and strong main effects of financial insecurity due to COVID-19 were found on the relative risk of planning to retire later over not changing retirement plans.

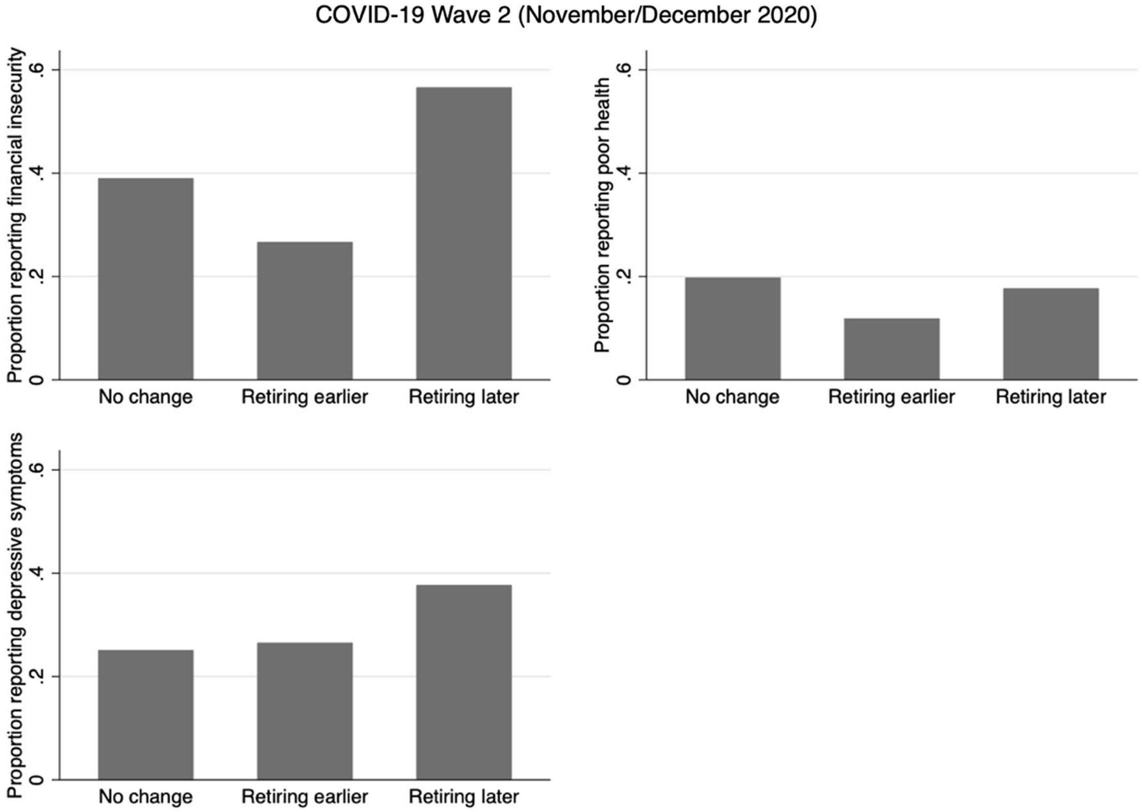

Fig. 2 Prevalence of financial insecurity, poor health, and depressive symptomology, by changes in retirement plans, in COVID-19 Wave 2

Discussion

The aim of this article was to examine how health factors and financial insecurity affected older adults' retirement plans during the COVID-19 pandemic in the UK. It was found that poor self-rated health was related to a higher risk of postponing retirement (relative to not changing retirement plans) when interviewed in June/July 2020, but a lower risk of postponing retirement, when interviewed later in November/December 2020. A positive association between depressive symptomology and risk of postponing retirement was only pronounced in November/December 2020. Financial insecurity was associated with a higher risk of postponing retirement at both timepoints. However, plans of retiring earlier were not affected by these health factors or financial insecurity. These findings can be broadly generalised among English adults aged 50 and older in the context of the COVID-19 pandemic.

In the first months of the pandemic, people with poor self-rated health had a stronger intention of postponing retirement than people reporting good or fair health. Despite having poor health, people would not leave their jobs during the pandemic, which was different from previous findings (e.g., Von Bonsdorff et al. 2010; Gørtz 2012; Scharn et al. 2018). It might be because people with poor health tend to be more risk averse (Decker and Schmitz 2016; Courbage et al. 2018). Faced with some negative socio-economic consequences of the pandemic, such as high unemployment rate and fewer vacancies (Mayhew & Anand 2020; Arthur 2021), they may have been more likely to postpone their retirement, to stay in the labour market to make a living. In the present study, older adults in poor health were more risk averse regarding financial circumstances than those in good health (score of 3.1 vs. 3.7, on a scale from 0 'avoid taking risks' to 10 'fully prepared to take risks', when observed in 2016/17). This explanation is also supported by the results of the interaction analysis showing that among older adults who were financially secure, those reporting poor health did not tend to change their retirement plans.

Another possible explanation is that self-rated healthier adults were trying to devote more time to leisure activities and to be with their families, rather than to work, after experiencing the outbreak of the pandemic and the first national lockdown in the UK, with the expectation that the pandemic was a short-lived event. In contrast, by November/December 2020, people may have realised that the pandemic would last longer than expected, and started to adapt to a 'new normal' (Corpuz 2021), so changes in retirement plans of healthier adults were not pronounced. However, poor self-rated health

Table 3 Panel multinomial logistic regressions

Ref: no change	Random effects with zero covariance			
	Retiring earlier		Retiring later	
Main exposure				
Poor self-rated health	0.634	(0.277)	0.972	(0.421)
Depressive symptomology	1.110	(0.393)	1.657	(0.581)
Worried about future financial situation	0.622	(0.217)	3.315**	(1.127)
Controls from 2018/19				
Male	0.749	(0.232)	1.850	(0.594)
Age	1.015	(0.029)	1.019	(0.035)
Non-white	4.373*	(2.681)	1.670	(1.012)
Partnered	1.984	(0.753)	0.933	(0.357)
Have children in benefit unit	0.781	(0.377)	1.365	(0.614)
Live in rural area	0.387*	(0.154)	1.530	(0.568)
Limiting, long-term illness	1.150	(0.476)	0.441	(0.237)
Depressive symptomology	0.326	(0.226)	2.342	(1.423)
Degree [NVQ4-5]	0.618	(0.217)	1.645	(0.628)
Social class				
Managerial, administrative, profsessional				
Intermediate	0.578	(0.322)	0.906	(0.505)
Routine/manual	0.806	(0.370)	1.434	(0.666)
Other/incomplete info	0.757	(0.300)	1.561	(0.668)
Index of Multiple Deprivation				
Quintile 1 (least deprived)				
Quintile 2	0.939	(0.385)	1.205	(0.509)
Quintile 3	0.374*	(0.174)	0.907	(0.426)
Quintile 4	0.390*	(0.185)	1.519	(0.767)
Quintile 5 (most deprived)	0.443	(0.250)	0.417	(0.287)
Financial difficulties	0.447	(0.297)	0.497	(0.267)
Own home	2.316*	(0.793)	0.822	(0.287)
Log wealth	1.000	(0.000)	1.000	(0.000)
Controls from 2020				
Have private pension	2.148*	(0.719)	1.744	(0.583)
Currently working	0.427	(0.200)	1.258	(0.641)
Modifiers				
Financial condition due to COVID				
Better off	1.257	(0.482)	1.687	(0.671)
Same (ref.)				
Worse off	1.764	(0.642)	4.011**	(1.206)
Covid exposure	1.108	(0.348)	0.980	(0.336)
var(u1)	115.753** (207.922)			
var(u2)	972.068** (2588.136)			
Wave dummy included	Yes			
N	1319			

Figures are relative-risk ratios. $*p < 0.05$, $**p < 0.01$

was associated with a lower possibility of delaying retirement, consistent with the literature that poor health pushes people out of their jobs (Mein et al. 2000; Homaie Rad et al. 2017).

The impact of mental health on retirement plans was only pronounced in November/December 2020, in line with the finding of greater depression among ELSA participants in November/December than in June/July 2020 (Zaninotto et al. 2022). Elevated depressive symptomatology almost doubled the risk of postponing retirement (relative to not changing retirement plans). This is plausible, since people with fewer depressive symptoms are more likely to be optimistic

(Conversano et al. 2010; Galatzer-Levy and Bonanno 2014; Hobbs et al. 2022). They are also more confident about the future (Carver et al. 2010), including potentially expecting an eventual upturn of their financial situation or having a stronger belief in their financial capabilities. In the present study, older adults with fewer depressive symptoms were more likely than those with depression symptomatology to 'feel hopeful' (71% vs. 49%, measured in 2010/11), to regard ageing as a positive experience (68% vs. 49%, measured in 2016/17), to report that they would change almost nothing if they could live their life again (61% vs. 36%, measured in 2018/19), to feel that life is full of opportunities (49% vs. 26%, measured in 2018/19), and to feel that the future looks good for them (54% vs. 24%, measured in 2018/19).

Compared with older adults who were not worried about their future financial situation, those reporting financial insecurity were more likely to plan to retire later at both timepoints, in line with the literature (Mein et al. 2000; Oksanen and Virtanen 2012; Van Droogenboeck and Spruyt 2014). Consistent results were found in the longitudinal multinomial logistic analysis. Put together, these findings suggest that financial insecurity was a stable and persistent predictor of changes in retirement plans during the pandemic. Our interaction analysis also showed an additional influence of financial insecurity on the risk of postponing retirement among adults with poor self-rated health, compared with those with good health. It might be because the receipt of disability benefits increased the likelihood of earlier retirement plans (Börsch-Supan et al. 2009; Autor et al. 2016). In the present study, among older adults who reported poor health, 11.6% of those who were financially insecure were receiving disability benefits, which is a smaller proportion than those reporting to be financially secure (13.9%). In contrast, among those reporting good health, 4.9% of those experiencing financial insecurity were receiving disability benefits, which is more than those reporting to be financially secure (3%).

Our findings should nonetheless be interpreted in the light of several limitations. First, due to the restricted observation period, the estimates of this study reveal changes in retirement plans among English older adults after experiencing the first national lockdown over March-July 2020 and the second national lockdown over November–December 2020 in England, rather than after experiencing the entire COVID-19 pandemic over 2020–2022. Second, even though self-rated health is typically used in the literature as a proxy for health, this subjective health measure may be endogenous and biased (Oksanen and Virtanen 2012). Third, older adults' actual retirement behaviour was not observed, and the findings were limited to self-reported changes in retirement plans. Finally, further research is needed to investigate differences in the impact of health factors and financial insecurity on older adults' changes in retirement plans, such as occupational differences.

In conclusion, this study highlights the critical role of financial insecurity on older adults' retirement decisions, even when facing a crisis that impacts multiple dimensions of their lives. Poor health and depressive symptomology played different roles in the two periods observed, which could be an artefact of the fluctuating nature of the crisis—one period was towards the end of the first national lockdown, whereas the other included not only the beginning of the second national lockdown but also some of the earliest days of the vaccine rollout—suggesting a more contextual role of health in retirement planning. Importantly, these findings may aid in informing decisions on budgets, risk management, and caring for the health of older workers, among government, private pension providers, and firms with an older workforce.

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Author contributions C.K.: Conceptualization, Data curation, Formal analysis, Visualization, Writing-original draft. J.Z.: Conceptualization, Investigation, Methodology, Writing-original draft. P.Z.: Conceptualization, Writing-review & editing. A.S.: Conceptualization, Writing-review & editing, Supervision.

Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Changes in physical performance according to job demands across three cohorts of older workers in the Longitudinal Aging Study Amsterdam

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Abstract

This study set out to evaluate the association between job demands at baseline and physical performance over a six-year period across three cohorts of older Dutch workers examined 10 years apart. Data were drawn from three cohorts (1992–1999, 2002–2009 and 2012–2019) of the Longitudinal Aging Study Amsterdam. Individuals aged 55–65 years from each cohort who worked for pay were included (n = 274, n = 416, n = 618, respectively). Physical performance was measured using gait speed and chair stand performance. A population-based job exposure matrix was used to indicate levels of exposure probability of physical (use of force and repetitive movements) and psychosocial (cognitive demands and time pressure) job demands. We found that psychosocial job demands increased and physical demands decreased across the three cohorts. No between cohort differences were found for how job demands affected changes in physical performance over follow-up. For men, faster decline in gait speed was observed when comparing higher and lower use of force at baseline (β −0.012, 95% CI −0.021, −0.004). Greater use of force and repetitive movements were associated with faster decline in chair stand performance (β −0.012, 95% CI −0.020, −0.004 and β −0.009, 95% CI −0.017, −0.001, respectively). In women, no association of job demands on change in physical performance was observed. The study concluded that higher physical job demands were associated with stronger decline in physical performance across six years for men in all cohorts, while no associations were found among women.

Keywords Physical job demands · Psychosocial job demands · Physical performance · Cohort study · Ageing

Introduction

Population ageing increases the need for information of factors that influence the patterns of health and functioning in the older population (Christensen et al. 2009). Work is a major part of adulthood as both men and women spend a considerable proportion of their time at the workplace. Working conditions play an important role in health and functioning in older age (Wahrendorf et al. 2012; Nilsen et al. 2017). During the past decades, physical demands of work have decreased during the previous decades while psychological demands of work have increased, and work participation of older employees and women have increased (Eurofound 2006; Ng and Popkin 2012). Little is known about the potential influence of this shift of working conditions on health, functioning and performance and particularly on changes in these outcomes in recent cohorts of older workers.

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Physical performance is an indicator of the ability of a person to function in everyday life and a good predictor of later health outcomes such as disability, increased need of healthcare services and premature mortality (Guralnik et al. 1995; von Bonsdorff et al. 2006; Cooper et al. 2010). Earlier studies have shown that change in physical performance across time is heterogeneous among older individuals (White et al. 2013; Hoekstra et al. 2020). This heterogeneity necessitates the assessment of a variety of factors including job exposures that may be related to change in physical performance across time.

Higher physical job demands, such as lifting, kneeling, and repetitive movements, have been linked with poor self-reported health and physical functioning in several cohort studies (Hinrichs et al. 2014; Platts et al. 2017; Møller et al. 2019). A few studies have reported on the association between physical job demands and objectively measured physical performance of which the findings have been inconsistent. A Danish cohort study showed a negative association between physical job demands and chair stand performance among middle-aged men but not women (Møller et al. 2015). A Swedish study showed that higher physical job demands were associated with poorer measures of isometric strength, physical fitness and dynamic endurance among women (Torgén et al. 1999). A Dutch study found no association between physical job demands and chair stand performance in analyses pooled by gender (van der Noordt et al. 2019).

Higher psychological job demands have been shown to be associated with poorer self-reported physical functioning in adulthood (Cheng et al. 2000; von Bonsdorff et al. 2014; Hansen et al. 2014; Stansfeld et al. 1998) and in older age (Wahrendorf et al. 2012). So far, only few studies have explicitly investigated psychosocial job demands and objectively measured physical performance in older employees showing no associations in analyses pooled by gender (van der Noordt et al. 2019) or stratified by gender (Nilsen et al. 2019).

The objective of this study was to evaluate whether associations between physical and psychological job demands at baseline and physical performance over a six-year period differed across three cohorts of older Dutch workers. We expect that the increase in work participation leads to a change in susceptibility to the effect of working conditions, as the ageing peers of people who exited from the workforce in earlier cohorts, in more recent cohorts continue working. In addition, the improvements in work conditions due to advances in occupational health and safety measures (Turek et al. 2020) may play a role in this development. For our study, we used unique data consisting of three measurement points in three cohorts that were assessed ten years apart.

Methods

Data

This study uses data from the population-based Longitudinal Aging Study Amsterdam (LASA), an ongoing study of changes in functioning of older adults aged 55 and above in the Netherlands, with follow-ups every three years. The sampling, data collection procedures and non-response have been described in detail earlier in the latest cohort profile update (Hoogendijk et al. 2020). Briefly, cohort 1 in 1992–1993 included 3107 older persons aged between 55 and 85 years, of which 966 were aged 55–65 years (response rate 62%). Cohort 2, started in 2002–2003, included 1002 (response rate 62%) and cohort 3, started in 2012–2013, included 1023 people aged 55–64 years (response rate 63%.

Study sample

Individuals aged 55 to 65 in paid work ≥ 1 h per week at baseline were included (van der Noordt et al. 2019; Boot et al. 2014). This sample consisted of 1308 occupationally active respondents at baseline (cohort 1: $n = 274$; cohort 2: $n = 416$; cohort 3: $n = 618$). Due to item-non-response at baseline, the sample in this paper included 1093 participants (see Supplementary Table S1). The item-non-responders ($n = 215$) were not significantly different in terms of age, gender and educational level (all p-values > 0.247). We included three measurement waves for all cohorts. All together 333 participants dropped out at wave 2 or 3, but they did not differ according to age, gender, and educational level (all p-values > 0.18) from the ones who participated in all three waves ($n = 975$). 1093 participants were included in the study sample and drop-out was accounted for in the analyses. Follow-up consisted of 1497, 2324 and 3107 person-years for Cohorts 1, 2 and 3, respectively. The Medical Ethics Committee of the VU University Medical Center approved the LASA study; informed consent was obtained from all respondents.

Measures

Physical performance

Two standardized tests on physical performance, timed measurements of gait speed and chair stand, were used as outcome measures across three time points for each cohort. Timed Chair Stand Test involved standing up without the use of arms five times at usual pace. Chair stand speed was defined as the number of chair rises per second. The chair stand test measures leg strength and has been shown to be a valid and reliable measure of functional mobility in a sample of older women (Goldberg et al. 2012). In the gait speed test, participants were asked to walk 3 m, turn around and walk back 3 m as quickly as possible without running. Time needed to complete the test was recorded to the nearest second using a stopwatch and the result was expressed as meters per second, with faster speed reflecting better performance. The gait speed test is a measure of functional status and overall health and has been found to be valid and reliable in diverse populations (Middleton et al. 2015).

Job demands

Job demands of the current job at baseline were derived from a general population job exposure matrix (GPJEM) for representative samples of 55- to 65-year-old workers (Rijs et al. 2014). This GPJEM indicates levels of exposure probability of physical and psychosocial job demands as the percentages low, intermediate, and high exposure within a job category. It has successfully been used in previous studies to determine work exposures and predict health effects (de Wind et al. 2020; Rijs et al. 2014). Physical job demands included the necessity to use force during work (i.e., use of a lot of force, such as in lifting, pushing, pulling or carrying or using force with work tools) and performing repetitive movements. Physical job demands were dichotomized into high (highest third) and low (two lowest thirds). Psychosocial job demands involved time pressure (i.e., working at high pace and working under high time pressure) and cognitive demands (e.g. intensive thinking, need to keep focused and requiring much concentration) (Rijs et al. 2014). Psychosocial job demands were dichotomized into high (highest third) and low (two lowest thirds) (Kulmala et al. 2014).

Covariates

We adjusted the analyses for age, socioeconomical status, body mass index and lifestyle factors as it has been shown in several studies that work demands and health behaviours each have independent, unique effects (Andersen et al. 2016; Lund and Csonka 2003; Schram et al. 2021). Sex and date of birth were obtained from municipal registries. Educational level was categorized into low (elementary education at most), middle (lower vocational and general intermediate education, Intermediate vocational education and general secondary education) and high (higher vocational education, college education and university). Body mass index (BMI) was calculated using the participant's measured height and weight. The number of alcohol consumption per week was categorized into none, moderate (men 1–3 and women 1–2 glasses/day) and high use (men at least 4 and women at least 3 glasses/day). Smoking status was categorized into never, former and current smoker. Physical activity was measured using the LASA Physical Activity Questionnaire, which covered frequency and duration of activities including walking outdoors, light household activities, heavy household activities and two most frequently performed sports performed in the past two weeks (Stel et al. 2004; Ainsworth et al. 2011) and defined as total metabolic equivalent of task (MET) based on hours/week spent on each activity. For work status, respondents were asked at each follow-up if they had a paid job at present, which included one or more hours of work per week. Thus, temporary unemployment or exit from the workforce during the follow-up period was accounted for.

Statistical analyses

Descriptive analyses were performed to examine main characteristics of participants by cohort at baseline. For continuous variables mean and standard deviation were calculated for each cohort. Also, the differences between first and third cohort group means were tested with t-test. Categorical variables were described with absolute and relative frequencies by cohort. Cohort differences were tested with Pearson's Chi-squared test.

To compare the differences between cohorts in change in gait speed and chair stands, linear mixed models were used. As study participants were measured multiple times, an individual-specific random intercept was added to models to take into account the correlation between observations. A linear mixed model approach was taken as it utilizes all the available data in parameter estimation. Physical performance variables were log-transformed because while examining the diagnostic plots with the untransformed outcome variables, the use of log-transformed variables provided better model fit (see Supplementary Fig. S1A-D). Estimation was performed with the REML (Restricted Maximum Likelihood) method to reduce bias in the standard errors of regression coefficients (Fitzmaurice et al. 2012), except when comparing models with a varying fixed effect part in which case models were estimated with the ML (Maximum Likelihood) method. Years since baseline as a continuous variable was used as the time variable. As the main interest of the study was in cohort differences in change in physical performance over time, the interaction term of time and cohort was included in all models. Separate models were fitted for men and women as there are gender differences both in the nature of the work careers (Nilsen et al. 2017) and in physical performance in older age (Wheaton and Crimmins 2016). First, the crude models including cohort, time and their interaction without covariates were fitted. Secondly, in model 2, we adjusted for baseline age and education, and finally in model 3 also for BMI, alcohol use, smoking and weekly total physical activity. Additionally, work status was added to the second and third model as a time-variant variable. Continuous variables were centred at their sample means. Finally, separate models for each psychosocial and physical job demand variable were fitted. The demand variables were added to the adjusted models including their two-way interactions with time and cohort. Also, three-way interactions between job demand, time and cohort were tested using F-tests and added to the models when significant. A sensitivity analysis was performed using only participants who at baseline worked 10 or more hours/week (N = 869). The significance level used was 0.05 at all steps. All analyses were conducted with R Software (R Core Team 2018) using packages lme4 (Bates et al. 2015) and lmerTest (Kuznetsova et al. 2017).

Results

Characteristics of the participants at each cohort's baseline are presented in Table 1. Psychosocial job demands increased for both women and men whereas physical job demands decreased across the cohorts. Baseline gait speed increased from cohort 1 to cohort 3 (0.99 m/s, SD 0.25 to 1.06 m/s, SD 0.23 for women and 0.99 m/s, SD 0.26 to 1.09 m/s, SD 0.23 for men, respectively). Conversely, chair stand performance decreased for both women and men. The correlation between gait speed and chair stand performance was 0.36 (women) and 0.33 (men) in the cohorts combined.

Cohort differences in physical performance

Cohort differences at baseline and across the 6-year follow-up for gait speed (m/s) and chair stand (times/s) are presented in Table 2. Women in cohort 3 had 8.1% ($p = 0.003$) and men in cohorts 2 and 3 had respectively 4.8% ($p = 0.047$) and 8.3% ($p < 0.001$) faster *gait speed* at baseline compared to women and men in cohort 1. After adjustments, the associations attenuated and were non-significant, however, for women in cohort 3 the association was borderline significant (5.7% faster gait speed, $p = 0.051$ compared to cohort 1). During the follow-up, gait speed of women in the first cohort decreased by 1.1% annually, but adjustments attenuated this decrease. Among women, the rate of change in gait speed in cohort 2 was more positive by an average of 1.3 percentage point (pp) annually compared to cohort 1 ($p = 0.047$) and attenuated after adjustments only slightly ($p = 0.051$).

Regarding *chair stand performance*, both women (9.7%, $p = 0.001$) and men (14.8%, $p < 0.001$) in cohort 3 performed worse at baseline compared to cohort 1 (Table 2). This association remained statistically significant after adjustments, 10.1% ($p = 0.001$) and 16.5% ($p < 0.001$) for women and men respectively. During the follow-up, the ability to perform chair stands in the first cohort decreased by 1.0% ($p = 0.040$) in women and 1.4% ($p < 0.001$) in men annually. After adjustments, this remained statistically significant only in men (1.1%, $p = 0.013$). Among men, after adjustments, in cohort 3 chair stand performance decreased less by an average of about 1.2 pp annually compared to cohort 1 ($p = 0.016$). There were no such associations found among women.

Differences in physical performance according to job demands

No between cohort differences were found in women or men in the associations between baseline physical or psychosocial job demands and 6-year follow-up of physical performance across the three cohorts assessed 10 years apart (Supplementary Table S2). The associations between job demands at baseline and change in physical performance are presented in Table 3. For men, the interaction between time and use of force in the fully adjusted model suggested a 1.2 pp faster decline in gait speed when comparing higher and lower use of force keeping other variables fixed ($p = 0.005$) (Fig. 1B). Greater use of force (Fig. 1D) and repetitive movements were associated with a 1.2 pp ($p = 0.002$) and 0.9 pp ($p = 0.021$) faster decline in chair stand performance, respectively. For women, regardless of the cohort, no interactions between time and job demands in gait speed or chair stand test were observed (as presented for use of force in Fig. 1A and C).

The sensitivity analyses, conducted for the participants who worked at least 10 h per week, resulted in associations in line with those that included participants who reported working at least 1 h per week, see Supplementary Tables S3–S5.

Discussion

To the best of our knowledge, this is the first study to investigate cohort differences in the association between physical and psychological job demands and change in physical performance among older employees. To do so, we compared three independent population-based samples of workers aged 55 to 65 with baseline data on job demands in 1992–1993, 2002–2003 and 2012–2013, respectively and physical performance over a six-year period. No between cohort differences for men and women were found for the association between job demands and changes in physical performance across the cohorts. Higher physical job demands affected the six-year rate of change in physical performance negatively among men but not women. Such associations were not observed for psychosocial job demands and physical performance after controlling for confounders. Furthermore, we found that the most recent cohort had faster gait speed at baseline, but slower chair stand speed compared to their counterparts

Table 1 Cohort differences at respective baselines for LASA cohorts measured in 1992–93 (Cohort 1), 2002–03 (Cohort 2) and 2012–13 (Cohort 3)

Women	Cohort 1	Cohort 2	Cohort 3	p
	n = 86	n = 139	n = 232	
Age, mean (standard deviation [SD])	59.2 (2.6)	58.5 (2.6)	59.2 (2.7)	0.998
Body mass index, mean (SD)	26.8 (3.8)	26.9 (4.6)	26.2 (4.6)	0.252
Working hours per week, mean (SD)	19.0 (16.0)	22.5 (14.9)	22.8 (11.0)	**0.044**
Total physical activity, MET hrs/week, mean (SD)	90.3 (47.9)	68.7 (43.2)	71.4 (47.2)	**0.002**
Alcohol use, n (%)				0.270
None	8 (9.3)	13 (9.4)	25 (10.8)	
Moderate	62 (72.1)	85 (61.2)	159 (68.5)	
High	16 (18.6)	41 (29.5)	48 (20.7)	
Smoking, n (%)				**<0.001**
Never	22 (25.6)	40 (28.8)	32 (13.8)	
Former	31 (36.0)	63 (45.3)	134 (57.8)	
Current	33 (38.4)	36 (25.9)	66 (28.4)	
Educational level, n (%)				**<0.001**
Low	28 (32.6)	20 (14.4)	15 (6.5)	
Moderate	42 (48.8)	89 (64.0)	142 (61.2)	
High	16 (18.6)	30 (21.6)	75 (32.3)	
Psychosocial job demands, n (%)				
Cognitive demands, high	16 (18.6)	40 (28.8)	82 (35.3)	**0.014**
Time pressure, high	18 (20.9)	42 (30.2)	96 (41.4)	**0.001**
Physical job demands, n (%)				
Use of force high	46 (53.5)	58 (41.7)	81 (34.9)	**0.010**
Repetitive moves high	64 (74.4)	97 (69.8)	122 (52.6)	**<0.001**
Gait speed, m/s, mean (SD)	0.99 (0.27)	0.98 (0.21)	1.08 (0.21)	**0.006**
Chair stand rise, times/s, mean (SD)	0.49 (0.11)	0.48 (0.12)	0.45 (0.10)	**0.001**
Men	n = 135	n = 219	n = 282	P
Age, mean (SD)	59.0 (2.8)	58.7 (2.6)	59.6 (2.6)	**0.030**
BMI, mean (SD)	26.1 (2.6)	27.3 (3.3)	27.4 (3.8)	**<0.001**
Working hours per week, mean (SD)	41.2 (15.8)	35.3 (15.8)	37.0 (13.2)	**0.007**
Total physical activity, MET hours/week	49.6 (41.1)	51.5 (44.4)	49.9 (40.5)	0.935
Alcohol use, n (%)				0.056
None	9 (6.7)	5 (2.3)	21 (7.4)	
Moderate	109 (80.7)	178 (81.3)	230 (81.6)	
High	17 (12.6)	36 (16.4)	31 (11.0)	
Smoking, n (%)				**<0.001**
Never	55 (40.7)	74 (33.8)	53 (18.8)	
Former	66 (48.9)	108 (49.3)	161 (57.1)	
Current	14 (10.4)	37 (16.9)	68 (24.1)	
Educational level, n (%)				**<0.001**
Low	16 (11.9)	33 (15.1)	16 (5.7)	
Moderate	90 (66.7)	104 (47.5)	149 (52.8)	
High	29 (21.5)	82 (37.4)	117 (41.5)	
Psychosocial job demands, n (%)				
Cognitive demands, high	36 (26.7)	76 (34.7)	144 (51.1)	**<0.001**
Time pressure, high	40 (29.6)	83 (37.9)	155 (55.0)	**<0.001**
Physical job demands, n (%)				
Use of force, high	63 (46.7)	105 (47.9)	109 (38.7)	0.082
Repetitive moves, high	93 (68.9)	131 (59.8)	123 (43.6)	**<0.001**
Gait speed, m/s, mean (SD)	1.02 (0.23)	1.06 (0.29)	1.09 (0.23)	**0.002**
Chair stand rise, times/s, mean (SD)	0.52 (0.13)	0.48 (0.13)	0.44 (0.10)	**<0.001**

Values in bold are statistically significant at alpha = 0.05

MET = metabolic equivalent of task based on hours/week spent on each activity, BMI = body mass index measured two decades earlier. As we are dealing with samples of workers, we might look for an explanation in terms of work exposures. Gait speed has been shown to be a good indicator of vitality (Studenski et al. 2011 JAMA). The increase in gait speed may then be explained by the lower prevalence of high physical work demands which may lead to better health in older workers. In contrast, the prevalence of sedentary jobs has increased, which may have led to a worse lower-body strength as indicated by the chair stands test.

Note, that the association for gait speed attenuated somewhat after accounting for confounders.

Against our expectations, we observed no cohort differences over the past 20 years in the association between physical work demands and change in physical performance. This suggests that the negative effect of work demands has not changed. Regarding physical job demands, we found that work that required higher use of force and/or included repetitive movements was associated with faster decline in gait speed and in chair stand performance in men. Albeit the research evidence on the association between physical job demands and objectively measured physical performance have been inconsistent (Torgén et al. 1999; van der Noordt et al. 2019), our findings support the study by Møller et al., which reported a negative association between physical job demands and chair stand performance among middle-aged men but not women (Møller et al. 2015). These findings may be explained by greater wear and tear of the body as a consequence of exposure to physical job demands. Performing the chair stand test requires adequate muscle power in the lower extremities, which is known to decrease with older age (Larsson et al. 1979). Thus, faster decline in the chair

Table 2 Differences for gait speed (m/s) and chair stand rise (times/s) at baseline and across 6-year follow-ups in three LASA cohorts measured in 1992–93 (cohort 1, ref.), 2002–03 (cohort 2) and 2012–13 (cohort 3)

	Women			Men		
	Model 1[a]	Model 2[b]	Model 3[c]	Model 1[a]	Model 2[b]	Model 3[c]
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Gait speed (m/s)						
Constant	−0.040 (−0.085, 0.005)	−0.112 (−0.175, −0.048)	−0.229 (−0.316, −0.141)	−0.022 (−0.059, 0.015)	−0.160 (−0.220, −0.100)	−0.212 (−0.297, −0.126)
Cohort 2	0.001 (−0.057, 0.059)	−0.019 (−0.077, 0.039)	−0.012 (−0.072, 0.048)	**0.048 (0.001, 0.096)**	0.039 (−0.008, 0.086)	0.011 (−0.039, 0.060)
Cohort 3	**0.081 (0.028, 0.133)**	**0.055 (0.001, 0.108)**	0.057 (0.000, 0.113)	**0.083 (0.037, 0.128)**	**0.072 (0.027, 0.117)**	0.045 (−0.003, 0.093)
Time	**−0.011 (−0.020, −0.001)**	−0.010 (−0.020, 0.000)	−0.011 (−0.022, 0.001)	−0.006 (−0.014, 0.002)	−0.001 (−0.010, 0.008)	−0.005 (−0.014, 0.005)
Cohort 2*time	**0.013 (0.000, 0.025)**	**0.013 (0.000, 0.025)**	0.013 (−0.000, 0.026)	0.003 (−0.008, 0.013)	0.001 (−0.009, 0.011)	0.005 (−0.006, 0.016)
Cohort 3*time	−0.001 (−0.012, 0.011)	−0.001 (−0.012, 0.011)	−0.001 (−0.013, 0.011)	−0.007 (−0.017, 0.003)	−0.010 (−0.020, 0.001)	−0.006 (−0.017, 0.005)
Chair stand rise (times/s)						
Constant	−0.730 (−0.777, −0.682)	−0.773 (−0.840, −0.706)	−0.899 (−0.994, −0.805)	−0.711 (−0.750, −0.672)	−0.753 (−0.818, −0.687)	−0.802 (−0.894, −0.710)
Cohort 2	−0.035 (−0.095, 0.026)	−0.047 (−0.108, 0.014)	−0.033 (−0.096, 0.030)	−0.036 (−0.086, 0.015)	−0.041 (−0.092, 0.009)	**−0.068 (−0.120, −0.017)**
Cohort 3	**−0.097 (−0.153, −0.042)**	**−0.110 (−0.167, −0.053)**	**−0.101 (−0.161, −0.041)**	**−0.148 (−0.196, −0.100)**	**−0.155 (−0.204, −0.107)**	**−0.165 (−0.215, −0.115)**
Time	**−0.010 (−0.019, −0.000)**	−0.009 (−0.019, 0.001)	−0.010 (−0.021, 0.001)	**−0.014 (−0.022, −0.006)**	**−0.012 (−0.021, −0.003)**	**−0.011 (−0.020, −0.002)**
Cohort2*time	0.008 (−0.004, 0.020)	0.008 (−0.004, 0.020)	0.009 (−0.003, 0.022)	0.009 (−0.001, 0.019)	0.009 (−0.002, 0.019)	0.007 (−0.003, 0.017)
Cohort 3*time	0.010 (−0.001, 0.021)	0.010 (−0.002, 0.021)	0.011 (−0.002, 0.023)	**0.016 (0.006, 0.026)**	**0.015 (0.005, 0.025)**	**0.012 (0.002, 0.022)**

[a] Crude model

[b] Adjusted for age at baseline, education and work status

[c] Adjusted for age at baseline, education, work status, BMI, smoking, alcohol use and total physical activity

Total physical activity MET based on hours/week spent on each activity divided by ten, where the coefficients refer to the change in ten MET

Coefficients in bold are statistically significant at alpha = 0.05

Table 3 Effects of job demands on gait speed (m/s) and chair stand (times/s) with job demands, 3-way interactions included, added to the fully adjusted model

Variable	Physical job demands		Psychosocial job demands	
	Use of force	Repetitive movements	Time pressure	Cognitive demands
	B (95% CI)[a]	B (95% CI)[a]	B (95% CI)[a]	B (95% CI)[a]
Gait speed—women				
Cohort 2	0.012 (−0.063, 0.087)	0.012 (−0.083, 0.108)	0.003 (−0.063, 0.069)	0.003 (−0.062, 0.068)
Cohort 3	0.064 (−0.006, 0.134)	0.064 (−0.023, 0.151)	0.062 (−0.001, 0.125)	0.060 (−0.003, 0.122)
Time	**−0.014 (−0.027, −0.002)**	−0.012 (−0.025, 0.001)	**−0.011 (−0.023, −0.000)**	**−0.012 (−0.023, −0.001)**
Job demand	−0.004 (−0.084, 0.076)	−0.005 (−0.096, 0.087)	0.046 (−0.055, 0.147)	0.019 (−0.084, 0.123)
Cohort 2*time	**0.015 (0.002, 0.028)**	**0.014 (0.001, 0.027)**	**0.014 (0.000, 0.027)**	**0.013 (0.000, 0.027)**
Cohort 3*time	0.000 (−0.012, 0.013)	−0.001 (−0.013, 0.012)	−0.001 (−0.014, 0.011)	−0.002 (−0.014, 0.011)
Cohort 2*job demand	−0.049 (−0.142, 0.045)	−0.029 (−0.133, 0.075)	−0.044 (−0.153, 0.066)	−0.043 (−0.156, 0.070)
Cohort 3*job demand	−0.013 (−0.102, 0.075)	−0.006 (−0.103, 0.091)	−0.018 (−0.122, 0.085)	−0.005 (−0.111, 0.102)
Time*job demand	0.006 (−0.004, 0.015)	0.001 (−0.009, 0.011)	0.003 (−0.007, 0.013)	0.006 (−0.005, 0.016)
Gait speed—men				
Cohort 2	0.016 (−0.046, 0.078)	0.022 (−0.052, 0.096)	0.018 (−0.038, 0.074)	0.020 (−0.036, 0.075)
Cohort 3	**0.066 (0.007, 0.126)**	0.068 (−0.002, 0.138)	0.044 (−0.013, 0.101)	0.038 (−0.018, 0.093)
Time	−0.000 (−0.011, 0.010)	−0.000 (−0.012, 0.011)	−0.008 (−0.017, 0.002)	−0.007 (−0.017, 0.003)
Job demand	0.024 (−0.040, 0.088)	0.003 (−0.068, 0.073)	0.038 (−0.034, 0.109)	0.040 (−0.034, 0.114)
Cohort 2*time	0.006 (−0.005, 0.017)	0.005 (−0.006, 0.016)	0.005 (−0.006, 0.016)	0.005 (−0.006, 0.017)
Cohort 3*time	−0.007 (−0.018, 0.004)	−0.008 (−0.019, 0.004)	−0.007 (−0.018, 0.004)	−0.006 (−0.018, 0.005)
Cohort 2*job demand	−0.011 (−0.087, 0.066)	−0.015 (−0.096, 0.067)	−0.024 (−0.107, 0.059)	−0.033 (−0.119, 0.053)
Cohort 3*job demand	−0.045 (−0.120, 0.030)	−0.041 (−0.120, 0.038)	−0.011 (−0.090, 0.069)	−0.002 (−0.083, 0.079)
Time*job demand	**−0.012 (−0.021, −0.004)**	−0.008 (−0.017, 0.000)	0.005 (−0.003, 0.014)	0.004 (−0.004, 0.013)
Chair stand rise—women				
Cohort 2	−0.018 (−0.099, 0.062)	0.007 (−0.099, 0.113)	−0.043 (−0.114, 0.027)	−0.034 (−0.104, 0.035)
Cohort 3	**−0.096 (−0.172, −0.020)**	−0.074 (−0.171, 0.023)	**−0.119 (−0.187, −0.050)**	**−0.112 (−0.179, −0.045)**
Time	**−0.014 (−0.026, −0.002)**	**−0.013 (−0.026, −0.001)**	−0.011 (−0.022, 0.000)	**−0.011 (−0.022, −0.000)**
Job demand	−0.020 (−0.109, 0.068)	0.036 (−0.067, 0.138)	−0.050 (−0.164, 0.064)	−0.045 (−0.162, 0.072)
Cohort 2*time	0.011 (−0.002, 0.023)	0.010 (−0.003, 0.023)	0.010 (−0.003, 0.023)	0.010 (−0.003, 0.023)
Cohort 3*time	0.012 (−0.000, 0.024)	0.012 (−0.001, 0.024)	0.011 (−0.001, 0.023)	0.011 (−0.001, 0.023)
Cohort 2*job demand	−0.045 (−0.150, 0.060)	−0.061 (−0.178, 0.056)	0.032 (−0.092, 0.156)	0.001 (−0.127, 0.129)
Cohort 3*job demand	−0.033 (−0.132, 0.066)	−0.046 (−0.155, 0.063)	0.050 (−0.067, 0.167)	0.028 (−0.093, 0.149)
Time*job demand	0.005 (−0.004, 0.015)	0.004 (−0.006, 0.013)	0.001 (−0.009, 0.010)	0.002 (−0.008, 0.012)
Chair stand rise—men				
Cohort 2	**−0.095 (−0.162, −0.029)**	−0.073 (−0.153, 0.006)	−0.051 (−0.111, 0.009)	−0.052 (−0.111, 0.007)
Cohort 3	**−0.170 (−0.234, −0.106)**	**−0.165 (−0.241, −0.090)**	**−0.148 (−0.209, −0.088)**	**−0.154 (−0.213, −0.095)**
Time	−0.006 (−0.015, 0.004)	−0.005 (−0.015, 0.005)	−0.013 (−0.023, −0.004)	−0.012 (−0.021, −0.002)
Job demand	−0.001 (−0.071, 0.070)	0.008 (−0.070, 0.085)	0.022 (−0.057, 0.100)	0.073 (−0.008, 0.154)
Cohort 2*time	0.006 (−0.004, 0.017)	0.006 (−0.005, 0.016)	0.006 (−0.005, 0.016)	0.006 (−0.004, 0.017)
Cohort 3*time	**0.011 (0.001, 0.021)**	0.010 (−0.001, 0.020)	0.010 (−0.000, 0.020)	**0.012 (0.001, 0.022)**
Cohort 2*job demand	0.056 (−0.029, 0.141)	0.012 (−0.080, 0.103)	−0.049 (−0.141, 0.043)	−0.056 (−0.151, 0.039)
Cohort 3*job demand	0.010 (−0.074, 0.094)	0.005 (−0.083, 0.094)	−0.041 (−0.131, 0.047)	−0.055 (−0.145, 0.036)
Time*job demand	**−0.012 (−0.020, −0.004)**	**−0.009 (−0.017, −0.001)**	0.007 (−0.001, 0.015)	0.002 (−0.006, 0.010)

[a] Adjusted for age at baseline, education, work status, BMI, smoking, alcohol use and total physical activity

Total physical activity MET based on hours/week spent on each activity divided by ten, where the coefficients refer to the change in ten MET

Coefficients in bold are statistically significant atalpha = 0.05

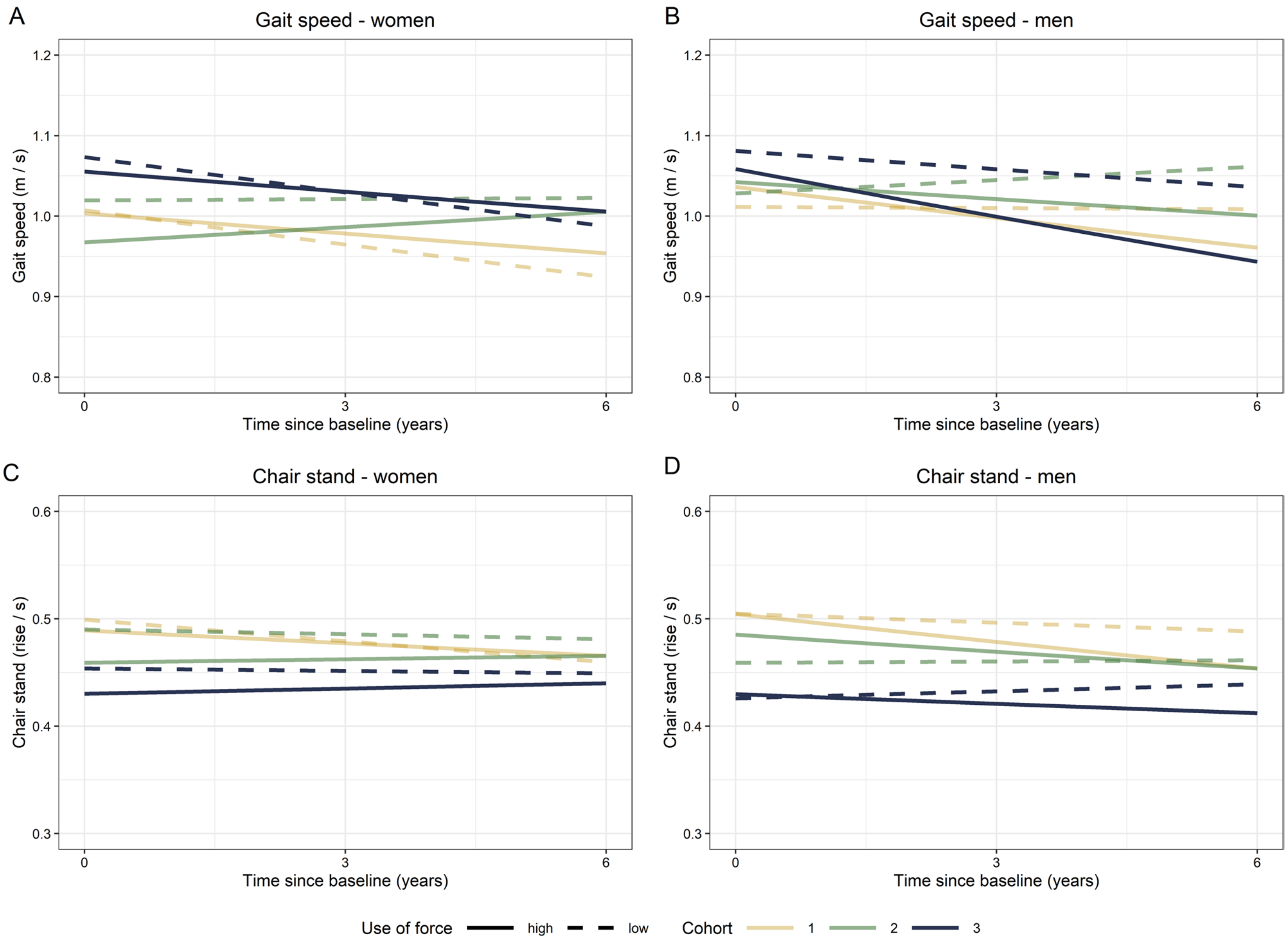

Fig. 1 Change in gait speed and chair stands according to use of force in three cohorts, women and men. Covariates were kept at their means or the most frequent class. Plots are based on back-transformations of linear mixed models including use of force. High and low use of force-groups are presented by solid and dashed lines, respectively. Yellow, green and blue refer to Cohorts 1, 2 and 3, respectively

stand test performance may be an indicator of accelerated decline in musculoskeletal health exacerbated by higher physical job demands (Gerr et al. 2014). Similar to the study by Møller et al. (2015), we did not find this association for women. This might be due to the preponderance of part-time work in Dutch women, resulting in a shorter weekly duration of exposure to physical job demands compared to men. However, little is known about the gender differences in the relation between work exposures and musculoskeletal aging across working life (Møller et al. 2015).

Regarding psychosocial job demands, the proportion of employees with higher demands has increased significantly over the past decades (Gallie 2005), which was also evident in the present study. Again, there were no cohort differences during the 6-year follow-up for the association between psychological work demands and change in physical performance. Furthermore, we did not find any association between psychosocial job demands and the rate of change in the physical performance measures. In line with our findings, a Swedish study found no association between high job demands in late midlife and physical performance measure scores in old age (Nilsen et al. 2017). Studies on the association between psychological job demands and self-rated physical functioning have been inconsistent for men and women. A US study found that lower psychological job demand were related to a better score on the physical functioning sub-scale of Short Form-36 health survey among middle-aged female nurses (Cheng et al. 2000). In the Whitehall II Study, high psychological job demands increased the odds for poor physical functioning among women but not men (Stansfeld et al. 1998). In a UK birth cohort, no associations were found between psychological job demands and the SF-36 physical summary component (von Bonsdorff et al. 2014). A Danish study found that men who often reported high work pace had a higher risk of mobility limitations while for women, reporting high work pace often protected from mobility limitations (Hansen et al. 2014). All in all, these differences may be due to differences in the measurements used for assessing physical functioning/performance as well as differences in work context in the different countries.

Strengths and weaknesses

One of the main strengths of this study was that it was based on a nationally representative population-based dataset. The first LASA cohort was studied first in 1992 and currently the dataset includes three birth cohorts, each with multiple follow-up waves. This provided a unique opportunity to compare physical performance according to job demands of the older working population across three decades using the same standardized measurement instruments. This study also had some limitations. First, the GPJEM does not take into account heterogeneity within job categories, because job demand information is aggregated (Rijs et al. 2014). Second, the 'healthy worker effect' might have influenced our findings because information on the current job was used, as opposed to the longest held job. Employees with reduced functioning may have switched to less demanding work because of not being able to continue to work in more demanding jobs. This may have limited our ability to detect relevant associations. However, data on the longest held job was available for cohort 1 showing that only a small minority of the respondents reported a different longest held job compared to the current job (Deeg et al. 2021) and the associated working conditions remained on average the same, thus proving some evidence for a lesser healthy worker effect in our data. However, in recent years changing jobs has been more frequent than it used to be.

Conclusions

This study showed that job demands were similarly associated with physical performance over six years across three cohorts. Regardless of the cohort, higher physical job demands of older employees aged 55 to 65 were associated with stronger six-year rates of decline in physical performance in men, while no associations were found among women. Furthermore, no associations were found between psychosocial job demands and change in physical performance in the cohorts. This could suggest that physical job demands have a lasting impact on physical performance in older age, particularly among men and that this situation has not appeared to improve in the past decades. Since nowadays more older workers need to continue working up to higher ages, it is important to alleviate their working conditions. If not, the health of more older workers would be affected in the long term, which would present an extra burden on health care and society. Work wellbeing interventions should primarily be focused on employees working in jobs that include high physical job demands.

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Data availability The datasets generated and analysed during the current study are not publicly available due the fact that they constitute an excerpt of research in progress but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate The Medical Ethics Committee of the VU University Medical Center approved the LASA study and informed consent was obtained from all respondents.

Competing interests The authors have no relevant financial or non-financial interests to disclose or other competing interests to declare that are relevant to the content of this article.

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ORIGINAL INVESTIGATION

Relationship of frailty status with health resource use and healthcare costs in the population aged 65 and over in Catalonia

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Abstract

Background Frailty is a geriatric syndrome with repercussions on health, disability, and dependency.
Objectives To assess health resource use and costs attributable to frailty in the aged population.
Methods A population-based observational longitudinal study was performed, with follow-up from January 2018 to December 2019. Data were obtained retrospectively from computerized primary care and hospital medical records. The study population included all inhabitants aged ≥ 65 years ascribed to 3 primary care centres in Barcelona (Spain). Frailty status was established according to the Electronic Screening Index of Frailty. Health costs considered were hospitalizations, emergency visits, outpatient visits, day hospital sessions, and primary care visits. Cost analysis was performed from a public health financing perspective.
Results For 9315 included subjects (age 75.4 years, 56% women), frailty prevalence was 12.3%. Mean (SD) healthcare cost in the study period was €1420.19 for robust subjects, €2845.51 for pre-frail subjects, €4200.05 for frail subjects, and €5610.73 for very frail subjects. Independently of age and sex, frailty implies an additional healthcare cost of €1171 per person and year, i.e., 2.25-fold greater for frail compared to non-frail.
Conclusions Our findings underline the economic relevance of frailty in the aged population, with healthcare spending increasing as frailty increases.

Keywords Health resource use · Healthcare costs · Frailty · Population ageing · Hospitalizations · Primary care visits · Emergency visits · Outpatient visits

Introduction

Population ageing is a reality of concern in most developed countries. Frailty is a major and well-known clinical condition associated with ageing, characterized by a decrease in the body's functional reserves and in its ability to respond to external stressors (Morley et al. 2013). Because of the impaired functioning of various organs and systems, frail subjects are at increased risk of disease, adverse health outcomes, functional decline, falls, fractures, disability, and dependency (Lahousse et al. 2014). Prevalence of frailty in the population aged ≥ 65 years is about 11%, but greatly increases with age (Collard et al. 2012; Garcia-Garcia et al. 2011; Jürschik et al. 2012). In a context of an ageing population, frailty represents a huge potential public health burden (Ilinca and Calciolari 2015). For individuals, it implies a greater risk of adverse health outcomes, reduced autonomy, and decreased quality of life and, for society, it implies an increase in health and social resource use and the corresponding increase in expenditure.

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Ageing increases demand for healthcare services and costs (Alemayehu and Warner 2004; Dios-Guerra et al. 2021; Vela et al. 2019), and frailty has been associated with an increased use of primary care, hospital, and community services (Hoeck et al. 2012; Ilinca and Calciolari 2015). Several scientific literature has addressed the cost of frailty from different perspectives. Some studies have considered health care resource use and costs related to frailty in specific clinical conditions or in specific group of patients such as hospitalized patients with heart failure (Kwok et al. 2020), surgical patients (Eamer et al. 2019), or cardiac implanted patients (Patel et al. 2020; Mohamed et al. 2019). Other studies only considered costs of hospital care (Liotta et al. 2019; García-Nogueras et al. 2017) or only costs of ambulatory health care (Sirven and Rapp 2017) and others assessed the cost-effectiveness or cost-utility of interventions addressing frailty (Yokoyama et al. 2020; Li et al. 2020; Bleijenberg et al. 2017; Peña-Longobardo et al. 2021). Few studies evaluated cost of frailty in the community. They are from different countries such as USA (Ensrud et al. 2020; Johnston et al. 2020), China (Gao et al. 2021; Fan et al. 2021), England (Han et al. 2019), Germany (Hajek et al. 2018a, b) or Mexico (Salinas-Escudero et al. 2022), and despite the heterogeneity in their settings, designs, perspectives, cost elements considered, or applied rates, they all suggest an increase in health care expenditure according to frailty severity. A systematic review and meta-analysis about healthcare costs associated to frailty in community-dwelling aged population incorporating 5 original articles found a dose–response relationship between frailty severity and healthcare resource use and costs, but also conclude that further research is needed (Kojima 2019). What studies have been done confirm that frail subjects are the main consumers of health resources, that frailty greatly increases healthcare expenditure (Hajek et al. 2018a, b; Liotta et al. 2019; Martínez-Reig et al. 2018; Sirven and Rapp 2017), and also that healthcare costs are very context dependent. As far as we are aware, there is only one study in Spain assessing additional costs attributed to frailty (the FRADEA study) (García-Nogueras et al. 2017). As mentioned, this study only consider hospital costs but not ambulatory costs. To date, therefore, the cost of frailty in the Spanish setting is not well known. This study aims to assess hospital and ambulatory health resource use by general elderly population according to frailty status, and to estimate additional healthcare costs attributable to frailty.

Material and methods

Study design and population

A population-based observational retrospective cohort study was designed with follow-up from 1 January 2018 to 31 December 2019. Data were retrospectively obtained from computerized primary care and hospital medical records. The study population included all inhabitants aged ≥ 65 years ascribed to 3 primary care centres in the province of Barcelona (Catalonia, Spain). The study protocol was approved by the local ethical committee for clinical research.

Study variables and data source

Frailty status was established according to the Electronic Screening Index of Frailty (e-SIF) (Serra-Prat et al. 2022), which includes the following clinical conditions: arthritis, atrial fibrillation, stroke, chronic renal failure, diabetes, heart failure, visual alterations, arterial hypertension, hypotension or syncope, coronary heart disease, dementia, osteoporosis or frailty fractures, Parkinson or neurodegenerative diseases, dyspepsia or gastroesophageal reflux disease, peripheral arterial disease, chronic lung disease, cutaneous ulcer, sleep disorders, inflammatory bowel disease or malabsorption, chronic liver disease, depression, sarcopenia, cachexia or muscular weakness, active cancer, psychosis, HIV infection, dysphagia, obesity, chronic pain, anaemia, weight loss in the last 6 months, anorexia or malnutrition, urinary or faecal incontinence, dyspnoea or fatigue, physical limitation or disability, dizziness or altered balance, falls in the last year, confinement or institutionalization, functional dependency or transfer problems, alcohol dependence, social vulnerability, polypharmacy, urgent admission in the last year with > 2 hospital days and age > 80 years. The e-SIF score is calculated by adding the clinical conditions present in a given time and is interpreted as follows: 0 to 4 as robust, 5 to 8 as pre-frail, 9 to 11 as frail and ≥ 12 as very frail. e-SIF was calculated for data corresponding to 1st of January 2018. Data were collected on institutionalization, planned and unplanned hospitalizations, major outpatient surgery hospitalizations, emergency visits, day hospital sessions, outpatient visits, and primary care visits, for both the study period (2018–2019) and the date of the event. The data used to calculate the e-SIF score were sourced from the primary care computerized medical history (e-CAP) for each subject, the pharmaceutical receipt database, and the hospital information system (HIS) of the reference hospital for the participating primary care centres. Data on age, sex, and health resource use during study period were obtained from e-CAP and HIS clinical records.

Cost analysis

The cost analysis was performed from a public health financing perspective, in this case, for the Catalan Health Service (CatSalut). The cost elements considered were hospitalizations (planned, unplanned, and due to major outpatient surgery), emergency visits, day hospital sessions, outpatient visits, and primary care visits. Unit healthcare costs were obtained from public cost accounting contracts with CatSalut for primary and specialized acute care provision, published on the official CatSalut website (CatSalut). CatSalut establishes 2 charging methods: a unit cost per hospitalization, emergency visit, and day hospital session, and an annual budget based on morbidity, territorial and demographic factors for outpatient and primary care visits. Unit costs were obtained as follows: (a) for hospitalizations, the weighted average of the medical and surgical hospitalization costs according to real medical and surgical discharges in the year of study; (b) for emergency visits, the sum of the unit cost per visit and an additional established triage cost; (c) for day hospital sessions, as set out in the contract terms; (d) for outpatient visits, the annual budget divided by the real annual number of visits as obtained from the transparency portal annual report of the reference hospital (CSdM); and (e) for primary care visits, the annual budget of each primary care centre divided by the real annual number of visits, averaged for the 3 primary care centres participating in the study. Costing was as follows: €2147.82 per hospitalization, €210.0 per day hospital session, €107.71 per emergency visit, €56.42 per outpatient visit, and €19.59 per primary care visit. Finally, the total health cost was calculated as the sum of costs for hospitalizations, emergency visits, day hospital sessions, outpatient visits, and primary care visits.

Statistical analysis

Frailty groups (robust, pre-frail, frail, and very frail) were compared for health resource use and health expenditure using the Kruskal–Walllis test (when considering all 4 frailty groups) and the Mann–Whitney *U* Test (when considering frail vs. non-frail categories). Percentage of attended subjects were compared using the Chi-square test. The effect of frailty on being attended to each of the health resources considered was evaluated using bivariate (unadjusted) and multivariate (adjusting for age and sex) logistic regression. The incremental cost of each frailty level in comparison to the previous frailty level was calculated using bivariate and multivariate lineal regression analysis (LRA), adjusting for age and sex. The incremental cost of frailty (frail vs. non-frail) was also calculated using bivariate and multivariate LRA. Statistical significance was established at $P < 0.05$.

Results

A total of 9315 subjects were included in the analysis, mean (SD) age 75.4 (7.96) years, and 56% women. Frailty prevalence overall was 12.3%, with 52.8% of the study population considered as robust, 34.9% as pre-frail, 9.8% as frail and 2.5% as very frail. Frailty prevalence was 10.04% in men and 14.11% in women ($P < 0.001$) and increased progressively with age, rising from 3.2% for the 65–69 age bracket to 25.8% for the ≥ 95 age bracket ($P < 0.001$). Description of main characteristics of study population is presented in Table 1.

Comparison of percentage of attended subjects between frail and non-frail and the unadjusted and adjusted effect of frailty on being attended at least once to each of the health resources considered is presented in Table 2. It shows a significant higher percentage of attended subjects in the frail group for all health resource considered, and an adjusted effect of frailty on all health resources considered except for institutionalization. Table 3 shows the average number of unplanned hospitalizations, planned hospitalizations, major outpatient surgeries, emergency visits, day hospital sessions, outpatient visits, and primary care visits per subject by frailty status, sex, and age for the period 2018–2019. Men used all services, except for primary care, more frequently than women. The rate of hospitalizations, emergency visits, and primary care visits for subjects aged > 80 years almost doubled that of subjects aged < 80 years. As frailty progressed, mean health resource use increased proportionally and significantly. Table 4 shows healthcare costs by frailty group. Higher frailty scores were associated with increased healthcare spending. Table 5 summarizes the bivariate and multivariate LRA results for the incremental cost attributed to frailty adjusted by age and sex. The progression from one frailty status to the next carries a €1392.21 increase in healthcare cost expenditure when adjusted by age and sex.

Table 1 Description of main characteristics of the study population

Clinical condition	Percentage	Clinical condition	Percentage
Arterial hypertension	52.56	Cancer	10.69
Polypharmacy	46.03	Dyspepsia	10.23
Arthritis	35.32	Social risk	9.82
Obesity	33.76	Chronic renal failure	7.64
Sleep disorders	21.56	Heart failure	3.95
Chronic lung disease	20.55	Dementia	3.32
Diabetes	19.29	Stroke	2.65
Depression	16.48	Neurodegenerative disease	0.98

Table 2 Relationship between frailty and use of different health care resources (attended at least once)

	% of attended in non-frail	% of attended in frail	*p*	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
Unplanned hospitalization	12.86	38.82	< 0.001	4.30 (3.76–4.92)	3.20 (2.76–3.70)
Institutionalization	4.60	11.05	< 0.001	2.57 (2.08–3.18)	1.09 (0.87–1.37)
Emergency visit	45.79	74.67	< 0.001	3.49 (3.04–4.02)	2.88 (2.49–3.34)
Outpatient visit	64.46	86.07	< 0.001	3.41 (2.87–4.05)	3.62 (3.02–4.34)
Day hospital session	9.94	25.24	< 0.001	3.06 (2.63–3.56)	2.76 (2.35–3.25)
Primary care visit	93.41	98.96	< 0.001	6.68 (3.76–11.88)	7.42 (4.15–13.27)

*Adjusted by age and sex

Similarly, when considering only the frail versus non-frail categories, the multivariate LRA (adjusted for age and sex) shows an increased cost of €2342.58 attributable to frailty. The multivariate LRA also points to an independent effect of age and sex on healthcare costs. In the model that considers 4 frailty status categories, the interaction between age and sex did not reach statistical significance ($p = 0.066$), but in the model that considers frailty in two categories, a significant interaction was observed between age and sex ($p = 0.034$) on healthcare costs.

Figure 1 depicts total healthcare cost according to frailty groups. The hospitalization cost progressively contributed more to the total cost as frailty increased. While in the robust population hospital admissions represented 47.7% of the overall cost, this percentage raised to 58.7% in the very frail population.

Discussion

Our findings confirm that frailty progression increases health resource use and that frailty increases healthcare costs by 125%, mainly due to hospitalizations. This represents an additional annual healthcare cost of approximately 1170€ per frail person compared to a non-frail person in our context. These results are similar to those reported by other authors in recent years. García-Nogueras et al. (2017) found, for the Albacete region of Spain, that pre-frail and frail patients cost €458 and €592 more, respectively, in total annual healthcare costs compared to robust patients. Sirven and Rapp (2017) showed, for France, that the incremental cost for ambulatory health expenditure was roughly €750 and €1500 for pre-frail and frail individuals, respectively. Although costs are context-specific and so may greatly vary between countries and healthcare financing systems, it can be generally agreed that healthcare costs are approximately 2.5-fold greater for frail individuals compared to non-frail individuals. Moreover, frailty has associated social costs due to dependency and disability that are not usually considered in these studies.

We found that older age groups were associated with higher frailty prevalence and with higher health resource use and cost, so age could act as a confounder when assessing cost of frailty. However, multivariate analysis showed an effect of frailty on healthcare costs independent from age and sex. Although frailty was more prevalent in women than in men, women used fewer health resources and ,consequently, had lower healthcare costs, with the multivariate LRA confirming the independent effect of sex on healthcare costs. Our results corroborate those of other studies conducted in the USA, India, and Spain (Cameron et al. 2010; Carretero et al. 2014; Mondal and Dubey 2020; Redondo-Sendino et al. 2006; Dalmau-Bueno et al. 2021), which have reported, adjusting by age and morbidity, lower health care expenditure and health care services use for women than men. We found, corroborating other Spanish studies (Aguado et al. 2012; Dios-Guerra et al. 2021), that the only service used more by women than men was primary care. Our findings are suggestive of gender inequality in health resource use. Causes of gender inequalities in healthcare use are complex and poorly understood. They may be related with socioeconomic status (women receive lower incomes) and social environment (twice as many women live alone as men), among others factors, and require to be further studied.

This study's findings have 3 major implications for public policy. First, prevention-oriented interventions, mainly from the primary care setting, should play a key role in reducing the personal, social, and economic impact of frailty. Frailty, especially in its initial phases, is a preventable, reversible, and treatable condition (Cameron et al. 2013; Gill et al. 2006; Ng et al. 2015; Serra-Prat et al. 2017). More than a third of the population aged over > 65 year is classified as pre-frail, and are at an increased risk of becoming frail. Pre-frailty interventions for frailty prevention are both easier and more effective than frailty interventions to reverse this condition, so screening and intervention programmes for the pre-frail group would probably lead to greater reduction in health resource use and cost and would be more efficient

Table 3 Healthcare resource use by frailty status, sex, and age group 2018–2019

	Unplanned hospitalizations		Planned hospitalizations		Major outpatient surgeries		Emergency visits		Outpatient visits		Primary care visits		Day hospital sessions	
	Mean (95% CI)	*P*	Mean (95% CI)	*P*	Mean (95% CI)	*P*	Mean (95% CI)	*P*	Mean (95% CI)	*P*	Mean (95% CI)	*P*	Mean (95% CI)	*P*
Robust	0.114 (0.10–0.13)	< 0.001	0.091 (0.08–0.10)	< 0.001	0.092 (0.08–0.10)	< 0.001	0.761 (0.72–0.80)	< 0.001	4.743 (4.50–5.00)	< 0.001	17.499 (17.03–17.97)	< 0.001	0.418 (0.32–0.51)	< 0.001
Pre-frail	0.304 (0.28–0.33)		0.180 (0.16–0.20)		0.149 (0.13–0.17)		1.365 (1.30–1.43)		8.564 (8.18–8.95)		33.670 (32.77–34.57)		0.932 (0.72–1.14)	
Frail	0.564 (0.50–0.63)		0.257 (0.21–0.31)		0.145 (0.12–0.17)		2.108 (1.94–2.27)		11.582 (10.67–12.49)		52.229 (49.81–54.65)		1.053 (0.82–1.29)	
Very frail	0.850 (0.70–1.10)		0.408 (0.28–0.53)		0.163 (0.10–0.23)		2.935 (2.53–3.34)		11.579 (9.78–13.38)		59.910 (55.28–64.53)		1.983 (1.17–2.79)	
Male	0.299 (0.27–0.32)	< 0.001	0.176 (0.16–0.19)	< 0.001	0.118 (0.10–0.13)	0.735	1.229 (1.17–1.29)	0.036	7.868 (7.50–8.23)	< 0.001	25.313 (25.53–27.09)	< 0.001	0.914 (0.75–1.08)	< 0.001
Female	0.200 (0.18–0.22)		0.123 (0.11–0.13)		0.121 (0.11–0.13)		1.103 (1.06–1.15)		6.184 (5.92–6.44)		28.622 (27.88–29.36)		0.532 (0.42–0.64)	
< 80 y	0.165 (0.15–0.18)	< 0.001	0.121 (0.11–0.13)	< 0.001	0.126 (0.12–0.14)	0.005	0.993 (0.95–1.03)	< 0.001	7.151 (6.88–7.42)	0.387	24.039 (23.51–24.57)	< 0.001	0.679 (0.57–0.78)	< 0.001
≥ 80 y	0.426 (0.39–0.46)		0.205 (0.18–0.23)		0.103 (0.09–0.12)		1.541 (1.46–1.62)		6.379 (6.02–6.74)		35.922 (34.66–37.18)		0.745 (0.55–0.94)	
Overall	0.243 (0.23–0.26)		0.146 (0.14–0.16)		0.119 (0.11–0.13)		1.158 (1.12–1.20)		6.919 (6.70–7.14)		27.612 (27.07–28.15)		0.699 (0.60–0.79)	

Table 4 Healthcare costs (€) by frailty status, sex, and age 2018–2019

	Total cost		Unplanned hospitalizations		Planned hospitalizations		Major outpatient surgeries		Emergency visits		Outpatient visits		Primary care visits		Day hospital sessions	
	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*	Mean (SD)	*P*
Robust	1420.19 (2523.3)	< 0.001	245.83 (993.6)	< 0.001	195.61 (827.0)	< 0.001	198.67 (769.3)	< 0.001	81.94 (150.3)	< 0.001	276.65 (493.4)	< 0.001	342.80 (328.9)	< 0.001	87.69 (721.8)	< 0.001
Pre-frail	2845.51 (3531.9)		653.54 (1609.8)		385.64 (1159.7)		320.82 (1027.3)		146.99 (205.5)		483.16 (631.6)		659.60 (509.9)		195.77 (1264.7)	
Frail	4200.05 (4275.8)		1212.25 (2083.7)		551.02 (1632.7)		311.86 (935.8)		227.06 (276.6)		653.45 (791.4)		1023.17 (731.9)		221.23 (767.6)	
Very frail	5610.73 (4823.0)		1825.19 (2473.7)		875.72 (2083.3)		350.29 (1108.6)		316.20 (334.1)		653.31 (786.7)		1173.63 (701.9)		416.39 (1319.8)	
Male	2555.93 (3762.8)	< 0.001	641.44 (1620.5)	< 0.001	378.31 (1299.6)	< 0.001	252.56 (886.1)	0.735	132.41 (218.2)	0.036	433.92 (667.6)	< 0.001	515.37 (495.9)	< 0.001	191.92 (1122.7)	< 0.001
Female	2093.33 (2977.5)		430.38 (1320.2)		263.88 (925.1)		258.97 (901.5)		118.81 (184.6)		348.88 (544.9)		560.70 (538.4)		111.72 (829.0)	
< 80 year	2008.57 (3122.7)	< 0.001	353.79 (1180.7)	< 0.001	259.82 (1019.9)	< 0.001	271.03 (918.2)	0.005	107.00 (185.0)	< 0.001	403.45 (623.1)	0.039	470.91 (425.9)	< 0.001	142.56 (901.1)	< 0.001
≥ 80 year	2961.81 (3745.2)		914.80 (1911.1)		439.38 (1274.4)		221.61 (837.0)		166.01 (226.1)		359.91 (553.6)		703.72 (645.0)		156.39 (1110.9)	
Overall	2295.20 (3350.6)		522.49 (1462.5)		313.81 (1105.6)		256.17 (894.8)		124.74 (200.1)		390.35 (603.4)		540.92 (520.7)		146.72 (968.9)	

Table 5 Linear regression analysis (LRA) of the incremental cost attributed to frailty adjusted by age and sex

	Model 1: Frailty in 4 categories		Model 2: Frailty in 2 categories	
	Bivariate LRA (unadjusted)	Multivariate LRA (adjusted)	Bivariate LRA (unadjusted)	Multivariate LRA (adjusted)
Frailty	1400.097**	1392.214**	2499.181**	2342.583**
Age		184.5115**		546.1348**
Female		(−) 643.1798*		(−) 606.113**
Constant	1426.738**	1738.646**	1986.932**	2183.636**
*R*2	10.17%	11.09%	6.02%	7.23%

Beta coefficients expressed in €

$^{*}P<.05$, $^{**}P<.001$

than frailty treatments. Second, public health systems need to plan for and accommodate a growing demand for health resources by the elderly, as the prevalence of frailty in recent decades has been growing (Hoogendijk et al. 2021), and an important increase in the population aged > 65 years is forecast for the coming decades. In fact, even if frailty and pre-frailty prevalence could be reduced through preventive actions, the absolute number of frail and pre-frail subjects will increase due to population ageing. Healthcare institutions need to anticipate the increase in the frail population in order to coordinate health and social interventions that guarantee adequate care for the elderly. Finally, factors that affect access to health resources need to be considered a priority area for research, especially in the case of women. It has been suggested that widowhood could explain the gender gap in health resource use (Dios-Guerra et al. 2021; Mondal and Dubey 2020), as widowed women are more likely to experience economic deprivation. However, when access to public health is free, as in Spain, economic hardship cannot be the only explanation. Further research is needed to better understand healthcare use predictors for women, as the results should serve to design specific gender policies aimed at reversing inequality in access to health resources.

Main study limitations include: (a) the tariffs applied to translate health resource use into monetary units (€) are specific for our context, so results cannot be extrapolated to other settings or healthcare systems, (b) medication costs and social costs of institutionalization or care for dependency were not considered, c) the study considered only inhabitants ascribed to 3 primary care centres in Catalonia, and although they represent heterogeneous population segments (urban, suburban, and rural), the results cannot be extrapolated to the whole population, and d) although the e-SIF contemplates a large number of comorbidities, clinical conditions and polypharmacy and that the effect of frailty on healthcare costs has been adjusted for age and sex, we cannot rule out some residual confounding by other variables not included in the model and not

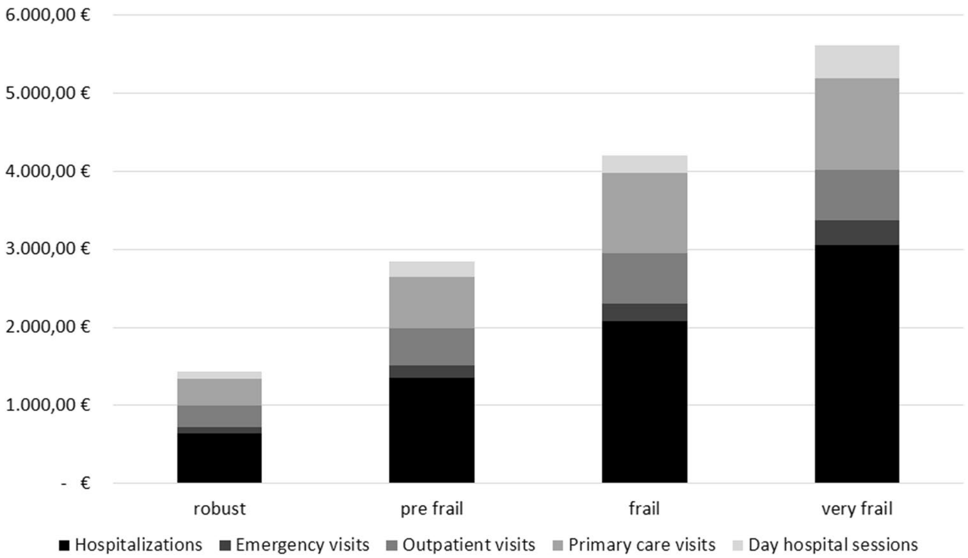

Fig. 1 . Healthcare costs by frailty status

part of the e-SIF. It is important to distinguish frailty from multi-comorbidity. While frailty is a geriatric syndrome characterized by greater vulnerability to suffering from illness and other adverse health outcomes, multi-comorbidity refers to the clinical condition of those people who accumulate two or more chronic diseases. Both concepts are closely related but must be distinguished because most but not all frail are comorbid and not all comorbid are frail. Despite this, with the definition of frailty according to the model of accumulation of deficits or clinical conditions, it is hard to differentiate which part of the increase in costs is due to frailty and which to comorbidity with demonstrated increased healthcare costs (Wang et al. 2018; Vela et al. 2019). This would require another operational definition of frailty that did not include comorbidities.

To sum up, in the population aged > 65, independently of age, as frailty increases, health resource use increases, to the point where the healthcare cost for frail subjects is more than double (2.25 times greater) that of non-frail subjects, representing an additional annual healthcare spend of nearly €1170 per frail person. For pre-frail subjects, the healthcare cost is also double that of robust subjects. Given that pre-frailty is much more prevalent than frailty in the population aged > 65, and that the effectiveness of preventive actions is high, interventions in the pre-frail group rather than in the frail group are likely to have a greater economic impact. Our results, which underline the economic implications of frailty in later life, suggest that postponing or reducing frailty will reduce healthcare costs and contribute to making the healthcare system more efficient and sustainable.

Author contributions AL: Design, data gathering, data interpretation, and reviewing manuscript. JS: Data analysis, design, data interpretation, and reviewing manuscript. MSP: Study conception and design, data interpretation, and writing first draft. EB: Study conception and reviewing manuscript. MC: Study conception and reviewing manuscript

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Declarations

Ethics The study protocol was approved by the local ethics committee (reference: CEIm CSdM 06/20). This project is part of the doctoral thesis of Àngel Lavado, Department of Medicine and Biomedical Sciences, University of Vic (UVIC).

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Social disadvantage, context and network dynamics in later life

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Abstract

How do personal networks evolve as individuals age? To what degree do social disadvantage and contextual factors matter for network dynamics in later life? This paper answers these two questions based on egocentric network data of older adults over a ten-year period. Specifically, I use longitudinal and nationally representative data on 1,168 older adults from the National Social Life, Health, and Aging Project. I use between-within models to separate the within- and between-individual effects of sociodemographic characteristics and contextual factors on three aspects of social connectedness in later life: network size, frequency of contact, and proportion of kin. Patterns of network change vary among people of different races and ethnicities as well as educational levels. Black and Hispanic respondents have a significantly smaller network size and a higher average frequency of contact with confidants. Moreover, Hispanic respondents have a higher proportion of kin in the network, compared to White respondents. Similarly, older adults with less education have a smaller network size, higher frequency of contact and higher proportion of kin in their confidant networks compared to those who attended college. Older adults who have better mental health are more likely to have a higher frequency of contact and higher proportion of kin. When an older adult starts to work for pay, their frequency of contact with confidants tends to increase. Older adults living in neighborhoods with stronger social ties are more likely to have a larger network size, higher frequency of contact, and lower proportion of kin in their confidant network. The above results show that disadvantaged backgrounds and contextual factors are associated with certain less favorable network characteristics, which helps to explain the concentration of social disadvantage on certain populations.

Keywords Social disadvantage · Network dynamics in later life · Between-within models · Contextual factors · Social connectedness

Introduction

Personal networks develop and evolve continuously throughout the life course (Wellman et al. 1997; Bidart and Lavenu 2005). Some scholars suggest that network size is bell-shaped as a function of age (Wrzus et al. 2013). On average, the size of the network initially increases with age, peaks at young adulthood, and decreases monotonically after middle adulthood (Carstensen 1995; Carstensen et al. 1999; Lang 2003). However, others claim that the network dynamics in later life can be more complex (Cornwell et al. 2021). To capture such complexities, one needs not only to examine the structure of older adults' personal networks, but also to investigate the social backgrounds and contextual factors that help shape these networks. Life course transitions and changes in social context result in exceptionally high network turnover rates for older adults (Cornwell and Laumann 2015). However, peripheral ties are especially likely to dissolve as individuals age, as compared with inner ties (English and Carstensen 2014). This illustrates an important phenomenon, namely, that different types of social ties have different likelihoods of dissolving as the social context shifts. This motivates my research questions: How do the size and structure of personal networks evolve as individuals age? To what degree do social disadvantage and contextual factors matter for network dynamics in later life?

A well-connected and well-structured personal network contributes to an individual's well-being. But people of different sociodemographic backgrounds have different

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chances of building and maintaining such a network. Empirical studies have shown a positive association between advantageous personal networks and other life outcomes, including lower mortality risk, and better physical health and emotional well-being (Litwin et al. 2020). The supporting role of personal networks becomes more substantial in later adulthood, as older adults tend to rely on close ties for social support, especially once their health substantially declines (Ducharme et al. 2011). Social disadvantage is associated with less desired network positions as well as less favored network characteristics. However, both these lines of research are faced with the problem of reverse causality. Is it that a good social relationship leads to advantage in health, living situation, and economic standing, or do those same factors contribute to both a good social relationship and other positive life outcomes? In other words, the success in social relationships and other life outcomes could be the result of some other social factors, such as favorable sociodemographic background or contextual factors. Moreover, social contexts and networks could co-evolve as adults age. One way of compensating for this is to incorporate existing social disadvantage indicators and dynamic contextual factors simultaneously in the analysis. Among the relevant factors, the residential, working, and health contexts are often considered to play a key role in shaping personal networks (Sharkey and Faber 2014). Therefore, I include all these factors in my models.

This paper has two main parts. First, I present how older adults' personal networks change over a ten-year period. Specifically, I show how the size, composition, and frequency of contact change. These are defining factors of a network's structure and function (Guadalupe and Vicente 2021). Second, I examine how disadvantaged backgrounds and shifts in contextual factors correlate with network features. By comparing the network features of disadvantaged groups and the reference group, one can see how pre-existing disadvantage can impact network size and structure. By including the contextual factors, one can see how contexts can alter network size and structure. I explore how networks are constrained by pre-existing social disadvantage but can be altered by the social contexts. In the meantime, one can also see how personal networks compensate for pre-existing disadvantages. To achieve the analysis goals, I apply between-within models. The between-individual effect compares network structure and size differences across social groups. The within-individual change shows how contextual factors and personal networks evolve for an individual across time. The results have significant implications on how social networks are associated with social inequality.

Social disadvantage, context, and network dynamics in later life

There is still debate about how personal networks evolve during the aging process. On the one hand, social disengagement theory claims that as individuals grow older, they become less engaged with their network members (Cumming and Henry 1961). This theory indicates that both network size and frequency of contact decrease as adults get older. Along this line of research, socioemotional selectivity theory proposes that as older adults age, they tend to downsize their networks in a way which benefits emotional well-being (Gross 1998; Carstensen 2006). They prioritize the social connections which satisfy their emotional needs, instead of social ties that give them useful information or financial benefits (English and Carstensen 2014). On the other hand, some scholars advocate that personal networks remain relatively stable as individuals age (Atchley 1989; Cornwell et al. 2021). These scholars acknowledge the potential network turnover that older adults experience due to changes in social contexts. For instance, retirement, health decline, relocation, and adult children moving away can all fracture existing ties of older adults. However, these scholars suggest that older adults actively adjust for the loss of ties and make efforts to build new connections. As a result, older adults achieve homeostasis in network size (Cornwell et al. 2021).

The structure of older adults' networks is as vital as the network size. Different types of networks, such as diverse networks, family-centered networks, friend-centered networks, and restricted networks, usually indicate different accessibility to social resources (Antonucci et al. 2014; Kim et al. 2017). Moreover, the type and structure of social networks are associated with health outcomes, such as life expectancy, health habits, and quality of life (Fiori et al. 2006; Litwin and Shiovitz-Ezra 2006; Kim et al. 2017; Litwin and Levinson 2018; Park et al. 2018; Ye and Zhang 2019; Choi and Jeon 2021; Guadalupe and Vicente 2021). More diverse networks are associated with better mental and physical health (Litwin and Shiovitz-Ezra 2006), while restrained networks are linked to inferior mental health (Kim et al. 2017). In older adulthood, family-based networks are prevalent and of great importance for older adults (Litwin et al. 2020). Older adults with family-based networks are less likely to experience depressive thoughts and are more satisfied with their quality of life (Litwin et al. 2020). This paper examines the size and structure of the confidant network because its members are essential for supporting older adults as age increases. I expand on work that has studied how age, contextual factors, and sociodemographic background are intertwined and impact the close ties of older adults. The answer to this question contributes to our understanding of the role of personal networks in aging and the corresponding consequences for social inequality.

Pre-existing social disadvantage is associated with less favorable network characteristics. Previous studies have used limited education and racial minority status as the key indicators of social disadvantage (Goldman and Cornwell 2018). Older adults with higher education are more likely to have their adult children as confidants despite geographical distance (Schafer and Sun 2021). Race and ethnicity affect the size and composition of an individual's network. Some scholars suggest that Black Americans are more likely to have a smaller network with higher frequency of contact. Their networks tend to be more family-based than other racial groups (Ajrouch et al. 2001). Older Black American adults and those who did not attend college are more likely to experience instability in their relationships with their adult children (Goldman and Cornwell 2018). This might cause them to lose access to important resources and support since parent-child ties are essential for older adults.

Contextual factors are the elements of the social environment in which one is embedded, and/or which describe essential changes in the life course which affect one's social interactions. Contextual factors including neighborhood environment, job entry, retirement, functional health decline, change in mental health status, and relocation can also lead to personal network changes (Vanhoutte and Hooghe 2012; Wrzus et al. 2013). Neighborhood environments have significant implications on social inequality in the US (Ludwig et al. 2013; Levy et al. 2020). The community in which an individual lives is closely linked to their income level, educational outcome, high risk behavior, delinquent activity, criminal involvement, and mental and physical health (Morenoff et al. 2001; Sampson et al. 2002; Sampson and Raudenbush 2004; Ludwig et al. 2013; Levy et al. 2020). Based on a randomized social experiment, Ludwig et al. (2013) found that moving from a disadvantaged neighborhood to a less disadvantaged neighborhood benefits both mental and physical health, which in turn contributes to a higher level of life satisfaction. Disadvantaged neighborhoods are more likely to experience higher rates of crime and homicide (Sampson and Raudenbush 2004). Social cohesion within a neighborhood is relevant to the networks of the residents. Disadvantaged neighborhoods are associated with smaller network size for older adults (York Cornwell and Behler 2015). Older male adults who live in disadvantaged neighborhoods tend to have less frequent contact with family and friends (York Cornwell and Behler 2015). The influence of residential contexts on individuals' personal networks persists across different life stages (Sharkey and Faber 2014).

Working status also impacts network composition and structure (Ajrouch 2005). Retiring adults are less likely to maintain co-worker relationships, which results in a decline in network size and a more closely knit network (Van Tilburg 2003). The closeness of social ties from work and the timing of retirement both impact how the network changes. Peripheral ties have a higher a probability to dissolve during the transition to retirement, regardless of occupational type (Van Tilburg 2003; Kauppi et al. 2021). Some scholars suggest that networks become more stable after the transition to retirement. Other life-course changes, such as mental health decline, functional health decline, and the transition into caregiving roles also affect how networks change in the long term (Perry and Pescosolido 2012; Roth 2020). For older adults, transitioning into caregiving roles might put a lot of strain on their psychological well-being and lead to conflicts with family members (Ducharme et al. 2011). Apart from impacting personal networks directly, social context can also be a moderating factor between networks and other life outcomes (Birditt et al. 2014).

The studies above provide us with broad knowledge of the essential factors shaping personal networks. As mentioned above, I take a dynamic perspective and track the changes in the contextual factors as well as the changes in personal networks across time. Social networks are dynamic in nature and the stability of networks differ for different social groups. Likewise, contextual factors can be unstable, especially for disadvantaged groups (Desmond 2012). Moreover, research in this area often focuses either solely on social disadvantage or contextual factors. Pre-existing social disadvantages and contextual factors may be closely intertwined. Individuals from disadvantaged social backgrounds have higher likelihood to be trapped in less favorable social environments and encounter more instability and insecurity throughout the life course (Desmond 2012; Goldman and Cornwell 2018). As a result, pre-existing disadvantage and the evolving contextual factors together shape the personal network of an older adult. Including both pre-existing social disadvantages and social contexts in the analysis allows one to distinguish between the impacts due to each separate factor. Examining the co-evolution of social environments and personal networks can help solve the problem of reverse causality. Furthermore, instability in personal networks can affect individuals' health and socioeconomic outcomes. Some research has shown how various life events impact network size and structure over an extended time period. Despite the innovation and advancement in these studies, most are only based on a small number of observations which are not necessarily representative for an entire nationwide social group. My study contributes to this line of inquiry by analyzing changes in personal networks and their association with evolving contextual factors as well as pre-existing social disadvantage, based on longitudinal and population-based data.

I claim that network change is intertwined with pre-existing social disadvantage and contextual factors. On the one hand, people from disadvantaged backgrounds are more likely to rely on resources provided by their close social circles. Thus, they have the motivation to sustain existing network ties and seek potential new connections. On the other hand, individuals from underprivileged backgrounds might have limited resources to maintain or construct social ties. Previous theories, such as social convoy theory, suggest that close ties are less likely to dissolve than peripheral ties (Antonucci and Akiyama 1987; Van Tilburg 1992, 2003; Ajrouch et al. 2018). Socioemotional selection theory also emphasizes the value of close ties and how older adults make great efforts to preserve these ties. Although close ties are more enduring than peripheral ties, they can still be highly dynamic in later life (Cornwell and Laumann 2015; Cornwell et al. 2021). By using longitudinal and nationally representative data on older adults' confidant networks, this paper captures the change in close ties over a 10-year period in later life. Furthermore, I examine how social disadvantage, contextual factors, and changes in these elements are associated with the change of network size and structure over a long time period in later life. Based on previous research, I propose the following hypotheses:

Hypothesis 1 On average, network size, frequency of contact, and proportion of kin tend to decrease over the long term as age increases.

Hypothesis 2 For older adults from disadvantaged backgrounds, personal networks tend to be smaller in size with a lower level of diversity.

Hypothesis 3 Changes in the contextual factors can alter network size and structure, even after controlling for pre-existing social disadvantage.

Data and methods

NSHAP data

This study uses three rounds of data on 1,168 older adults from the National Social Life, Health, and Aging Project (NSHAP). NSHAP is the first nationally representative dataset on community-dwelling older adults egocentric network change in the United States. This study collected detailed information from older adults, including sociodemographic backgrounds, egocentric networks, marital and sexual relationship history, health, and neighborhood environment. This paper mainly utilizes the network section and sociodemographic background section. The first round of data was collected in 2005/2006 with a sample size of 3,005. The second round and third round of data were collected in 5-year increments. At Round 1, the older adults were aged between 57 and 85 years old. The sample of this study consists of older adults who were surveyed in all three rounds. The weighted and conditional response rates for Round 1, Round 2, and Round 3 are 75.5%, 89%, and 89.2%, respectively (Cornwell et al. 2021).

Measures

The outcome variables are network size, frequency of contact, and proportion of kin. The confidant network is an egocentric network with the respondent as the center of the network. These egocentric networks were elicited by a widely used name generator. Specifically, each respondent was asked to give a list of names of people with whom they discussed important matters in the past 12 months.[1] Three aspects of the egocentric confidant network are of most interest in this paper, namely, network size, average contact frequency, and network kin composition. Network size is the number of close contacts that older adults have in the egocentric network. The frequency of contact captures how often the ego talks to the alters on average. The proportion of kin is the percentage of kin members in respondent's confidant network.

The explanatory variables can be divided into two groups: sociodemographic characteristics and contextual factors. For sociodemographic characteristics, I focus on respondent's race and ethnicity and educational attainment. These two variables are often used to identify social disadvantage. For race and ethnicity, I generated three dummy variables with White respondents as the reference group. Racial groups and educational attainment are treated as time-invariant variables. For contextual factors, I primarily examine respondent's functional and mental health status, working status, and neighborhood ties. Ideally, all the contextual variables should be time-varying variables. However, some variables are only available in a certain round of the survey. For instance, neighborhood ties are only collected at Round 2. It is still meaningful to include these screenshots of context to present a whole picture of how contextual factors impact network dynamics. Other contextual variables are all treated

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[1] The confidants include a variety of identities: Ex-spouse, Romantic/Sexual partner, Parent; Parent in-law; Child; Step-child; Brother or sister; Other relative of yours; Other in-law; Friend; Neighbor; Co-worker or boss; Minister, priest, or other clergy; Psychiatrist, psychologist, counselor, or therapist; Caseworker/Social worker; Housekeeper/Home health care provider; Other.

as time-varying variables in the models. Functional health, mental health, and working status were collected at all three rounds. The range for self-rated mental health is from 1 to 5,[2] with larger scores indicating better mental health. Functional health is evaluated by respondent's difficulty in ADL and IADL activities. The range of the functional health score is from − 27 to 0.[3] 0 represents that there is no difficulty in ADL and IADL activities, while more negative values represent more difficulty in the ADL and IADL activities. Working status is a binary variable, documenting whether the older adult worked for pay in the last week.

Control variables include gender, age, marital status, and household size. Previous research has suggested networks and their change could differ among people of different gender, age, marital status, and household size. Based on the design of the NSHAP survey, gender is treated as a time-invariant variable. Age, marital status, and household size are treated as time-varying variables. Age is scaled by 10 to demonstrate the coefficient of age more clearly, and to show the differences between 10-year age groups more straightforwardly. Household size measures how many people live in the household being interviewed, including the respondent.

Methods and models

The main model that I utilized is the between-within model (Allison 2009; Schunck and Perales 2017). I use some key social disadvantage indicators and contextual indicators to predict the change in network size, frequency of contact, and network composition. Three models were estimated using the explanatory variables and controls to predict the change in network size, the frequency of contact, and network kin composition in later life, respectively. I estimated the following between-within model:

$$y_{it} = a_i + \sum_{m=1}^{M} \beta_{W,m}\left(x_{it,m} - \bar{x}_{i,m}\right) + \sum_{m=1}^{M} \beta_{B,m}\bar{x}_{i,m} + \sum_{k=1}^{K} \gamma_k c_{i,k} + e_{it}$$

where y_{it} is the network characteristic, $x_{it,m}$ is individual i's explanatory variable m at time t, $\bar{x}_{i,m}$ is individual i's average value of variable m over ten years, $\beta_{W,m}$ are the within-individual estimators, $\beta_{B,m}$ are the between-individual estimators, and $c_{i,k}$ is a set of control variables. The coefficient $\beta_{W,m}$ means each unit of within-individual change in explanatory variable m is linked to $\beta_{W,m}$ change in the outcome variable y_{it}. One strength of between-within models over OLS models is that they separate within-individual effects and between-individual effects. This advantage is especially valuable for the time-varying explanatory variables that I study. The within-individual estimator captures how changes in a feature of an individual over ten years are associated with changes in network structure.

Results

Table 1 shows the descriptive statistics of the variables in the models. The upper panel of the table shows the concentration tendency of the sociodemographic variables. 76% of the respondents are White. Black, non-Black Hispanic,[4] and other race and ethnicity constitute 12%, 9%, and 2% of the sample respectively. 37% of the older adults only graduated from high school or less. On average, the mean of the self-rated mental health score is 3.9, per the range of 1–5. At Round 1, the average score of functional health is -1.4. This suggests that the respondents have moderate difficulty in ADL and IADL activities, on average. Over ten years, mental health scores remain relatively stable, while functional health declines monotonically. At Round 1, 40% of the respondents worked for pay recently. The average household size at Round 1 is 2, meaning that, on average, older adults live with at least one other person. The average size of older adult's confidant network at Round 1 is 3.65. This number increases slightly to 3.92 five years later and remains steady in the following five years. On average, older adults talk to network members more than once a week. The frequency of contact decreased slightly in the following 10 years. At Round 1, 67% of the network members are kin. The composition of kin in confidant network decreases in the next 10 years, on average. As older adults get older, their confidant networks tend to shrink more. At the same time, the frequency of contact and proportion of kin tend to decrease.

My first research question asks how networks change as age increases. The between- and within-individual coefficients of age in Table 2 show that as an individual ages, the size of the social network increases while the frequency of contact and proportion of kin decrease. But if the results from the lower panel of Table 1 are combined, one can see that for the entire sample, the absolute change in network size, frequency of contact, and proportion of kin is relatively small. Based on Table 1, network size has a small increase while the frequency of contact and proportion of

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[2] I assigned the scores to different mental health categories as below: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent. Higher scores indicate better mental health.

[3] Similar to previous research, I assigned scores to each of nine functional health categories as follows: 0 = no difficulty, − 1 = some difficulty, − 2 = much difficulty, − 3 = unable to do. Scores closer to 0 indicate better functional health.

[4] The race/ethnicity category in this paper is the same as the category in the original data from NSHAP. NSHAP divides race and ethnicity into four categories: 1) White, 2) Black, 3) Hispanic, non-Black, 4) Other.

Table 1 Sociodemographic variables, contextual variables, network characteristics and change ($N = 1{,}168$). *Source*: NSHAP

	R1 (Mean/%)	R2 (Mean/%)	R3 (Mean/%)
Age	66	71	76
Gender (%)			
Male (ref.)	46	46	46
Female	54	54	54
Race/Ethnicity[a] *(%)*			
White (ref.)	76	76	76
Black	12	12	12
Hispanic, non-Black	9	9	9
Other	2	2	2
Education (%)			
College or more (ref.)	63	63	63
High school graduates or less	37	37	37
Marital status (%)			
Not married or no partner present (ref.)	29	33	40
Married or partner present	71	67	60
Health			
Mental health score	3.9	3.8	3.9
Functional health score	− 1.4	− 1.6	− 2.7
Working status (%)			
Did not work for pay lately (ref.)	60	73	85
Worked for pay lately	40	27	15
Neighbor ties		4.6	
Household size	2	2	2
Network characteristics			
Network size	3.65	3.92	3.95
Frequency of contact	6.88	6.75	6.65
Proportion of kin	.67	.66	.63

[a] In the sample of 1168, no older adults reported changes in their race and ethnicity or gender or educational level over the ten-year period

kin decrease monotonically for the entire sample, on average. Hypothesis 1 is partially supported. In addition, none of the between-individual coefficients are statistically significant. This indicates that no cohort difference in network size and structure is observed. However, this might be due to the small sample size of each cohort in the overall sample.

When performing more detailed analyses by social groups, I find statistically significant differences between people from different social groups. The upper panel of Table 2 shows the association between pre-existing social disadvantage and network size and structure. As suggested beforehand, racial minority status and lack of college education are indicators of social disadvantage. In the upper panel of Table 2, the coefficients suggest that older Black and Hispanic adults tend to have a smaller network size than older White adults. At the same time, older Black and Hispanic adults tend to have higher frequency of contact. Older Hispanic adults tend to have higher proportion of kin in the confidant network. These findings align with previous studies. Lower educational level is associated with a smaller network size, more frequent contact, and higher proportion of kin in the confidant network. These results suggest that people from disadvantaged groups tend to have smaller networks, a higher frequency of contact, and are more likely to have kin-centered networks. Hypothesis 2 is partially supported. Previous literature has suggested that a larger network size and a more diverse network are more beneficial. My findings suggest that older adults from disadvantaged socioeconomic backgrounds are less likely to have these beneficial networks. However, pre-existing disadvantages do not dictate the size and structure of individuals' networks over a long-time period. During older adulthood, as contextual factors shift, network features also shift.

Contextual factors play an important role in shaping older adults' networks, net of pre-existing social disadvantage. Mental health is an important indicator of network change. Better mental health is associated with more frequent contact with confidants and higher proportion of kin. As mental health improves, the average frequency of contact increases. No significant difference in network change has been found

Table 2 Between-within models of network change, unstandardized coefficients, and standard errors ($N = 1{,}168$). *Source*: NSHAP

	Network size	Frequency of contact	Proportion of kin
	Model 1 (COEF/SE)	Model 2 (COEF/SE)	Model 3 (COEF/SE)
Race/Ethnicity (ref. White)			
Black	−.095***	.330***	.008
	(.029)	(.059)	(.023)
Hispanic, non-Black	−.112***	.342***	.088***
	(.033)	(.068)	(.026)
Other	.008	.054	.033
	(.059)	(.129)	(.049)
Education (ref. College or more)			
High school graduates or less	−.100***	.256***	.078***
	(.019)	(.041)	(.016)
Mental health			
Between individuals	.006	.108***	.023*
	(.013)	(.027)	(.011)
Within individuals	.008	.045*	−.004
	(.016)	(.021)	(.007)
Functional health			
Between individuals	.007	−.009	−.005
	(.004)	(.008)	(.003)
Within individuals	.004	.005	−.004
	(.005)	(.007)	(.002)
Worked for pay lately			
Between individuals	−.015	.081	−.018
	(.028)	(.060)	(.023)
Within individuals	−.034	.151***	.019
	(.032)	(.043)	(.015)
Neighbor ties	.010*	.026**	−.012***
	(.004)	(.009)	(.003)
Control Variables			
Female (ref. Male)	.128***	.036	−.010
	(.019)	(.040)	(.015)
*Age * 10*			
Between individuals	−.006	−.023	.020
	(.015)	(.032)	(.012)
Within individuals	.072**	−.171***	−.039***
	(.024)	(.032)	(.011)
Married or partner present			
Between individuals	.007	.097	.112***
	(.024)	(.052)	(.020)
Within individuals	−.004	.036	.051*
	(.049)	(.065)	(.023)
Household size			
Between individuals	.005	.094***	.027**
	(.013)	(.027)	(.010)
Within individuals	.010	.037	-.002
	(.015)	(.020)	(.007)
Constant	1.305***	5.907***	.312**
	(.126)	(.267)	(.102)
AIC	12760.736	8379.334	1233.609
BIC	12877.807	8508.729	1363.004

Table 2 (continued)

	Network size Model 1 (COEF/SE)	Frequency of contact Model 2 (COEF/SE)	Proportion of kin Model 3 (COEF/SE)
Number of observations level 2	1,168	1,168	1,168
Number of observations level 1	3,504	3,504	3,504

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

between those older adults who worked for pay recently and those who did not. However, transitioning into working for pay is linked to more frequent contact with network members. The cohesiveness of the neighborhood in which older adults live also has implications for network change. Older adults who live in a more cohesive community tend to have a larger network size, higher frequency of contact, and lower proportion of kin. These results suggest that, despite pre-existing social disadvantage, positive contextual factors can lead to increase in network size, more contact with friends, and lower proportion of kin. Hypothesis 3 is partially supported. As for control variables, older adults who were married or had a partner present at Round 1 tend to have a higher proportion of kin than those who were not married or did not have a partner present. Those who transitioned into being married or having a partner present increased their proportion of kin in the confidant network. Older adults with a larger household size are likely to contact network members more often. Moreover, a greater proportion of these contacts are kin members.

Conclusions and discussion

The changes in the size and structure of close social ties impact essential life outcomes of older adults (English and Carstensen 2014; Goldman and Cornwell 2018; Litwin and Levinson 2018). However, what leads to these changes is not yet fully understood. Socioemotional selectivity theory and social convoy theory claim close social ties are more enduring than peripheral or weak ties in the aging process. The core question these theories address is which type of social ties are more enduring throughout the life course. However, even the strongest ties dissolve or change over a long-time period (Cornwell et al. 2021). Moreover, the pattern of network change differs for different social groups. For instance, Suanet and Huxhold's (2020) study on two Dutch cohorts suggests that the 1938–47 birth cohort is more likely to have an increase in network size around retirement age than the 1928–37 cohort, which is related to increased educational level and more diverse social roles. For another, the size and structure of the convoys of an adult are contingent on their own position in the network (Antonucci et al. 2014).What previous scholarship leaves unanswered is how the change in the strongest ties across time differs by socioeconomic status. To what extent do pre-existing social disadvantage and contextual factors shape one's closest social network ties? Based on the longitudinal study of older adults egocentric networks, I find that the pattern of network change in later life is contingent on the social background and the contextual factors in which individuals are situated. Additionally, I did not observe a monotonic decrease in network size over the ten years as previous studies suggested.

My findings suggest that pre-existing social disadvantage is associated with less favorable network features for older adults. Older adults who did not attend college have fewer close friends with whom to discuss important matters and have a higher proportion of kin in their close social circles. Likewise, Black older adults and Hispanic older adults have fewer confidants and are more likely to have kin as their close friends. Some scholars argue that the rule of homophily based on race and ethnicity might contribute to a smaller network size for older Black adults (Vanhoutte and Hooghe 2012). However, studies have shown that homophily based on racial and ethnic background in the friendship network does not benefit racial minorities (Moody 2001). A larger and more diverse network often indicates more social resources and benefits are available from the network members (Litwin and Levinson 2018). However, whether an individual can build and maintain such advantageous networks largely depends on their socioeconomic status and pre-existing resources. These findings align with previous scholarship. In the meantime, I find that less educated and racial minority older adults have a higher frequency of contact with confidants, compared to their counterparts. This could be because these older adults are more reliant on their network members for support and resources on a daily basis. I propose that contacting network members frequently is a necessity and functions as a strategy to activate the potential resources in the network. Close social ties, in this case, act as a complementary resource to make up for the lack of financial, cultural, and political resources available for these older adults.

I claim that social contexts and the shifts in these contexts can alter personal networks in significant ways, even though pre-existing social disadvantage restrains the size and diversity of personal networks. For instance, neighborhood cohesion is positively associated with the network size and negatively associated with proportion of kin. The social capital at the community level can be transferred to an individual level. Older adults living in a cohesive community have more chances to meet people outside of their family and build connections. A welcoming community also encourages people to initiate contacts and stay connected. On the other hand, instability in a variety of key social and personal variables might cause shifts in the network and the pattern of network change (Goldman and Cornwell 2018). Also, I find that mental health is linked to the size and structure of the close social circle. Older adults with better mental health tend to contact their close friends more often. Transitioning into better mental health or transitioning into working status is associated with more frequent contact with confidants. Better mental health empowers older adults to reach out and activate their social capital. If retired older adults return to work, this can still ignite social contact and connections.

Based on these findings, I propose that older adults make efforts to adjust to changes in their networks during the aging process. While holding the social background constant, within-individual changes in personal networks can be seen as the consequence of individual's efforts to cope with changes in the social context. Since a diverse and well-connected network is associated with more positive life outcomes (Litwin and Levinson 2018), older adults from disadvantaged backgrounds have more motivation to initiate contacts and stay connected. For instance, the death of a spouse is related to an increase in participation in group activities, frequency of contacting friends and family, and familial support (Iveniuk et al. 2020). For disadvantaged older adults, the close social circle can be the only resource to cope with negative life events. However, for privileged older adults, there can be multiple alternative resources at their disposal. Thus, these adults have less frequent need to contact their close ties. The cultivation and maintenance of social ties in later life depends not only on socioeconomic background, but also on propulsive action that not everyone can take. However, to what extent personal effort counts in making and sustaining social connections needs to be further examined. It takes a considerable amount of time, material resources, and emotional labor to maintain and convert social capital to materialistic or emotional resources. Individuals from disadvantaged social backgrounds have a higher likelihood of experiencing instability in the social environment and are more vulnerable to negative changes (Goldman and Cornwell 2018). When pre-existing disadvantage and less favorable social context compound, the stress they place on the social networks of the disadvantaged is also aggregated. In the end, it can lead to the concentration of social disadvantage.

This paper has a few limitations. First, this paper did not investigate the socioeconomic status of the network members of the older adults. Previous research suggests that older adults adjust networks in a way that favors their emotional needs over their materialistic needs. However, I propose that the way older adults utilize their network is highly likely to depend on their life situation and socioeconomic background. I mainly focus on the features of the ego and the contexts in which the ego is situated. I did not include any dyadic-level factors. Due to this limitation, I did not examine the network members' social resources. To understand how much the confidant network could help older adults in daily life, one needs to know what resources these network members provide for the older adults. Frequent contact could offer the emotional support that older adults need. Financial assistance is also a critical aspect of networks as resources. However, the NSHAP dataset does not have information on the degree to which the confidants provide financial aid for older adults. I also do not have data on the general material support that older adults obtained from their confidants. But previous studies based on empirical data have repeatedly shown that networks can provide various resources. Therefore, I assume this as a given. For future research, it would be helpful to collect data on what type of resources the ego obtains from each social tie.

Second, this paper uses only three rounds of data across ten years to model change in network size and structure. That is to say, the survey may fail to capture changes in contextual factors and network features over short time scales. However, considering the size of the final sample, I still found significant association between the change in the social context and network features. Ideally, future research will benefit from more frequently collected longitudinal network data. Third, this paper only investigates the dynamics of older adults' close ties. It does not show how the weaker ties change as adults age. The pattern of change in social ties could be very different for the stronger ties and the weaker ties. Finally, due to the limitations of the data, the aspects of key explanatory variables and their change that I can include in the models are limited. Further research along these lines will help to improve our understanding of the relationship between various contextual factors and network dynamics.

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Author contributions N.F. wrote and revised this manuscript.

Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Transitions across states with and without difficulties in performing activities of daily living and death: a longitudinal comparison of ten European countries

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Abstract
Ageing has been related to the onset of disability and dependency in older adults. There is a need to better understand the disability and dependency trajectories of older adults and their relationship with socio-demographic characteristics and institutional or cultural context. This study analyses the role of age, sex, education and self-perceived health in disability, dependency and death transitions, addressing the heterogeneity across European countries and inconsistencies when using different measures of disability. Multi-state models were adjusted to evaluate the role of risk and protective factors in the transitions to disability, dependency and death. Difficulties in performing activities of daily living (ADLs) assess disability and dependency states. Data were from the Survey of Health, Ageing and Retirement in Europe conducted in 2004–2013, considering individuals aged 65 and older at baseline from Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden and Switzerland. The results showed that transitions to disability and dependency varied with age, sex, education and self-perceived health. The probability of transition to disability and dependency states increases until the age of 70 for all countries. However, there was heterogeneity in the disability and dependency trajectories with ageing between men and women. In most countries, women live with difficulties and may need help for longer than men. Care policies should consider sex differences to decrease the burden of care of informal caregivers, particularly in countries where care systems are absent or partially developed and a high level of family obligations to care needs exist.

Keywords Ageing · Care dependency · Activities of daily living · Multi-state models · Longitudinal analysis · SHARE

Introduction

Ageing has been related to the onset of disability and care dependence in older adults, and help from others may be needed daily (Barnay and Juin 2016; Navarro Espigares et al. 2008; Van Houtven and Norton 2004). Some individuals start having difficulties and may require help earlier in life, while others may preserve independence for longer. The different disability and care dependency trajectories with ageing could vary according to socio-demographic characteristics and may be related to the institutional or cultural context, the type of help needed, the met or unmet care needs, and their quality of life (Abdi et al. 2019; Geerts and Van den Bosch 2012).

Disability and care dependence are complex and multidimensional constructs related to health conditions and contextual factors. Disability is an umbrella term for impairments, activity limitations and participation restrictions, and represents the negative aspects of the interaction between the individual's health condition and personal and environmental factors (WHO 2001). Meanwhile, care dependence is defined as the need for human help or care beyond that habitually required (Harwood et al. 2004). In previous works, the activities of daily living (ADLs) were used to operationalise these constructs (Amengual et al. 2021; Carmona-Torres et al. 2019; Edjolo et al. 2016; Jerez-Roig et al. 2018; Lima et al. 2018; Millán-Calenti et al. 2010; Rodríguez-Sampayo et al. 2011; Scheel-Hincke et al. 2020; WHO 2015). Typically, ADLs are classified into Basic Activities of Daily Living (BADLs) and Instrumental Activities of Daily Living (IADLs), thus representing the diversity

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and multidimensionality of the constructs (Katz et al. 1963; Lawton and Brody 1969). The ability to perform BADLs assesses functional capacity related to the individual's physical condition, whereas the IADLs evaluate activities that are more cognitively demanding and often approximate the potential of older adults to live independently (Millán-Calenti et al. 2010). Recently, Advanced Activities of Daily Living (AADLs), including social and community participation, the ability to communicate, and making decisions, have been also considered (WHO 2001).

The health status of older adults is characterised by the interaction of comorbidity, disability and frailty, which are also related to the use of health and social services, as older adults may need help with activities of daily living (Fried et al. 2004). Increasing age is associated with a higher risk of disability and need for help (care dependency), while sex, education and health status emerged as stratifying factors for disability and need for help (Arrighi et al. 2017; Barnay and Juin 2016; Bora and Saikia 2015; Cameron et al. 2010; Carmona-Torres et al. 2019; Crimmins et al. 2011). A higher educational attainment is associated with better health status as it is associated with better social and economic conditions (Hoogendijk et al. 2014). Health conditions such as dementia, stroke, limb impairment and depression are key contributors to disability and care dependence (Prina et al. 2020) and self-perceived health has been reported as the most informative measure of health status predicting mortality in population studies (Jylhä 2009). Moreover, hypertension confers a greater risk for ischemic stroke among women compared with men and after nonfatal stroke women have greater disability than men (Mokdad et al. 2018; Wenger et al. 2016). Therefore, it is relevant to evaluate how sex, education and self-perceived health shape the disability trajectories of older adults.

Previous studies stated that women outlive men with poorer health conditions, which is a well-documented phenomenon known as the “male–female health-survival paradox” (Austad 2006; Lima et al. 2018; Oksuzyan et al. 2008; Thorslund et al. 2013). Some studies looked at sex differences in performing ADLs (Crimmins et al. 2011; Lima et al. 2018; Millán-Calenti et al. 2010; Scheel-Hincke et al. 2020). In particular, Scheel-Hincke et al. (2020) analysed sex differences in performing ADLs using a large pooled cross-sectional setting for middle-aged and older adults who participated in the Survey of Health, Ageing, and Retirement in Europe (SHARE). They reported heterogeneity in the differences between men and women across European regions. Moreover, they argued that a widening of the sex gap with increasing age may be consistent with a survival effect, which leaves the healthiest men in the sample (Scheel-Hincke et al. 2020).

This study aims to evaluate whether transitions towards states with difficulties in performing ADLs in European older adults vary with sex, education and self-perceived health over time while simultaneously considering death in the models to eliminate the survival bias. Additionally, it addresses whether there is heterogeneity in sex differences in these trajectories across European countries and contextualises these results according to their cultural and institutional characteristics.

Previous literature on disability and care dependence of older adults in Europe

In addition to the work of Scheel-Hincke et al. (2020), there is a wide literature focusing on the disability of older adults in Europe. For instance, a previous cross-sectional study estimated the prevalence of disability, defined by the difficulties in performing BADLs, using data from SHARE in 2015 (Jerez-Roig et al. 2018). The authors reported regional differences across European regions (Northern, Central, Eastern and Southern), particularly they reported that older adults with disabilities from East Europe presented the most disadvantaged health profile, followed by the Southern region, and older adults living in the Northern region showed the most advantaged characteristics. Another study reported a considerable prevalence of disability that has been slowly decreasing in the period 2009 to 2017 (Carmona-Torres et al. 2019). Using cross-sectional data from Spain, they also reported that disability was associated with female sex, advanced age, and lower educational attainment, among other risk factors.

In a cross-sectional study, it was reported that older women have worse functioning and higher levels of disability in performing IADLs than men, but disability in performing BADLs was not different between men and women in the USA and in European countries (Crimmins et al. 2011). Moreover, a previous work using cross-sectional data from India showed sex differences in self-reported disability (Bora and Saikia 2015). Besides, older women have a higher number of activity limitations and there was heterogeneity across European countries (Lima et al. 2018).

Sex patterns of difficulties in performing BADLs and/or IADLs may be affected by the different roles of men and women in household activities, and a comparison across different cultures and institutional contexts could provide new insights into this heterogeneity (Millán-Calenti et al. 2010; Sheehan and Tucker-Drob 2019). Hence, differences between men and women may be relevant to inform actions that ensure the quality of life in older adults despite their difficulties and care needs (Beach et al. 2018).

Thorslund et al. (2013) reported that the female advantage in Life Expectancy found worldwide has been narrowing. However, the differences in disability-free life expectancies could still be relevant to understand for how long older adults live with difficulties in BADLs and/or IADLs that may require help (Moreno et al. 2020; Solé-Auró et al. 2015).

Many previous studies addressed differences in disability between older women and men using cross-sectional data. However, there is relatively less previous work using a longitudinal perspective which considers death simultaneously. Nevertheless, some studies have implemented a longitudinal perspective to analyse the health trajectories of older adults. For instance, Amengual et al. (2021) developed a methodology to classify individuals into groups, exploiting health information from panel data they estimated transitions across latent categories (health groups) and death, conditioning on socio-demographic characteristics and current health status. In turn, Arrighi et al. 2017) analysed the socio-economic determinants of transitions across disability and frailty states in European countries and reported an overrepresentation of socio-economically disadvantaged groups in the current cohorts of dependent older adults.

On the other hand, some studies aimed to understand the mix of care used by dependent older adults. For instance, Geerts and Van den Bosch (2012) analysed the transitions between formal and informal care utilisation across nine European countries between the first two waves of SHARE. Their results suggested that, while rates of formal care utilisation continue to differ considerably across European countries, formal care allocation practices are not very different across Northern and Continental European welfare states. In addition, they explored how macro-contextual factors affect transitions in formal and informal care utilisation by older Europeans considering two dimensions in which Long-Term Care (LTC) systems could vary: the degree of familial obligations (cultural dimension), and the existence of universal entitlements to public support, in-kind and/or by means of cash benefits (institutional dimension). Briefly, the authors reported that, in Spain and Italy, there is a high degree of family obligations in the cultural dimension and in the institutional dimension a universal needs-based system is absent or partial. In contrast, in the Netherlands, Sweden and Denmark, widely accessible public services coexist with a cultural dimension characterised by limited family obligations. In Austria and Germany, the needs-based entitlement system coexists with a culture of high levels of family obligations. Finally, the authors identify a medium level of family dependency obligations in France and Belgium, coexisting with a universal needs-based entitlement system in France, while in Belgium this system is either non-existent or partial (Geerts and Van den Bosch 2012). The different welfare states in European countries may facilitate (or not) female autonomy and economic independence from the family (Bambra 2004, 2007) and also it has been reported that less developed social policies and more pronounced socio-economic inequalities are related to higher levels of disability (Wahrendorf et al. 2013).

Aim and contributions

Although the literature on disability in older adults is extensive, previous research has overlooked transitions to disability and death simultaneously and focused on between-person rather than within-person transitions. A better understanding of trajectories to disability of older adults and how sex, education, and self-perceived health shape these trajectories is crucial to inform care policies designed to improve their quality of life and that of their families. However, our current understanding of disability trajectories in older adults is still limited and notably, most of the previous studies used cross-sectional design and ignored death. The proposed analytical strategy allows to consider the competing risks between transitions to disability and death to draw unbiased inferences and evaluate how sex, education, and self-perceived health change the risks of transitions. Moreover, assessing disability trajectories of older adults is particularly relevant in European countries where population ageing is putting pressure on the sustainability of social and health care systems. Finally, it is important to compare the results across countries, as this can provide new insights into disability trajectories and the role of sex in different institutional and cultural contexts (Geerts and Van den Bosch 2012). As a result, this study aims to analyse the role of socio-demographic characteristics (age, sex, and education) and health condition (assessed by the self-perceived health) on transitions towards states with and without difficulties in ADLs considering simultaneously the transition to death. This analysis considers ten European countries that participated in the SHARE study during the period 2004–2013. Additionally, it aims to address the heterogeneity across these European countries, particularly regarding sex differences in the patterns of transition towards disability and death, relating these results to the institutional and cultural contexts. Furthermore, to assess the multidimensionality of disability, the construct is approached by considering difficulties in different types of ADLs, namely BADLs and IADLs.

This analysis improves knowledge of ageing trajectories to inform long-term care policies, applying a longitudinal perspective which considers death, sex differences and the multidimensionality of disability, and contextualising the results regarding differences in cultural and institutional characteristics of the European countries. In particular, this study aims to investigate whether sex differences in the transition to disability can be explained by survival bias. Thus, the contribution is to better understand disability trajectories during the decade 2004–2013 considering death to avoid survival bias, and focusing on sex and cross-country differences. The analytical approach ensures comparability across European countries in order to contextualise the results in the different cultural and institutional contexts. Finally, this work contributes to analysing the heterogeneity in the role of the associated factors on the difficulties to perform different types of ADLs.

Methods

Data

The data come from the SHARE study, a multidisciplinary and cross-national panel database where information on health, socio-economic status and social and family networks of individuals aged 50 or older in Europe has been collected since 2004 across European countries (Bergmann et al. 2019; Börsch-Supan et al. 2013). For each participating country, a separate ethical approval was obtained by the respective ethics committees whenever it was required (for more details on the ethical approvals see: http://www.share-project.org/fileadmin/pdf_documentation/SHARE_ethics_approvals.pdf).

This current study includes data of individuals aged 65 years or older at baseline, from 10 European countries (Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden and Switzerland). The information was collected over 4 occasions (waves 1, 2, 4 and 5) covering the period from 2004 to 2013. Waves 3, 6, 7 and 8 were excluded from the current analysis to harmonise longitudinal data across countries: a special questionnaire was used in waves 3 and 7, the Netherlands did not participate in wave 6, and wave 8 was different due to COVID-19 and was 6 years apart from the last wave considered hampering the transition analysis. The total analytical sample for the 10 countries combined is 19,691 individuals. Table 1 presents descriptive characteristics of the study entry of the sample in each country. Only respondents with valid data on the difficulty in performing ADLs (> 99%), education (> 97%) and self-perceived health (SPH) (> 99%) and also with two known states during the period 2004–2013 (> 78%) were included in the analyses. Pairwise deletion was used to handle missing data and no weighting procedures were applied to address loss of follow-up (< 32%). Death status and age at death were retrieved from SHARE data up to wave 7 (2017).

Variables and measures

For the purposes of the analysis, a series of dummy variables were derived to account for differences in education (1 = the highest educational attainment is first or second stage of tertiary education according to the International Standard Classification of Education 1997, ISCED-97, coding, 0 = otherwise), sex (1 = Female, 0 = Male) and self-perceived health (1 = declared "Excellent" or "Very good" self-perceived health, 0 = declared "Good", "Poor" or "Fair" self-perceived health). Education was measured at baseline

Table 1 Descriptive characteristics at study entry (N = 19,691)

Country	N	Age	Female	High education	Better health	ND B&IADLs	D B&IADLs	ND BADLs	D BADLs	Deaths
Austria	2453	73.26 (6.49)	1407 (57.36)	559 (22.79)	664 (27.07)	1861 (75.87)	592 (24.13)	2123 (86.55)	330 (13.45)	245
Belgium	2493	73.45 (6.87)	1374 (55.11)	592 (23.75)	585 (23.47)	1791 (71.84)	702 (28.16)	2021 (81.07)	472 (18.93)	312
Denmark	1345	72.83 (6.84)	734 (54.57)	387 (28.77)	597 (44.39)	1059 (78.74)	286 (21.26)	1181 (87.81)	164 (12.19)	312
France	2647	74.21 (7.04)	1531 (57.84)	365 (13.79)	381 (14.39)	1975 (74.61)	672 (25.39)	2210 (83.49)	437 (16.51)	328
Germany	1282	71.43 (6.00)	643 (50.16)	332 (25.90)	182 (14.20)	1020 (79.56)	262 (20.44)	1113 (86.82)	169 (13.18)	159
Italy	2054	71.77 (6.08)	1051 (51.17)	88 (4.28)	316 (15.38)	1655 (80.57)	399 (19.43)	1763 (85.83)	291 (14.17)	317
The Netherlands	1573	71.94 (6.35)	816 (51.88)	281 (17.86)	407 (25.87)	1320 (83.92)	253 (16.08)	1432 (91.04)	141 (8.96)	214
Spain	2380	74.24 (7.10)	1294 (54.37)	115 (4.83)	288 (12.10)	1709 (71.81)	671 (28.19)	1906 (80.08)	474 (19.92)	552
Sweden	1873	73.04 (7.22)	969 (51.74)	343 (18.31)	678 (36.20)	1481 (79.07)	392 (20.93)	1640 (87.56)	233 (12.44)	455
Switzerland	1591	73.11 (6.63)	826 (51.92)	175 (11.00)	589 (37.02)	1404 (88.25)	187 (11.75)	1474 (92.65)	117 (7.35)	117
Total	19,691	73.09 (6.77)	10,645 (54.06)	3237 (16.44)	4687 (23.80)	15,275 (77.57)	4416 (22.43)	16,863 (85.64)	2828 (14.36)	3011

Values are sample size and %, or mean and standard deviation for Age. "High education" indicates that the highest educational attainment is the first or second stage of tertiary education according to the International Standard Classification of Education 1997, ISCED-97, coding. "Better health" represents that the person reported an "Excellent" or "Very good" self-perceived health, as opposed to reporting "Good", "Poor" or "Fair" self-perceived health.

ND, no disability; D, disability; B&IADLs, basic and/or instrumental activities of daily living; BADLs, basic activities of daily living and self-perceived health at each wave. Age and age at death were measured in years.

Activities of daily living and the disability state. Difficulties in performing BADLs and/or IADLs were considered to determine states. Six BADLs were considered: dressing, including putting on shoes and socks; walking across a room; bathing or showering; eating, such as cutting up your food; getting in or out of bed; and using the toilet, including getting up or down, while six IADLs were preparing a hot meal, shopping for groceries, making telephone calls, taking medications, doing work around the house or garden, and managing money, such as paying bills and keeping track of expenses.

At study entry, individuals were classified into two possible states: one represents a state without difficulties in performing ADLs (ND) and the other a state with difficulties in performing any ADLs (D). As information about death becomes available, the individuals were classified in the death state (Death).

Two operationalisations of the D state were assessed. First, the D state was determined when the individual had difficulties in performing at least one BADL and/or IADL, corresponding to a comprehensive disability state which considers different types of ADLs (Millán-Calenti et al. 2010). I refer to this operationalization of D state as "disability state". Secondly, an individual was classified in the D state when declared to have difficulties in performing at least one BADL, without considering the difficulties in performing IADLs. This second operationalization could be considered a "proxy" of the care dependency state. Like in previous studies, having one or more difficulties in BADLs would probably be associated with the need for help to perform daily activities (Rodríguez-Sampayo et al. 2011) and considers also the hierarchy in the loss of functionality with increasing age (Dunlop et al. 1997; Edjolo et al. 2016). Although it is a "proxy" of care dependence, I refer to this operationalization of the D state as a "dependency state".

Statistical approach

Multi-state models (MSM) were used to analyse the transitions across states with and without difficulties in performing ADLs and death (van den Hout 2016b). The MSM model can be defined as an overall fixed-effects model for the process of interest as well as for survival, and when it includes a death state is called a multi-state survival model (van den Hout 2016b). In this model, the probability of transition to disability and the probability of death are estimated simultaneously in such a way that survival bias is considered in the inferences. This parametric approach allows to model transitions among the three states: ND, D and death, and examines the role of risk factors on all transitions simultaneously. As previously mentioned, the D state corresponds to a disability state, with difficulties in performing BADLs and/or IADLs, or a dependency state, with difficulties in performing BADLs, depending on the operationalisation used. See Fig. 1 for a pictorial representation of the three-state model.

Two empirical strategies were implemented. The first strategy assessed simultaneously the role of age, sex, education and self-perceived health on transitions among the three states, with pooled data of individuals from ten European countries. In this strategy, age was included as a covariate on all transitions modelled. Sex, education, self-perceived health and country-specific fixed effects were included in all transitions except for the backward transition from D to ND state. These effects were excluded from the backward transition because it is challenging to assess the recovery from disability with the low number of individuals transitioning from D to ND and the 2-year time windows between observations (Hardy and Gill 2004).

The second strategy focuses on assessing the heterogeneity among these ten European countries with respect to the role of sex in transitions between disability states. In this case, the MSM were estimated for each country allowing the cross-country comparison of the role of sex on the transitions. Hence, age and sex were included as covariates on all transitions, with the exception of the transition from D to ND, due to the same reason as before.

In both strategies, age at death was used to identify death status. In cases where the individual was still alive at the last wave considered (wave 5 in 2013) but the age at death was known from a later wave (wave 6 in 2015 or wave 7 in 2017), it was incorporated in the analysis. Interval censoring was used for transitions between living states because the transition times are not observed in the data (van den Hout 2016b). For instance, the time of onset of disability is known to lie in the time interval defined by two successive observations.

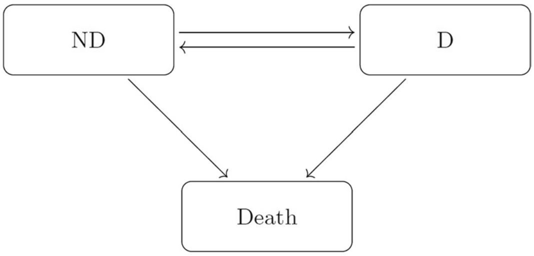


Fig. 1 Three-state model for states with and without difficulties in performing ADLs and death. *Notes*: D state was operationalised in two ways: 1-at least one difficulty in performing Basic Activities of Daily Living and/or Instrumental Activities of Daily Living, 2-at least one difficulty in performing Basic Activities of Daily Living. The arrow illustrates transitions modelled over time. ND, no disability; D, disability

The *msm* package for R (Jackson 2011) was used to estimate the MSM. As a result, the hazard ratios of the covariates over the transitions and their confidence intervals are estimated. The hazard ratios represent the instantaneous transition rate and if they are greater than one indicates a higher instantaneous transition risk conditional on the covariates. In addition, the transition probability across states and its change with age are estimated. At each time point, the probability of transition to disability and to death is estimated as competing event probabilities rather than estimating the transition probability to disability conditional on being alive.

After estimating the MSM, the R package *elect* estimate total and marginal Life Expectancy (LE) (van den Hout 2016a). Total LE is the expected number of years of life remaining at a given age. Marginal LE is obtained for states in which individuals are alive and for a specific state represents the expected number of years spent in that state regardless of the initial state at a given age. The *elect* package fits a multinomial regression model to estimate total and marginal LEs. In this work, the marginal LE obtained for the ND state represents the disability-free LE. Total and disability-free life expectancies were estimated at 65 years for men and women to evaluate the role of sex.

Results

Role of age, sex, education and self-perceived health on disability transitions

Table 2 shows the effects of covariates on transitions across disability, dependency and death states with pooled data from ten European countries. Figures 2 and 3 depict the hazard ratios for the effects of sex (1 = Female vs. 0 = Male) and education on transitions.

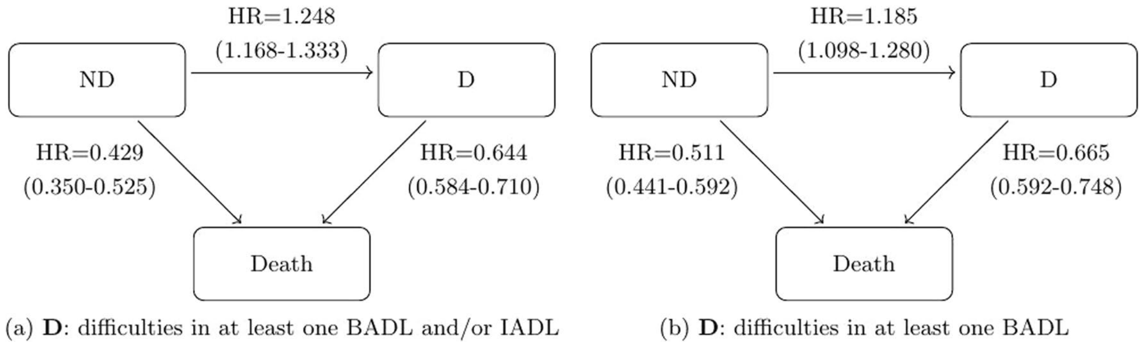
Table 2 Hazard ratio and 95% confidence intervals for the effect of covariates on transitions

	Difficulties in BADLs and/or IADLs				Difficulties in BADLs			
	Age	Female	High education	Better health	Age	Female	High education	Better health
ND-D	1.088* (1.081–1.094)	1.248* (1.168–1.333)	0.791* (0.715–0.875)	0.434* (0.395–0.478)	1.085* (1.078–1.092)	1.185* (1.098–1.280)	0.784* (0.695–0.885)	0.436* (0.387–0.492)*
ND-Death	1.085* (1.069–1.101)	0.429* (0.350–0.525)	0.843 (0.652–1.090)	0.530* (0.416–0.677)	1.096* (1.085–1.108)	0.511* (0.441–0.592)	0.947 (0.781–1.148)	0.476* (0.388–0.583)
D-ND	0.949* (0.941–0.957)	–	–	–	0.957* (0.949–0.965)	–	–	–
D-Death	1.079* (1.072–1.086)	0.644* (0.584–0.710)	0.996 (0.838–1.183)	0.629* (0.491–0.804)	1.078* (1.069–1.086)	0.665* (0.592–0.748)	0.874 (0.702–1.090)	0.626* (0.448–0.876)

The table shows the effects of covariates on the risk of transitioning with pooled data from ten European countries. “High education” indicates that the highest educational attainment is first or second stage of tertiary education according to the International Standard Classification of Education 1997, ISCED-97, coding. “Better health” represents that the person reported an “Excellent” or “Very good” self-perceived health, as opposed to reporting “Good”, “Poor” or “Fair” self-perceived health

ND, no disability; D, disability; BADLs, basic activities of daily living; IADLs, instrumental activities of daily living

*5% significant ratio



(a) **D**: difficulties in at least one BADL and/or IADL (b) **D**: difficulties in at least one BADL

Fig. 2 Three-state model with the effect of sex on transitions with pooled data. *Notes*: The figures include the HRs (95% confidence intervals) with pooled data from ten European countries for both operationalisations of D. ND, no disability; D, disability; HR, hazard ratio; BADLs, basic activities of daily living; IADLs, instrumental activities of daily living

(a) **D**: difficulties in at least one BADL and/or IADL

(b) **D**: difficulties in at least one BADL

Fig. 3 Three-state model with the effect of high education on transitions with pooled data. *Notes*: The figures include the HRs (95% confidence intervals) with pooled data from ten European countries for both operationalisations of D. ND, no disability; D, disability; *HR* hazard ratio; BADLs, basic activities of daily living; IADLs, instrumental activities of daily living

Age

Increasing age was associated with a higher risk of transition to death, either from ND or D states. This result holds for both operationalisations of the D states, specifically when considering difficulties in performing BADLs and/or IADLs (HR = 1.088 CI = [1.081, 1.094]) as well as when considering only difficulties in BADLs (HR = 1.085 CI = [1.078, 1.092]). With regards to the reverse transition, the results suggested that increasing age was associated with a decreasing risk of transitioning from D to ND, also in both operationalisations of D state (see Table 2).

Sex

Being female was associated with a lower risk of transitioning from ND or from D to death and a higher risk of transitioning from ND to D for both operationalisations: considering BADLs and/or IADLs (HR = 1.248 CI = [1.168, 1.333]) or only BADLs (HR = 1.185 CI = [1.098, 1.280]) (see Fig. 2).

Education

Having a high educational attainment was associated with a lower risk of transitioning from ND to D, when D is a disability or a dependency state. However, a high level of education was not significantly associated with the risk of transitioning to death (see Fig. 3).

Self-perceived health

Having reported a better self-perceived health was associated with a lower risk of transitioning from ND to D for both operationalisations and transitioning to death irrespective of the initial state (see Table 2).

Cross-country comparison of sex differences

Sex differences on disability transitions considering death

The results showed great heterogeneity among the European countries regarding the effect of sex on transitions to disability or dependency and death (see Table 3). Also, there were inconsistencies within countries when different operationalisations of the D state were used. When difficulties in performing BADLs and/or IADLs are considered, and D represents a disability state, Spain, Italy, the Netherlands, Austria and Belgium showed a higher risk of transition from ND to D for women than men. However, when considering only difficulties in performing BADLs and the D state represents a dependency state, sex differences are statistically significant only in Spain, Italy and Belgium.

Regarding the transitions to death, most of the countries showed a lower risk of transition for women than men, for both operationalisations and irrespective of the initial state. However, there were some hazard ratios not statistically significant (i.e. for Belgium, Germany and Austria when the initial state is ND and D is a disability state).

Fitting multi-state models also gives the probability of transition among states and how this varies with increasing age (see Figure S.1 and Figure S.2 in supplementary material). The results showed that the probability of transitioning to disability and dependency increases until the age of 70, across countries. This result suggests that after that age, when this probability is stable, the transition to death is more likely. Furthermore, the probability of transition to disability over time is higher than the probability of transition to dependency and, in some countries, statistically

Table 3 Hazard ratios and 95% confidence intervals for the effect of sex on transitions by country

Country	Transition ND-D		Transition ND-Death		Transition D-Death	
	Diff. B&IADL	Diff. BADL	Diff. B&IADL	Diff. BADL	Diff. B&IADL	Diff. BADL
Austria	1.365* (1.096–1.700)	1.190 (0.926–1.530)	0.477* (0.258–0.880)	0.609* (0.384–0.968)	0.729 (0.503–1.056)	0.771 (0.496–1.198)
Germany	1.204 (0.936–1.549)	1.057 (0.795–1.405)	0.616 (0.301–1.260)	0.619 (0.340,1.128)	0.692 (0.430–1.114)	0.818 (0.474–1.411)
Sweden	1.086 (0.887–1.331)	0.970 (0.760–1.238)	0.463* (0.271–0.793)	0.565* (0.382–0.834)	0.842 (0.653–1.086)	0.903 (0.660–1.234)
The Netherlands	1.469* (1.155–1.869)	1.201 (0.875–1.648)	0.190* (0.069–0.527)	0.348* (0.205–0.592)	0.637* (0.437–0.929)	0.697 (0.430–1.132)
Spain	1.646* (1.388–1.952)	1.609* (1.323–1.957)	0.362* (0.211–0.620)	0.494* (0.332–0.735)	0.627* (0.503–0.782)	0.592* (0.464–0.755)
Italy	1.562* (1.284–1.901)	1.490* (1.198–1.852)	0.258* (0.114–0.586)	0.364* (0.210–0.630)	0.631* (0.476–0.836)	0.684* (0.494–0.948)
France	1.172 (0.988–1.391)	1.135 (0.932–1.382)	0.292* (0.106–0.801)	0.522* (0.297–0.917)	0.702* (0.537–0.916)	0.720* (0.522–0.994)
Denmark	1.077 (0.839–1.382)	1.045 (0.772–1.415)	0.725 (0.435–1.210)	0.724 (0.500–1.047)	0.653* (0.480–0.889)	0.710 (0.470–1.071)
Switzerland	0.968 (0.730–1.282)	1.101 (0.777–1.560)	0.376* (0.175–0.811)	0.338* (0.193–0.590)	0.482* (0.266–0.874)	0.688 (0.308–1.535)
Belgium	1.242* (1.052–1.466)	1.225* (1.013–1.482)	0.613 (0.315–1.194)	0.590* (0.358–0.974)	0.472* (0.358–0.623)	0.461* (0.331–0.642)

Disability state was determined when the individual had difficulties in at least one BADL and/or IADL. Dependency state was determined as a proxy, when the individual had difficulties in at least one BADL

ND, no disability; D, disability; Diff. B&IADL, difficulties in BADLs and/or IADLs; Diff. BADL, difficulties in BADLs; HR, hazard ratio; BADL, basic activities of daily living; IADL, instrumental activities of daily living

*5% significant ratio

significant differences between women and men occur (i.e. Spain and Italy). This result is consistent with the hazard ratios (see Figure S.1 and Figure S.2 in supplementary material).

Total and disability-free life expectancies

Table 4 shows the total and disability-free life expectancies for males and females in each country at the age of 65 years.

Table 4 Life expectancies for male and female participants at 65 years old

Country	Life expectancies in years (95% CI)[a]		Disability-free life expectancy in years (95% CI)[b]	
	Female	Male	Female	Male
Austria	20.87 (20.03,21.72)	18.01 (17.05,18.98)	12.70 (11.86,13.55)	12.74 (11.77,13.70)
Germany	20.98 (19.83,22.13)	18.67 (17.56,19.78)	13.18 (12.04,14.33)	13.13 (12.03,14.24)
Sweden	19.43 (18.61,20.24)	17.19 (16.45,17.93)	14.14 (13.33,14.95)	13.16 (12.42,13.89)
The Netherlands	22.66 (21.51,23.81)	18.11 (17.07,19.15)	14.81 (13.66,15.96)	14.16 (13.12,15.20)
Spain	19.11 (18.48,19.73)	15.97 (15.27,16.66)	11.23 (10.60,11.86)	11.76 (11.07,12.46)
Italy	20.64 (19.87,21.41)	17.69 (16.88,18.50)	12.36 (11.59,13.13)	13.07 (12.26,13.88)
France	22.35 (21.66,23.04)	19.42 (18.65,20.19)	13.05 (12.36,13.74)	12.83 (12.06,13.60)
Denmark	18.80 (17.77,19.83)	16.49 (15.45,17.53)	13.01 (11.99,14.04)	12.42 (11.39,13.46)
Switzerland	24.71 (23.45,25.96)	19.77 (18.67,20.87)	18.16 (16.91,19.42)	15.72 (14.62,16.82)
Belgium	22.94 (22.21,23.66)	18.86 (18.11,19.61)	12.55 (11.82,13.27)	12.54 (11.79,13.29)

D state is a disability state, and was determined when the individual had difficulties in at least one BADL and/or IADL

[a] Total LE in years

[b] LE in state no disability irrespective of where you are at a given age

Across all countries total LE at this age is higher for women than men. However, the disability-free LE is very similar for women and men in most countries (except Switzerland or Sweden).

Sensitivity analyses

Sensitivity analyses were conducted to assess the robustness of the results regarding the role of sex on the transitions across states in the cross-country analysis. First, we added the covariate indicating high educational attainment to all transitions, with the exception of the transition from D to ND. The results regarding the role of sex on the transitions to disability and dependency were essentially the same as the model that does not include the educational attainment (see Table S.1). Secondly, the models were adjusted by self-perceived health, and some differences emerged in Belgium. In the case of dependency, when only BADLs were considered to determine D state, sex differences were statistically significant in Spain and Italy but not in Belgium. However, for disability state (BADLs and/or IADLs) the results were consistent across the different model specifications (see Table S.2).

Additional analyses were performed by changing the dichotomic variables that measure education and self-perceived health. Tables S.3 and S.4 detail the recoding of the dichotomic variables and showed that results did not change substantially.

Discussion

This study analysed the role of socio-demographic characteristics and health status in the transition to states with and without difficulties in performing ADLs in ten European countries. A longitudinal perspective was used for the decade 2004–2013. The analytical approach allowed to look at the transition to disability, dependency and death states and how different factors affect them simultaneously.

In pooled country analyses, results showed that the risk of transition varied with age, sex, education and self-perceived health. As expected, increasing age was associated with a higher risk of transition to disability and death. This result was consistent between both measures of disability state, that is when considering difficulties in performing BADLs and/or IADLs or difficulties in BADLs only. Moreover, in the cross-country analyses, the effect of age in all transitions is consistent across European countries and both measures of disability.

Furthermore, in the pooled country analysis, female sex emerged as a risk factor for disability and sex effect in the transition to disability (the risk of transition is 24.8% higher for women) is more than double the effect of age (the risk of transition is 8.8% higher for each additional year). Also, the results showed that female sex is a protective factor for mortality in keeping with previous works (Arrighi et al. 2017; Austad 2006; Bora and Saikia 2015; Cameron et al. 2010; Carmona-Torres et al. 2019; Crimmins et al. 2011; Lima et al. 2018; Oksuzyan et al. 2008; Thorslund et al. 2013). Several factors and a range of explanations have been proposed to understand sex differences in health and mortality. The most common are biological risks, risks acquired through social roles, lifestyle and illness behaviours, and differential healthcare access treatment and use (Oksuzyan et al. 2010). Regarding education, current results suggest that higher educational attainment reduces the risk of transition to disability. However, higher educational attainment does not affect the transition to death. Education has been suggested as a stable indicator of people's social position after young adulthood, representing their material and non-material resources (von dem Knesebeck et al. 2006), ultimately leading to a strong predictor of health in old age (Hoogendijk et al. 2014). Finally, in keeping with previous studies better self-perceived health is associated with a lower risk of disability and mortality, which may be due to its ability to reflect the state of the human organism (Carmona-Torres et al. 2019; Jylhä 2009). However, previous studies have reported that increasing age is associated with worse self-perceived health, but reporting biases would not be as relevant when comparing differences by sex or education (Oksuzyan 2019; Spitzer and Weber 2019).

In the cross-country analysis, it was possible to compare the differences in trajectories towards disability and dependency considering death, in the different cultural and institutional contexts of the ten European countries. The results showed that for some countries the effect of sex on the risk of transition to disability remains significant, while for others the corresponding p values suggested no significant differences between men and women. There were sex differences in the transition to a state with difficulties in performing BADLs and/or IADLs in Spain, Italy, the Netherlands, Austria and Belgium. However, sex differences were not statistically significant when considering the transition to a state with difficulties in performing only BADLs, except in Italy and Spain. The higher risk of transition to the dependency of women in Spain and Italy complements existing cross-sectional findings that less developed social policies and more pronounced socio-economic inequalities are associated with higher levels of disability (Wahrendorf et al. 2013). In addition, welfare states in Spain and Italy may increase the risk of disability and dependency for women, where high levels of family obligations coexist with an absent or only partial universal needs-based social care system (Geerts and Van den Bosch 2012). In other countries, such as Denmark or Sweden, the welfare state could provide gender protection. Thus, these results suggest that welfare state policies may be associated with women’s autonomy (Bambra 2004, 2007) and their risk of disability and dependency.

The different results between disability, measured by the difficulties in performing BADLs and/or IADLs, and dependency, measured by the difficulties in performing BADLs are in line with the literature. Previous analyses reported sex differences in difficulties to perform IADLs but not BADLs (Crimmins et al. 2011). As already suggested, the sex division of household tasks could explain the differences between men and women in performing IADLs, with men not performing this type of activities and therefore not reporting difficulties in performing them (Fleishman et al. 2002; Millán-Calenti et al. 2010; Sheehan et al. 2019; Sheehan and Tucker-Drob 2019). Previous work has reported that some IADLs, such as preparing a hot meal or shopping, are mainly performed by women, who may report higher level of difficulty than men (Sheehan and Tucker-Drob 2019).

On the other hand, no statistically significant sex differences are observed in the risk of transition to dependency in most countries (the Netherlands, Austria, Belgium, France, Germany, Sweden, Denmark and Switzerland), suggesting that the “male–female survival-health paradox” do not hold for dependency state. As already argued, difficulties in BADLs can be considered as an indicator of care dependence and thus of a state in which individuals need help from others (Rodríguez-Sampayo et al. 2011). Sex differences in the transition to dependency, as measured by difficulties in performing BADLs, only emerged in Italy and Spain. In Belgium, the results were not robust to different model specifications, so that sex differences in the transition to dependency cannot be ensured in this country. Despite this, the results for Spain and Italy are concerning. In these countries, universal social care systems are absent or partially developed and their cultural norms have a high level of family obligations to care needs, which usually falls in women unpaid work (Geerts and Van den Bosch 2012). Therefore, care policies should take special account of sex differences in order to decrease the burden of care on (informal) family caregivers.

Current results allowed us to understand how the probability of transition to disability changes with increasing age across countries. This probability increases until 70 years old for all countries and both disability measures. Considering that death is not observed for all the individuals participating in the study, the estimated probability of transition to death increases with age, though it is always lower than one. Similarly, the estimated probability of transition to disability after 70 years old flattens rather than decreases to zero with age. Additionally, in most countries the LE suggests that women live with difficulties and may require daily help from others for longer than men.

The current results are not without limitations. Firstly, the approximation of older adults' dependence was analysed through a proxy measure, due to the lack of information about the need for help to perform ADLs in SHARE data. Thus, these results can only contribute to the understanding of dependence that is generated by the person's functional difficulty in performing daily activities. However, with the available data it is not possible to inform about the level of dependence and the need for help from others. For instance, dimensions related to mental health, depressive symptoms, among others may affect the level of dependence state of older individuals beyond their functional disability. It would be imperative that surveys of longitudinal studies of ageing incorporate questions gathering the need for help in ADLs in order to assess the level of dependence in future analyses. Second, the disability measures are based on self-reported and although they are good for approximating this condition, it would be desirable to complement them with other objective measures (Bravell et al. 2011; Duim and Ferrer 2017).

Transitions to disability, dependency and death are affected by age, sex, educational attainment and self-perceived health status. Heterogeneity across European countries in terms of sex differences in transitions to disability and dependency was evident, although not as widespread when we proxy dependence on the basis of difficulties in performing BADLs. However, there were some countries (Italy and Spain) with sex differences in dependency and with their cultural and institutional contexts gender-sensitive care policies are crucial.

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Author contributions The author confirms sole responsibility for the following: study conception and design, data analysis and interpretation of the results, and manuscript preparation.

Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Joint predictability of physical frailty/pre-frailty and subjective memory complaints on mortality risk among cognitively unimpaired older adults

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Abstract

The aim of the present study was to investigate how frailty/pre-frailty in combination with subjective memory complaints predicts all-cause mortality in community dwelling cognitively unimpaired older adults. There were 1904 community-dwelling cognitively unimpaired persons aged 65 years or older who participated in the 2013 Taiwan National Health Interview Survey with a 5-year follow-up. Frailty was determined based on the fatigue, resistance, ambulation, illness, and loss of weight (FRAIL) scale. Two questions ("Do you have difficulties with your memory or attention?" and "Do you have difficulties with your memory only or attention only or both?") were used to screen for subjective memory complaints (SMC). In this study, 11.9% of participants had both frailty/pre-frailty and SMC. A total of 239 deaths were recorded after 9009.5 person-years of follow-up. After adjustment for other factors, compared with participants who were physically robust with no SMC, participants who reported either SMC alone (HR = 0.88, 95% CI = 0.60–1.27) or were frail/pre-frail alone (HR = 1.32, 95% CI = 0.90–1.92) had no significantly increased mortality risk. However, coexisting frailty/pre-frailty and SMC was associated with a significantly increased hazard ratio for mortality of 1.48 (95% CI = [1.02–2.16]). Our results highlight the high prevalence of co-occurring frailty/pre-frailty and SMC and that this co-occurrence is associated with an increased risk of mortality among cognitively unimpaired older adults.

Keywords Frailty · Subjective memory complaints · Mortality · Taiwan

Introduction

Subjective memory complaints (SMC) is a condition characterized by self-perceived memory deficits in everyday life. Most previous studies of factors associated with SMC in older adults have focused on normal aging processes, poorer objective memory performance, self-perceived health, and the presence of psychiatric and neurologic disorders (Elfgren et al. 2010; Genziani et al. 2013; Lehrner et al. 2014; Montejo et al. 2014; Montejo Carrasco et al. 2017). SMC has been linked to an increased risk of falls, health care utilization, nursing home admission, and incident dementia (Waldorff et al. 2009; Mitchell et al. 2014; Al-Sari et al. 2017). Therefore, SMC could have value as a clinical marker that could be used to identify individuals who require more care.

Frailty is an important concept as it can enable the identification of older individuals with increased vulnerability who are at higher risk of adverse outcomes. Physical frailty is also associated with increased mortality (Lahousse et al. 2014). However, among cognitively unimpaired older persons, associations between physical frailty and mortality reported in the literature have been inconsistent (Avila-Funes et al. 2009; Feng et al. 2017). Feng et al. (2017) analyzed data from 2375 community-living Singaporeans aged 55 years and older participating

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in the Singapore Longitudinal Ageing Study. They found that the presence of frailty or pre-frailty in older persons without cognitive impairment at baseline was not associated with an increased risk of mortality during an approximately 3-year period.

Robertson et al. (2014) conducted a cross-sectional study using data from The Irish Longitudinal Study on Aging that included participants aged 50 and older without a history of stroke, Parkinson's disease, severe cognitive impairment, or antidepressant use. The authors found worse performance across multiple cognitive domains such as memory, processing speed, executive function, and attention in those who were pre-frail or frail. Wu et al. (2015) also conducted a cross-sectional study using data from the I-Lan Longitudinal Aging Study including a total of 1839 community residents aged 50 years or older without dementia or global cognitive impairment or cognitive complaints at baseline. They found that frail individuals were 2.55 times more likely to have memory-domain impairment than robust individuals. These findings highlight that SMC may be under-recognized among community dwelling cognitively unimpaired older people and that a vulnerable subgroup of these older adults will have both frailty/pre-frailty and SMC. Despite this evidence, data about the epidemiology of co-occurring frailty/pre-frailty and SMC among cognitively unimpaired older persons have not been well characterized. Little is known about how frailty/pre-frailty in combination with SMC is associated with mortality risk among cognitively unimpaired older persons.

Previous studies show that older adults with pre-frailty have different profiles in terms of clinical, functional, and behavioral and biomarker characteristics to robust individuals (Abellan van Kan et al. 2008a). It has also been reported that older adults with pre-frailty and frailty share similarities in pathological aging (Ruan et al. 2015). There is increasing evidence that prompt interventions in older adults with pre-frailty to achieve a better outcome than intervening at a later stage (Abellan van Kan et al. 2008a). Therefore, in this study, we have merged the categories of pre-frailty and frailty as a single category.

In view of these considerations, we have analyzed data from a 5-year prospective study of a national sample of community-dwelling cognitively unimpaired older adults in Taiwan. The aims of the present study were twofold. First, we aimed to describe the distribution of co-occurring frailty/pre-frailty and SMC among cognitively unimpaired older people. Second, we aimed to examine the association between coexisting frailty/pre-frailty and SMC and mortality in cognitively unimpaired older adults. We hypothesized that those with coexisting frailty/pre-frailty and SMC would have an increased risk of all-cause mortality.

Methods

Study population

This was a prospective study involving participants in the National Health Interview Survey (NHIS) in Taiwan, 2013. The sample design of the NHIS has been described in detail previously (Li et al. 2020; Li et al. 2021a, b). All study participants provided signed written informed consent. There were a total of 3203 individuals aged 65 years and older of whom we excluded 172 persons with a pre-existing dementia or Parkinson's disease diagnosis and 461 persons with incomplete data for the Mini-Mental State Examination (MMSE), physical frailty, depressive symptoms, or SMC. Out of these 2570 participants, we excluded a further 666 participants who were diagnosed as cognitively impaired (MMSE score < 18 for participants who were illiterate and had no schooling, < 21 for those with 1–6 years of education, and < 25 for those with 7 or more years of education) (Folstein et al. 1975; Katzman et al. 1988). This resulted in 1904 eligible participants for the analysis. The study cohort was followed until death or the end of the study period (December 31, 2018). Deaths were confirmed by the computerized data files of the National Register of Deaths. The processes of data set linkage and statistical analysis were performed at the Data Science Center of the Ministry of Health and Welfare. This study was approved by the relevant institutional review board.

Measures

Assessment of physical frailty and SMC

In this study, frailty and pre-frailty were determined based on the fatigue, resistance, ambulation, illness, and loss of weight (FRAIL) scale (Abellan van Kan et al. 2008a, b). Fatigue was assessed by asking individuals how much of the time they felt tired in the past 1 week. Responses of "all" or "most of the time" were given a score of 1. Resistance was assessed by asking individuals whether they have difficulty climbing ten steps, and ambulation was assessed by asking individuals whether they have difficulty walking 100 m (about one block). Responses of "some difficulty", "much difficulty", or "unable to carry out" received a score of 1. Illnesses were assessed by asking individuals if a medical professional has ever told them that they have any of the following conditions: diabetes, heart disease, hypertension, stroke, asthma, kidney disease, chronic lung disease, cancer, and arthritis. A report of five or more illnesses received a score of 1. Loss of weight was assessed by body mass index (BMI was calculated as weight [kg] divided by height squared [m^2]), and participants scored 1 point if their BMI was less than 18.5 kg/m^2 (Woo et al. 2012). FRAIL scores range from 0 to 5. Participants with scores ranging from 3 to 5 were defined as frail, 1–2 as pre-frail, and 0 as robust. We grouped frail and pre-frail participants into a single category.

SMC was assessed in the self-report questionnaire by two questions. The first question was "Do you have difficulties with your memory or attention?". The response categories were "no difficulty", "some difficulty", "much difficulty", or "completely unable". Participants responding with "some difficulty", "much difficulty", or "completely unable" were asked a second question, "Do you have difficulties with your memory only or attention only or both?". The response categories were "memory alone", "attention alone", or "both memory and attention". SMC was defined as reporting some difficulty, much difficulty or being completely unable to use their memory alone or both their memory and attention. The same approach to screen for SMC in this study has been shown to be predictive of incident dementia in our previous study of older adults (Li et al. 2021a).

Assessment of baseline characteristics

Depressive symptoms were assessed by the 10 item version of the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff 1977; Andresen et al. 1994). Participants with scores ranging from 10 to 30 were defined as having depressive symptoms. Demographic and health information such as age, sex, years of education, marital status (married or living with partner; yes/no), smoking status (current or former smoker; yes/no) and physical activity (individuals were classified as active if they did report engaging in any kind of leisure activity during the last one month; yes/no) were obtained from the questionnaires. Individuals were categorized as having fallen if they self-reported at least one fall during the previous year. Hospital admissions and emergency department visits were assessed by respondents' self-reporting at least one hospital admission or emergency department visit in the previous year before the interview (any or none).

Statistical analysis

We used Pearson's Chi-square test to compare baseline characteristics between surviving and non-surviving participants. We also used Pearson's Chi-square test to compare baseline characteristics between participants with frailty/pre-frailty and/or SMC. We also used Pearson's Chi-square test to compare baseline characteristics between included and excluded participants. Cox proportional-hazards models were used to investigate the association between baseline characteristics and all-cause mortality. The proportional hazards assumption (tested using Schoenfeld residuals) was not violated. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for mortality were estimated. We used Cox regression models to examine the joint associations between frailty/pre-frailty, SMC and mortality. All analyses were conducted using SAS statistical software, version 9.4 (SAS Institute, Cary, NC).

Results

Table 1 compares baseline characteristics between surviving and non-surviving participants. Surviving participants were significantly younger and were more likely to be female, have higher education levels, be married or living with partner, and likely to be physically active. They were less likely to be current or former smokers, have depressive symptoms, be hospitalized or visited the emergency department during the past year. Surviving participants were also less likely to be frail, to report SMC, or to have coexisting frailty/pre-frailty and SMC.

Table 2 presents the baseline characteristics of participants by physical frailty/pre-frailty and/or SMC. The prevalence of co-occurring frailty/pre-frailty with SMC was 11.9%. Compared to participants who were physical robust without SMC, participants with co-occurring frailty/pre-frailty and SMC were less likely to be married or living with a partner, be a current or former smoker, and be physically active. They were more likely to be older, female, have less education, report depressive symptoms, have fallen during the last year, and have been hospitalized or visited the emergency department during the past year.

Table 3 presents the number of deaths, person-years, mortality rate, and crude and adjusted HR and 95% CIs. The crude mortality rate in the whole sample was 26.5 per 1,000 person-years. After adjustment for age, sex, education, marital status, smoking status, physical activity, and depressive symptoms, the adjusted HR for mortality was 0.89 (95% CI = [0.62–1.29]) in those with SMC alone, 1.40 (95% CI = [0.96–2.04]) in those with frailty/pre-frailty alone, and 1.66 (95% CI = [1.15–2.39]) in those with coexisting frailty/pre-frailty and SMC, compared to robust individuals without SMC. After adjustment for age, sex, education, marital status, smoking status, physical activity, depressive symptoms, history of falls, hospitalization, and emergency department visits during the past year, the adjusted HR for mortality was 0.88 (95% CI = [0.60–1.27]) in those with SMC alone, 1.32 (95% CI = [0.90–1.92]) in those with frailty/pre-frailty alone, and 1.48 (95% CI = [1.02–2.16]) in those with coexisting frailty/pre-frailty and SMC, compared to robust individuals without SMC.

Table 4 presents the comparison of baseline characteristics between those who were included and excluded from

Table 1 Baseline characteristics of participants

	Total sample ($N = 1904$)	Survivors ($N = 1665$)	Deceased ($N = 239$)	P-value*
Age (%)				< 0.0001
65–74 years	1201 (63.1)	1112 (66.8)	89 (37.2)	
75 + years	703 (36.9)	553 (33.2)	150 (62.8)	
Sex (% female)	958 (50.3)	874 (52.5)	84 (35.2)	< 0.0001
Education (%)				0.0068
0 years	511 (26.8)	440 (26.4)	71 (29.7)	
1–6 years	890 (46.7)	765 (46.0)	125 (52.3)	
7 + years	503 (26.4)	460 (27.6)	43 (18.0)	
Marital status (% married or living with partner)	1285 (67.5)	1148 (69.0)	137 (57.3)	0.0003
Current or former smoker (% yes)	532 (27.9)	439 (26.4)	93 (38.9)	< 0.0001
Physically active (% yes)	1044 (55.0)	945 (56.8)	99 (41.8)	< 0.0001
Depressive symptoms (% yes)	196 (10.3)	150 (9.0)	46 (19.3)	< 0.0001
Fallen during past year (% yes)	263 (13.8)	222 (13.3)	41 (17.2)	0.1102
Hospitalization (% yes)	226 (11.9)	176 (10.6)	50 (20.9)	< 0.0001
Emergency department visit (% yes)	302 (15.9)	249 (15.0)	53 (22.2)	0.0043
Frailty status (%)				< 0.0001
Robust	1430 (75.1)	1290 (77.5)	140 (58.6)	
Pre-Frail	420 (22.1)	344 (20.7)	76 (31.8)	
Frail	54 (2.8)	31 (1.9)	23 (9.6)	
SMC (% yes)	641 (33.7)	548 (32.9)	93 (38.9)	0.0665
Frail/Pre-frail and/or SMC (%)				< 0.0001
No/No	1015 (53.3)	915 (55.0)	100 (41.8)	
No/Yes	415 (21.8)	375 (22.5)	40 (16.7)	
Yes/No	248 (13.0)	202 (12.1)	46 (19.3)	
Yes/Yes	226 (11.9)	173 (10.4)	53 (22.2)	

*Categorical variables were compared using Pearson's Chi-square test and shown as percentages

Table 2 Baseline characteristics of participants by the presence of physical frailty/pre-frailty and/or subjective memory complaints

Variables	Frail or pre-frail/subjective memory complaints				
	No/No ($N = 1015$)	No/Yes ($N = 415$)	Yes/No ($N = 248$)	Yes/Yes ($N = 226$)	P-value*
Age (%)					< 0.0001
65–74	729 (71.8)	260 (62.7)	118 (47.6)	94 (41.6)	
75 +	286 (28.2)	155 (37.4)	130 (52.4)	132 (58.4)	
Sex (% female)	449 (44.2)	214 (51.6)	159 (64.1)	136 (60.2)	< 0.0001
Education (%)					< 0.0001
0 years	205 (20.2)	110 (26.5)	104 (41.9)	92 (40.7)	
1–6 years	477 (47.0)	213 (51.3)	106 (42.7)	94 (41.6)	
7 + years	333 (32.8)	92 (22.2)	38 (15.3)	40 (17.7)	
Marital status (% married or living with partner)	744 (73.3)	280 (67.5)	138 (55.7)	123 (54.4)	< 0.0001
Current or former smoker (% yes)	314 (30.9)	109 (26.3)	57 (23.0)	52 (23.0)	0.0125
Physically active (% yes)	619 (61.1)	252 (60.7)	90 (36.4)	83 (37.1)	< 0.0001
Depressive symptoms (% yes)	43 (4.2)	29 (7.0)	58 (23.4)	66 (29.2)	< 0.0001
Fallen during past year (% yes)	109 (10.8)	57 (13.7)	48 (19.4)	49 (21.7)	< 0.0001
Hospitalization (% yes)	77 (7.6)	41 (9.9)	48 (19.4)	60 (26.6)	< 0.0001
Emergency department visit (% yes)	116 (11.4)	65 (15.7)	60 (24.2)	61 (27.0)	< 0.0001

*Categorical variables were compared using Pearson's Chi-square test and shown as percentages

Table 3 Crude and adjusted hazard rations (HR) and 95% confidence intervals (95% CI) for incidence of mortality

	Overall	Robust		Frail/Pre-Frail	
		Without SMC	With SMC	Without SMC	With SMC
N	1904	1015	415	248	226
Deaths	239	100	40	46	53
Person years	9009.5	4856.6	1991.6	1135.5	1025.8
Incidence Rate (per 1000 person-years)	26.5	20.6	20.1	40.5	51.7
Model 1					
HR (95% CI)		Reference	0.98 (0.68–1.41)	1.99 (1.40–2.82)	2.54 (1.82–3.55)
P-value			0.8967	0.0001	< 0.0001
Model 2					
HR (95%CI)		Reference	0.89 (0.62–1.29)	1.40 (0.96–2.04)	1.66 (1.15–2.39)
P-value			0.5409	0.0800	0.0065
Model 3					
Adjusted HR (95% CI)		Reference	0.88 (0.60–1.27)	1.32 (0.90–1.92)	1.48 (1.02–2.16)
P-value			0.4776	0.1530	0.0397

Model 2: adjusted for age, sex, education, marital status, current or former smoker, physically active, and depressive symptoms

Model 3: adjusted for age, sex, education, marital status, current or former smoker, physically active, depressive symptoms, have fallen, hospitalization, and emergency department visits during the past year

Table 4 Characteristics of included versus excluded participants

	Included (*N* = 1904)	Excluded (*N* = 461)	*P*-value*
Age (%)			< 0.0001
65–74 years	1201 (63.1)	174 (37.7)	
≥ 75 years	703 (36.9)	287 (62.3)	
Sex (% female)	958 (50.3)	224 (48.6)	0.5063
Education (%)			< 0.0001
0 years	511 (26.8)	168 (38.7)	
1–6 years	890 (46.7)	188 (43.3)	
7 + years	503 (26.4)	78 (18.0)	
Marital status (% married or living with partner)	1285 (67.5)	245 (53.3)	< 0.0001
Current or former smoker (% yes)	532 (27.9)	134 (29.2)	0.5923
Physically active (% yes)	1044 (55.0)	148 (40.8)	< 0.0001
Fallen during past year (% yes)	263 (13.8)	96 (20.9)	0.0001
Hospitalization (% yes)	226 (11.9)	104 (30.9)	< 0.0001
Emergency department visit (% yes)	302 (15.9)	109 (32.7)	< 0.0001

*Categorical variables were compared using Pearson's Chi-square test and shown as percentages

this study. Study participants were significantly younger, had higher education levels, were more likely to be married or living with a partner, and more likely to be physically active. They were less likely to have a history of falls, hospitalization, or an emergency department visit during the past year.

Discussion

Our study found that 11.9% of participants had co-occurring frailty/pre-frailty and SMC. Our results confirm our hypothesis that the co-occurrence of frailty/pre-frailty and SMC among cognitively unimpaired older adults is significantly associated with an increased risk of all-cause mortality. Moreover, compared with participants who were physically robust without SMC, participants who had either frailty/pre-frailty alone or had SMC alone did not have an increased risk of mortality. These findings highlight that among community dwelling cognitively unimpaired older adults, the concurrent presence of frailty/pre-frailty and SMC has incremental predictive validity for all-cause mortality.

Our results contribute to the literature by providing new data on co-occurring frailty/pre-frailty and SMC associated with increased mortality in a population-based national sample of cognitively unimpaired older adults. In this study, after adjustment for other factors, compared to physically robust participants without SMC, frail/pre-frail participants with SMC had an HR for all-cause mortality of 1.48 (95% CI = [1.02–2.16]). These estimates are similar to those from the Italian Longitudinal Study on Aging (Solfrizzi et al. 2017). The authors assessed subjective cognitive decline (SCD) with the question "Do you feel you have more problems with memory than most?" and adjusted for the Geriatric Depression Scale (GDS)-30 total score. They reported that participants with both frailty/pre-frailty and pre-mild cognitive impairment (SCD) had a HR for all-cause mortality of 1.74 (95% CI = [1.07–2.83]) over 3.5 years and 1.39 (95% CI = [1.03–2.00]) over 7-years of follow-up.

We failed to find an association between frailty/pre-frailty alone and all-cause mortality, although frail/pre-frail participants who had SMC did have an increased risk of mortality. There are several possible explanations for this finding. It could be that frail/pre-frail participants with memory complaints have greater vulnerability which manifests itself as increased mortality compared to those participants with frail/pre-frail alone. Physical frailty/pre-frailty and SMC may have common risk factors, such as poorer objective memory performance, slower gait speed, worse cognitive performance, and depressive symptoms (Elfgren et al. 2010; Genziani et al. 2013; Lehrner et al. 2014; Wu et al. 2015; Lin et al. 2022; Montejo Carrasco et al. 2017; Chang et al. 2019). Lin et al. (2022) performed an investigation of adults aged 60 years or older with memory complaints recruited from an outpatient geriatric service in Brazil and found that pre-frailty was associated with poor performance in the memory domain. Moreover, they found that slower gait speed was associated with a worse performance in the memory domain. Slow gait speed has been linked to risk of mortality (Studenski et al. 2011). Our previous longitudinal study found that among community dwelling cognitively unimpaired older adults aged 65 or older, frail/pre-frail persons with SMC were at increased risk of incident dementia (Li et al. 2021a). Maxwell and colleagues performed a retrospective cohort study of long-stay home care of clients aged 50 or older. They found that frail or pre-frail participants with dementia had increased mortality (Maxwell et al. 2019). Our data showed that frail/pre-frail participants with SMC more likely to have depressive symptoms. Chang and colleagues analyzed data of 3352 individuals aged 60 or older who participated in the Taiwan Longitudinal Study of Aging from 1989 to 2007 and concluded that depressive symptoms in frail older adults were associated with a lower likelihood of reversal of frailty and increased mortality risk (Chang et al. 2019). These observations provide possible biology pathway behind our finding that frailty/pre-frailty in combination with SMC increases mortality risk.

We did not find an association between SMC alone and all-cause mortality among cognitively unimpaired older adults. It is possible that better health status is contributing to the association between physical robust and no excess mortality in older adults with memory complaints. Similar results have been reported by Siersma and colleagues from a prospective cohort study of 758 patients aged 65 years and older visiting their general practitioner with four years of follow-up (Siersma et al. 2013). The authors defined SMC according to the response to "How would you judge your memory?". There were five response categories: "less good", "poor", or "miserable" were classified as SMC, while participants rating their memory as "excellent" or "good" were classified as no SMC. After adjustment for cognitive impairment and other factors, they found that the presence of SMC was not significantly associated with an increased risk of all-cause mortality.

There are some limitations in our study that should be noted. Our analytic sample could be biased due to included participants being limited to those who were able to complete the assessments for cognitive function, physical frailty/pre-frailty, depressive symptoms, and SMC. The comparison of baseline characteristics between respondents who were included ($N = 1904$) and excluded ($N = 461$) from this study (Table 4) suggests that our sample could be biased toward individuals of younger age, with a higher education level, who are married or living with partners, physical active, and who were less likely to have a history of falls, hospitalization, or emergency department visit in the year before the interview. It suggests that our sample could be biased toward individuals with better health status. Thus, the observed crude mortality rate of 26.5 per 1,000 person-years may be an underestimate and the association between frailty/pre-frailty and SMC with mortality may also be underestimated. Moreover, history of falls and healthcare utilization can occur as a result of frailty, but that they can also lead to frailty. Given that the sequence of events is not clear from the data collected, we have provided the analysis results with and without adjustment for these variables (Table 3, Model 2 and Model 3). The results do not actually change a lot, although without adjustment for these variables, frailty/pre-frailty alone showed a marginally significant association with mortality (Table 3, Model 2). We consider that the effect of frailty/pre-frailty alone on mortality could be clinically important, not only because of the adjusted point estimate of 1.32 (Table 3, Model 3), but also because the confidence interval was almost entirely above 1. It is likely that lack of sufficient statistical power resulted in the failure to reach statistical significance. The frailty/pre-frailty condition we assessed by the FRAIL scale was based on self-report, and therefore, recall bias was unavoidable. However, the strengths of using the FRAIL scale are relatively simple and easy to use. As this study was an observational study and frailty and SMC were assessed at the same time, there are limitations on the causal interpretation of our study findings. Further investigation is needed to explore the underlying cause of mortality in people with frail/pre-frail and SMC.

Conclusions

We found that 2.8%, 22.1% and 33.7% of Taiwanese cognitively unimpaired adults aged 65 years and above were frail, pre-frail, or had SMC, respectively. The prevalence of SMC is consistent with most other studies where the prevalence of SMC in older adults lies within the range of 25% to 50% (Jonker et al. 2000; Montejo et al. 2011). It is notable that as many as 51.9% of frail participants and 47.1% of pre-frail participants had SMC. Moreover, our findings suggest that the concurrent presence of frailty/pre-frailty and SMC has incremental predictive validity for older adults without cognitive impairment who are at increased risk of mortality in the absence of laboratory and clinical indicators. We suggest that clinicians should pay careful attention to memory complaints in their frail/pre-frail older patients at regular clinic attendances to identify individuals who would benefit most from interventions aimed at preventing death. In summary, our results indicate that a substantial proportion of frail/pre-frail older adults have memory complaints. Our findings highlight the importance of screening for SMC to identify frail/pre-frail persons who may need interventions aimed at improving survival among cognitively unimpaired older adults.

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Author contributions CLL drafted the manuscript and FFS revised the manuscript and HYC and MCC and YHT analysis and interpretation of data and prepared tables. All authors were involved in conceptualization and discussions about the study and reviewed the manuscript.

Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Civic engagement among foreign-born and native-born older adults living in Europe: a SHARE-based analysis

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Abstract

Civic engagement is one of the cornerstones of participatory democracy and fundamental to preventing old-age social exclusion. Even though civic engagement late-in-life has received considerable attention, there is a lacuna of research on older migrants' civic engagement. This study aims therefore to examine potential predictors of civic engagement in terms of formal volunteering and participation in political organisations among foreign-born and native-born older adults in Europe. Attention is hereby given to how socio-structural resources and social capital are associated with civic engagement, and whether these associations differ between foreign-born and native-born. Data from wave 7 of the Survey of Health, Ageing and Retirement in Europe [$n = 74{,}150$; 5710 of them are foreign-born] were used in multivariable logistic regression analyses. Results show that socio-structural and social capital variables are positively associated with volunteering and participation in political organisations, both in native-born and foreign-born older adults. The study also suggests that place of birth (in Europe vs. outside Europe) and age-upon-migration play a role in predicting civic engagement among foreign-born older adults, and are therefore features worth considering when studying older migrants' civic engagement.

Keywords Civic engagement · Civic participation · Volunteering · Political participation · Migrants · Foreign-born

Introduction

Older adults' civic engagement has become a key topic in social gerontology in the last half century (Serrat et al. 2020), due to its potential to promote healthy and successful ways of ageing while benefiting and strengthening communities (Morrow-Howell et al. 2019). This type of engagement is also relevant to participatory democracy (Barnes et al. 2011), age friendly communities (Buffel et al. 2012), and old age social inclusion (Walsh et al. 2021). Despite the notable increase of scholarly research on the topic in the last decades, there are still areas of investigation that need our attention (Serrat et al. 2020). One of these areas concerns older migrants' civic engagement (Torres and Serrat 2019).

According to the United Nations, the share of migrants 65+ in the international migration stock is 16.2% in Europe (Migration Data Portal 2021). This is one of the many reasons why close to two decades ago European scholars in social gerontology (Warnes et al. 2004; Torres and Karl 2016), and in migration (Warnes and Williams 2006), began to pay attention to foreign-born older people, and why this paper aims to identify and compare potential predictors of civic engagement in terms of formal volunteering and

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participation in political organisations among foreign-born and native-born older adults living in Europe, using data from wave 7 of the Survey of Health, Ageing and Retirement in Europe (SHARE).

In the following sections, we address what civic engagement means in later life and what research has shown about civic engagement predictors among older adults, before we review the scarce literature on older migrants' civic engagement.

What is civic engagement?

Civic engagement is a contested concept for which there is no agreed-upon definition. While some scholars defined it broadly, referring to any activity that fosters social capital (e.g. Putnam 2000), others restricted it to specific activities, such as formal volunteering (e.g. Cutler et al. 2011). A recent review of the definitions of civic engagement used in the gerontological literature (Serrat et al. 2021) identified two main dimensions within the concept: volunteering, referred to as activities which seek benefits or improvements for other people, the community, or society as a whole, and political participation, which includes activities seeking an impact on decision-making processes occurring at any level of the political system. The first dimension includes both informal helping behaviours within and outside the family, and formal activities conducted in the frame of volunteering, community, or charitable organisations. The second dimension covers both institutionalised activities, such as voting or participating in political organisations, and non-institutionalised activities, such as participating in protest activities or social movements.

While older adults' volunteering, and particularly formal volunteering, has been extensively researched, their political participation has been far less addressed. In a recent scoping review of the literature on older adults' civic engagement (Serrat et al. 2020), 83% of the 429 papers reviewed addressed volunteering, with only 17% focused on political participation. This is in part because civic engagement in later life has tended to be framed against the successful and active ageing paradigms, a matter that has been problematized by some social gerontologists (e.g. Martinson and Minkler 2006). An exclusive focus on formal volunteering reinforces the notion that older adults are contributors to their communities, but not necessarily political actors who could potentially question public debates as far as political understandings, values, and practices are concerned (Martinson and Minkler 2006; Serrat et al. 2020). Although both angles of investigation are important in relation to older migrants, the study of political participation seems particularly relevant at a time when migrants' ability to integrate into their host societies is being discussed among scholars (Fernandez 2019; Lucassen 2019), and policy makers due to, among others, the 2030 Sustainable Development Agenda's call to "leave no one behind" [see for example International Organisation for Migration (IOM) 2018].

What are the predictors of civic engagement among older adults?

Research into the potential predictors of older adults' civic engagement has come a long way in the last fifty years. One of the most well-researched theoretical frameworks regarding predictors of civic engagement in later life is the so-called integrated theory, proposed by Musick and Wilson (2008). This is the theory that informs the analyses that this paper will present (see also Principi et al. 2012 and Cheng et al. 2022 who have also relied on this theoretical lens). Integrated theory brings together socio-structural resources theory (e.g. Warburton and Stirling 2007; Principi et al. 2012; Serrat et al. 2015), which highlights the role of individual resources on civic engagement, and social capital theory (e.g. Warburton and Stirling 2007; Einolf and Chambré 2011; Dury et al. 2015, 2020), which stress the role of social connections on civic engagement.

Socio-structural resources theory focuses on individual resources fostering civic engagement (Warburton and Stirling 2007; Principi et al. 2012), including educational level, income level, and health status, as assets that strengthen individuals' civic engagement. Previous research has shown that older adults' higher educational levels (e.g. Cheng et al. 2021), income levels (e.g. Nygård and Jakobsson 2013), and better health status (e.g. Dury et al. 2015) are associated with greater likelihood of civic engagement.

Social capital theory focuses instead on social connections and the roles that foster older adults' civic engagement (Warburton and Stirling 2007; Nygård et al. 2015; Dury et al. 2015, 2020; Boerio et al. 2021). This includes marital status, work status, or participation in social activities. Older adults' civic engagement—measured in terms of volunteering—has been positively associated with being widowed or never married as opposed to being married (e.g. Dury et al. 2015). Participation in sporting and social activities has also been positively associated with volunteering in later life (e.g. Principi et al. 2016). The evidence regarding work status is mixed. On the one hand, the social networks that are established through work could promote civic engagement opportunities, and some studies have found a positive association between paid work and volunteering (e.g. Kim et al. 2007). On the other hand, from a role overload perspective, paid work could reduce the amount of time available to commit to other activities, such as volunteering, which is in line with research that has found a negative association between these two activities (e.g. Cheng et al. 2021).

The analyses performed in this study, as well as the manner in which the results sections of this paper has been crafted, are both informed by integrated theory, which is why the various angles hereby alluded to are regarded as parameters worthy of investigation.

What do we know about older migrants' civic engagement?

Studies on older migrants' civic engagement are extremely rare even if studies on migration-related aspects affecting younger migrants' civic engagement are not (see e.g. Stoll and Wong 2007; Tran 2017). The scoping review conducted by Serrat et al. (2020) identified that only seven of the 429 papers reviewed addressed older migrants' civic engagement. Torres and Serrat 2019 analysed these papers in detail and laid out the arguments for why older migrants' civic engagement deserved our attention. To the best of our knowledge only one paper addressing this topic has been published since the analysis mentioned here was performed (i.e. Cao et al. 2021).

A few trends about the little research that is available on older migrants' civic engagement are worthy of being mentioned and the first thing to note is that the research has so far focused exclusively on formal volunteering, with no research addressing political participation. Most studies available thus far address older Asian migrants settled either in the USA (Mui et al. 2013; Lee et al. 2018; Cao et al. 2021) or in New Zealand (Wright-St Clair and Nayar 2017; Nayar and Wright-St Clair 2018; Wright-St Clair et al. 2018), with only two papers bringing attention to the civic engagement of older migrants living in Europe (Gele and Harsløf 2012; Haas 2013). Moreover, except for Lee et al. (2018), who analysed differential patterns of formal volunteering among a large sample of first-generation Asian ethnic groups (Chinese, Filipino, Korean, and Vietnamese) from the California Health Interview Survey, the remainder seven papers are based on exploratory studies that rely on small and purposively selected samples.

Results from the few studies that are available show that socio-structural variables such as poor health (Gele and Harsløf 2012), and low educational level (Lee et al. 2018), could decrease older migrants' engagement in formal volunteering. With regard to social capital variables, the study by Lee et al. (2018) found that marital status and work situation were unrelated to the formal volunteering that the older migrants in that study were engaged on. Importantly, the few studies that are available suggest that older migrants' civic engagement vary according to a range of features associated with migration (Wright-St Clair and Nayar 2017; Lee et al. 2018; Wright-St Clair et al. 2018). For instance, age-upon-migration (Wright-St Clair and Nayar 2017; Wright-St Clair et al. 2018), as well as ethnicity (Youssim et al. 2015; Wright-St Clair and Nayar 2017), have been shown to influence patterns of volunteering among older migrants. Citizenship in the host country has also been deemed to be relevant since it could increase the probabilities of volunteering among this group (Lee et al. 2018), and may also influence their political participation.

To the best of our knowledge, no previous study has analysed potential predictors of civic engagement using a large dataset of older foreign-born and neither has the civic engagement of this group been compared to native-born older people living in Europe. In addition, no study on older migrants has brought attention to their political participation (irrespective of where the studies have been conducted). And neither has there been studies that have looked into the potential associations that geographical origin, age-upon-migration and citizenship have with the civic engagement of older migrants living in Europe. Thus, to fill these knowledge gaps, this study aims to examine the potential predictors of civic engagement in terms of formal volunteering and participation in political organisations among foreign-born and native-born older adults in Europe. The following research questions are posed:

- How are volunteering and participation in political organisations associated with socio-structural and social capital variables among older adults in Europe?
- Do these associations vary between native-born older adults, and their foreign-born counterparts of European, as well as non-European origin?
- Are age-upon-migration and citizenship in the host country associated with civic engagement among foreign-born older adults of European and non-European origin?

Data and methods

Study sample

The study is based on the Survey of Health, Ageing and Retirement in Europe (SHARE) wave 7 conducted in 2017 (Börsch-Supan 2020). SHARE is a multidisciplinary cross-national survey focused on adults aged over 50 across 26 European countries and Israel. SHARE data were gathered using probability-based sampling and computer-assisted personalised interviews (CAPI) at the respondents' households. Further methodological details can be found in Bergmann et al. (2019) and Börsch-Supan et al. (2013), while information on the SHARE project is available at www.share-project.org. In the analyses we will present in the next section, we have excluded respondents under the age of 50 in 2017, respondents from Israel (due to different patterns of migration, see Constant et al. 2018) and respondents missing the migration indicator variable response. Thus, the final data includes a total of 74,150 Europeans aged 50 and older from Austria, Germany, Sweden, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Czech Republic, Poland, Luxembourg, Hungary, Portugal, Slovenia, Estonia, Croatia, Lithuania, Bulgaria, Cyprus, Finland, Latvia, Malta, Romania, and Slovakia. 5710 of these respondents are categorised as foreign-born, as they were not born in the country where the data were collected. The foreign-born respondents have been further categorised into European foreign-born ($n = 4975$) or non-European foreign-born ($n = 735$). The other 68,440 respondents were categorised as native-born. Missing values were negligible since only 0.2% had missing values on the migration indicator variable. For the other variables included in the analyses, the percentage of respondents with missing data was less than 2%.

Variables

The outcome measures of formal volunteering and political participation were based on two questions: Have you done voluntary or charity work/taken part in a political or community-related organisation in the past twelve months? (Response categories yes/no). Regarding migration indicator variables, respondents were asked whether they were born in the country of interview and if not, they were asked in which country they were born. This enabled the sample to be divided into three categories: European foreign-born, non-European foreign-born and native-born. The largest foreign-born non-European groups in the wave we are using were born in one of the following three countries, namely Morocco, Congo and Algeria. The largest European foreign-born groups in this wave were instead born in the Russian Federation, Germany and Italy. Age-upon-migration was derived from self-reported year of migration and grouped into migration below/above 18-year-old, as other studies on this topic have done (e.g. Sand and Gruber 2018). Respondents were also asked whether they hold citizenship in the country of interview (Response categories yes/no).

The control variables included age at interview (continuous) and gender (female and male). Regarding socio-structural resources variables, education was determined by the question: What is the highest school leaving certificate or school degree that you have obtained? Educational level was categorised into three groups based on International Standard Classification of Education (ISCED) 1997 codes: low (ISCED score 0–2), medium (ISCED score, 3–4) and high (ISCED score 5–6). Adequacy of a respondent's income was captured with the question: Thinking of your household’s total monthly income, is your household able to make ends meet? The response categories were “with great difficulty”, “with some difficulty”, “fairly easily” and “easily”. The ability of making ends meet was recoded into “no” (for those reporting “with great difficulty” or “with some difficulty”) and “yes” (for those reporting “fairly easily” or “easily”). An imputed variable was used for the analysis, since economic hardship is measured at the household level with only one member of the household responding to the item. The “not applicable” category of the imputed variable was recoded as missing values ($n = 782$). Self-rated health was assessed with the question: How would you rate your current health state? Responses were based on a five-point scale (excellent, very good, good, fair, poor) and were grouped into “good health” (excellent/very good/good) and “poor health” (fair/poor).

With regards to social capital variables, marital status was categorised into three categories: married/cohabiting, single/separated/divorced/never married, and widowed. Work situation was assessed by the question: In general, which of the following best describes your current employment situation? The response alternatives were grouped into retired, employed (or self-employed), and other (unemployed/ permanently sick or disabled/ homemaker/ other). Attending clubs was based on the question: Have you visited a sport, social or other type of club in the past twelve months? (Response categories yes/no).

Analyses

The distribution of all variables was calculated by the two foreign-born groups and the native-born group. The analyses consisted of Chi-square tests including the z-test with adjusted p-values according to the Bonferroni correction to limit the potential for type I errors ($\alpha = 0.05$) (Field 2018). The z-test compares the proportion of the frequencies of the columns within each row. Each value is given a superscript in the z-test, and if the superscript differs between cells in the same row, then these proportions differ significantly from each other. Analysis of variance (ANOVA) was used to test differences between the age means.

Multivariable logistic regression analyses were conducted to analyse potential predictors of civic engagement. The variables, organised in blocks, were entered into three models: migration indicator (native-born, European foreign-born, non-European foreign-born) and control variables (Model 1), socio-structural resources variables (Model 2) and social capital variables (Model 3). To account for possible dependency on household as well as country levels, standard errors were adjusted for clustering at the level of household and country level, respectively. Using models with standard errors did not change the main results and the models are therefore not shown.

Interactions for the association between the migration indicator variable and all other variables were first tested one-by-one for the two civic engagement outcomes. Significant interaction terms were then entered in the same model also including all other variables (Model 4). Only statistically significant interaction estimates are shown. As a result, significant interaction terms were only applicable for participation in political organisations. The results are

Table 1 Descriptive characterstics of the sample

	Native-born	Foreign-born		Total
		European	Non-European	
	(*n* = 68,440)	(*n* = 4975)	(*n* = 735)	(*n* = 74,150)
	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Age at interview (years^{1})	68.6^{a} (9.8)	69.2^{b} (9.8)	65.4^{c} (8.8)	68.7 (9.8)
Female	56.6^{a} (38,740)	58.8^{b} (2924)	55.6^{a,b} (409)	56.7 (42,073)
Age upon migration above 18		62.9^{a} (4916)	69.9^{b} (509)	63.8 (5644)
Has citizenship in the country of interview		63.3^{b} (3146)	73.6^{a} (541)	64.6 (3687)
Socio-structural resources				
Educational level				
Low	37.1^{a} (25,321)	31.5^{b} (1555)	33.1^{a,b} (239)	36.7 (27,115)
Medium	42.3^{b} (28,869)	42.5^{b} (2099)	28.7^{a} (207)	42.2 (31,175)
High	20.6^{c} (14,052)	26.1^{b} (1289)	38.2^{a} (276)	21.1 (15,617)
Able to make ends meet	58.6^{a} (39,710)	54.1^{b} (2662)	57.1^{a,b} (417)	58.3 (42,789)
Good self-rated health	58^{c} (39,687)	47.6^{b} (2369)	62.7^{a} (461)	57.3 (42,517)
Social capital				
Marital status				
Married, in partnership	70^{a} (47,869)	67.6^{b} (3364)	72.2^{a} (531)	69.9 (51,764)
Widowed	16.7^{c} (11,419)	19^{b} (943)	9^{a} (66)	16.8 (12,428)
Single, divorced, separated	13.3^{b} (9100)	13.4^{b} (667)	18.8^{a} (138)	13.4 (9905)
Work situation				
Retired	62.9^{c} (42,465)	65.3^{b} (3199)	44.2^{a} (321)	62.9 (45,985)
Employed	22.8^{c} (15,389)	20.7^{b} (1016)	33.7^{a} (245)	22.8 (16,650)
Other	14.3^{b} (9674)	14^{b} (685)	22.1^{a} (161)	14.4 (10,520)
Attends clubs	22.4^{a} (15,077)	19.6^{b} (958)	23.4^{a,b} (170)	22.2 (16,205)
Civic engagement in last year				
Engages in voluntary or charity work	14.3^{c} (9611)	11.4^{b} (559)	17.9^{a} (130)	14.1 (10,300)
Engages in political or community-related organisations	5.6^{a} (3800)	3.5^{b} (172)	6.5^{a} (47)	5.5 (4019)

[1] Mean (Standard Deviation)

Cells followed by different lowercase letter(s) in the columns are significantly different at $p < 0.05$ and cells with the same lowercase letter are not significantly different from each other

presented as odds ratios (ORs) and 95% confidence intervals (CIs) with *p* values.

To analyse the associations between age-upon migration and citizenship in the host country with foreign-born civic engagement, logistic regression analyses were repeated for Model 3, only with the foreign-born groups. Data were analysed using the IBM SPSS Statistics, version 28 and Stata, version 17.

Results

Table 1 includes descriptive statistics of all variables for native-born, European foreign-born, non-European foreign-born, and for the total sample.

The results of the multivariable logistic regression analyses are presented in Table 2, regarding voluntary and charity work (VW), and in Table 3, for participation in political or community-related organisations (PO).

Model 1 shows that non-European foreign-born were 1.2 times more likely (95% CI 1.02–1.49) to do VW than native-born. On the contrary, for European foreign-born the odds ratio was 0.78 (95% CI 0.71–0.86) compared to native-born (see Table 2). The association remained statistically significant for European foreign-born when taking socio-structural resources (Model 2) and social capital variables (Model 3) into account. For the non-European foreign-born the association was significant in Model 1 only. Regarding PO (see Table 3), the odds ratio in Model 1 was lower among European foreign-born as compared to native-born (OR 0.62, 95% CI 0.53–0.83). The association remained significant in all models.

When considering socio-structural resources (Model 2), the results showed a clear gradient in educational level

Table 2 Odds ratios (ORs) and 95% confidence intervals (CIs) for the probability of civic engagement in voluntary and charity work

	Model 1 ($n = 73{,}025$)		Model 2 ($n = 72{,}664$)		Model 3 ($n = 72{,}615$)	
	OR	95% CI	OR	95% CI	OR	95% CI
Migration-related variable						
Native-born	1		1		1	
Foreign-born: European	0.78***	(0.71–0.86)	0.78***	(0.71–0.86)	0.80***	(0.72–0.88)
Foreign-born: Non-European	1.23*	(1.02–1.49)	1.09	(0.89–1.33)	1.11	(0.90–1.36)
Age at interview (years)	0.98***	(0.98–0.98)	0.99***	(0.99–0.99)	0.98***	(0.98–0.99)
Gender						
Female	1		1		1	
Male	0.94**	(0.90–0.98)	0.87***	(0.83–0.91)	0.85***	(0.81–0.89)
Socio-structural resources						
Educational level						
Low			1		1	
Medium			1.53***	(1.45–1.62)	1.44***	(1.36–1.53)
High			2.90***	(2.73–3.08)	2.48***	(2.33–2.65)
Ability to make ends meet						
No			1		1	
Yes			1.94***	(1.85–2.04)	1.67***	(1.58–1.75)
Self-rated health						
Poor			1		1	
Good			1.48***	(1.41–1.55)	1.35**	(1.28–1.42)
Social capital						
Marital status						
Married, in partnership					1	
Widowed					0.95	(0.88–1.02)
Single, divorced, separated					1.11***	(1.05–1.18)
Work situation						
Retired					1	
Employed					0.70***	(0.66–0.75)
Other					1.01	(0.94–1.09)
Attending clubs						
No					1	
Yes					3.04***	(2.90–3.18)
Constant	0.52***		0.042***		0.08***	

Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

so that older adults who enjoyed a high level of education were 2.9 times more likely (95% CI 2.73–3.08) to do VW whereas those with a medium level of education were 1.5 more likely (95% CI 1.45–1.62), compared to older adults with a low educational level. In the case of PO, those with a high level of education were 3.2 times more likely (95% CI 2.91–3.50) to participate in PO, while respondents with a medium level were 1.5 more likely (95% CI 1.40–1.68). Looking at financial resources, older adults who did not have problems making ends meet were 1.9 (95% CI 1.85–2.04) and 1.6 (95% CI 1.47–1.71) times more likely to do VW and participate in PO respectively. For the self-rated health variable, respondents who reported good health were 1.5 times more likely (95% CI 1.41–1.55) to do VW, and 1.4 times more likely (95% CI 1.31–1.51) to participate in PO. The effect sizes were only slightly lower in Model 3 and remained significant for VW and PO, respectively.

When considering social capital variables (Model 3), single, divorced or separated older adults were 1.1 times more likely (95% CI 1.05–1.18) to do VW than older adult that were either married or in a partnership. Moreover, employed older adults were less likely to do VW (OR 0.70, 95% CI 0.66–0.75) compared to retired. In the case of participation in PO, neither marital status nor work situation were significant. Finally, older adults attending clubs were 3 times more likely (95% CI 2.90–3.18) to do VW, and 2.4 times more likely (95% CI 2.27–2.60) to participate in PO than those that did not report attending these clubs.

Most of the interactions were not statistically significant, except for attending clubs in relation to participation in PO among European foreign-born (See Model 4 in Table 3). The interaction term indicates that attending clubs is associated with higher odds of participating in PO for European foreign-born. Nevertheless, the odds were still 0.82 of native-born without participation[1] (not shown in Table 3).

Finally, logistic regression analyses on the foreign-born groups were conducted to account for possible associations of age-upon-migration and citizenship with engagement in VW and PO, respectively (Tables 4 and 5). The results showed that having migrated before the age of 18 increased the odds of doing VW (OR 1.3, 95% CI 1.06–1.52). The variable was not significant for PO. Citizenship did not have a significant association with neither one of the civic engagement types studied.

Discussion

Despite the increased scholarly interest in older migrants over the last two decades (Warnes et al. 2004; Warnes and Williams 2006), their civic engagement has remained largely underexplored (Torres and Serrat 2019). Against this backdrop, this study aimed to identify and compare the potential predictors of civic engagement among European foreign-born, non-European foreign-born, and native-born older adults living in Europe. This study has focused on two types of civic engagement: formal volunteering and participation in political organisations, and has explored the associations between civic engagement and socio-structural and social capital variables that are stipulated by integrated theory.

Our results show that compared to native-born older adults, European foreign-born, but not non-European foreign-born, participate less in volunteering and political organisations, even when sociodemographic, socio-structural, and social capital variables were considered simultaneously in multivariable regression analyses. In this respect, it is important to consider that the largest group of European foreign-born in our sample were born in the Russian Federation or Germany (including German Democratic Republic), and that previous research has shown that older cohorts raised in post-communist countries have the lowest levels of civic engagement in Europe (e.g. Lee 2021). The results from this study suggest that they might maintain these low levels of civic engagement when they migrated to a different European country. Youssim et al. (2015) observed indeed a similar pattern using data from Israel. They found that immigrants from the former Soviet-Union were less likely to engage in formal volunteering than Veteran Jewish Israelis. Our study extends therefore Youssim et al. (2015) findings to the case of participation in political organisations, and also to a larger sample of foreign-born older adults living in Europe.

In line with what emerging research on older migrants' civic engagement has pointed out (see e.g. Wright-St Clair and Nayar 2017; Wright-St Clair et al. 2018), foreign-born older adults who migrated earlier in life (before the age of 18 in our study) were more likely to engage in volunteer and charity work, which may be indicative of greater integration in their host countries. Worth noting is also that although citizenship in the host country has been positively associated with volunteering in previous studies that have focused on older migrants (Lee et al. 2018), and with political participation in younger migrant cohorts (Stoll and Wong 2007), we did not find a significant association neither for volunteer or charity work nor for participation in political organisations. This is somewhat puzzling but may be explained by the fact that SHARE is not a survey that is sensitive enough to the array of migration-related aspects that one needs in order to contribute to scholarship on migrancy, naturalisation and civic engagement (e.g. language acquisition, levels of integration into the host society, civic engagement in the country of origin and whether one has been socialised in a participatory context or not). Thus, since this study was only able to analyse the associations between age-upon-migration

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[1] Odds ratio for participation in political organisation (PO) if attending clubs = yes; OR[1.PO]*OR[European foreign-born* Attending clubs] = 0.47*1.74.

Table 3 Odds ratios (ORs) and 95% confidence intervals (CIs) for the probability of civic engagement in political or community organisations

	Model 1 ($n = 73{,}025$)		Model 2 ($n = 72{,}664$)		Model 3 ($n = 72{,}615$)		Model 4 ($n = 72{,}615$)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Migration-related variable								
Native-born	1		1		1		1	
Foreign-born: European	0.62***	(0.82–1.48)	0.60***	(0.51–0.70)	0.62***	(0.53–0.72)	0.47***	(0.38–0.60)
Foreign-born: Non-European	1.10	(0.82–1.48)	0.91	(0.67–1.24)	0.93	(0.68–1.27)	1.07	(0.72–1.59)
Age at interview (years)	0.99***	(0.98–0.99)	0.99*	(0.99–0.99)	1.00	(0.99–1.00)	1.00	(0.99–1.00)
Gender								
Female	1		1		1		1	
Male	1.58***	(1.48–1.68)	1.48***	(1.39–1.58)	1.46***	(1.36–1.56)	1.46***	(1.36–1.56)
Socio-structural resources								
Educational level								
Low			1		1		1	
Medium			1.54***	(1.40–1.68)	1.45***	(1.33–1.59)	1.45***	(1.33–1.59)
High			3.19***	(2.91–3.50)	2.70***	(2.45–2.97)	2.70***	(2.45–2.97)
Ability to make ends meet								
No			1		1		1	
Yes			1.59***	(1.47–1.71)	1.35***	(1.25–1.46)	1.35***	(1.25–1.46)
Self-rated health								
Poor			1		1		1	
Good			1.41***	(1.31–1.51)	1.28***	(1.19–1.38)	1.28***	(1.19–1.38)
Social capital								
Marital status								
Married, in partnership					1		1	
Widowed					0.98	(0.88–1.09)	0.98	(0.88–1.09)
Single, divorced, separated					1.06	(0.62–1.16)	1.06	(0.62–1.16)
Work situation								
Retired					1		1	
Employed					1.08	(0.98–1.19)	1.08	(0.98–1.19)
Other					1.04	(0.92–1.17)	1.04	(0.92–1.17)
Attending clubs								
No					1		1	
Yes					2.43***	(2.27–2.60)	2.38***	(2.22–2.55)
Interaction terms								
*Migrant-related variable*attending clubs*								
Foreign-born: European*yes							1.74***	(1.26–2.40)
Foreign-born: non-European*yes							0.71	(0.37–1.34)
Constant	0.084***		0.009***		0.008***		0.013***	

Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

and naturalisation and older migrants' civic engagement, and these two variables are seldom studied in isolation when focusing on migrants' civic engagement (Bauböck et al 2006; Itzigsohn 2000), we urge future research to be cognizant of the angles of investigation that are relevant when focusing on foreign-born.

In general, and consistent with previous research on volunteering (Warburton and Stirling 2007; Principi et al. 2012; Dury et al. 2015), higher socio-structural and social capital resources were related with higher involvement in volunteering and political participation for both native-born and foreign-born. In the total sample, a higher level of education, a higher level of income and better self-rated health were associated with greater likelihood of civic engagement.

As for the role of social capital variables, attending clubs was significantly associated with the two types of civic engagement activities considered in this study, which mirrors previous research on formal volunteering (e.g. Dury et al. 2015; Principi et al. 2016). In line with Musick and Wilson's (2008, p. 460) assertion that "participation breeds

Table 4 Odds ratios (ORs) and 95% confidence intervals (CIs) for the probability of civic engagement in voluntary and charity work among foreign-born older adults, $n = 5479$

	OR	95% CI
Foreign-born		
European	1	
Non-European	1.40**	(1.11–1.76)
Age-upon-migration below/above 18		
0–17	1.27*	(1.06–1.52)
18+	1	
Citizenship in the country of interview		
No	1	
Yes	0.98	(0.81–1.18)
Age at interview (years)	0.98**	(0.97–0.99)
Gender		
Female	1	
Male	0.95	(0.80–1.13)
Socio-structural resources		
Educational level		
Low	1	
Medium	1.43**	(1.13–1.83)
High	2.61***	(2.05–3.31)
Ability to make ends meet		
No	1	
Yes	1.89***	(1.54–2.30)
Self-rated health		
Poor	1	
Good	1.38**	(1.15–1.66)
Social capital		
Marital status		
Married, in partnership	1	
Widowed	0.95	(0.72–1.25)
Single, divorced, separated	1.08	(0.85–1.37)
Work situation		
Retired	1	
Employed	0.63***	(0.48–0.81)
Other	1.11	(0.84–1.47)
Attending clubs		
No	1	
Yes	3.07***	(2.57–3.68)
Constant	0.076***	

OR odds ratio

Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 5 Odds ratios (ORs) and 95% confidence intervals (CIs) for the probability of civic engagement in political and community organisations among foreign-born older adults, $n = 5479$

	OR	95% CI
Foreign-born		
European	1	
Non-European	1.41	(0.98–2.03)
Age-upon-migration below/above 18		
0–17	1.31	(0.97–1.77)
18+	1	
Citizenship in the country of interview		
No	1	
Yes	1.24	(0.89–1.72)
Age at interview (years)	0.99	(0.97–1.02)
Gender		
Female	1	
Male	1.48**	(1.10–1.98)
Socio-structural resources		
Educational level		
Low	1	
Medium	1.70*	(1.09–2.65)
High	2.90***	(1.88–4.48)
Ability to make ends meet		
No	1	
Yes	1.46*	(1.04–2.04)
Self-rated health		
Poor	1	
Good	1.3	(0.95–1.77)
Social capital		
Marital status		
Married, in partnership	1	
Widowed	1.05	(0.66–1.67)
Single, divorced, separated	0.81	(0.53–1.24)
Work situation		
Retired	1	
Employed	1.14	(0.75–1.75)
Other	1.78*	(1.12–2.83)
Attending clubs		
No	1	
Yes	3.51***	(2.62–4.70)
Constant	0.006***	

Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

participation", it is plausible that when one already participates socially, one also has a stronger tendency to engage civically. Research has namely shown that social participation makes people more aware of what volunteering and political participation can entail (McBride et al. 2011), and that people who participate socially tend to be more exposed to receiving invitations to participate in other activities (Wilson and Son 2018; Dury et al. 2020).

Volunteering, but not political participation, was also significantly associated with the two social capital variables included in this study. With regards to work status, being employed was associated with lower odds of formal volunteering. This is in line with role overload theory, which states that paid work may reduce the amount of time available to commit to other activities, such as civic engagement (e.g. Cheng et al. 2021). Regarding marital status, our results are also in line with previous research (e.g. Dury et al. 2015) showing that being married is negatively associated with volunteering in later life. It could be that the positive association found between being single, divorced or separated and participation in formal volunteering could be explained by a willingness to gain or increase social contacts and roles. Worth mentioning is, however, that as far as we know, the associations between work and marital status and political participation in later life have not been previously explored. Of interest is perhaps that research with other age groups has shown mixed effects (e.g. Serrat and Villar 2020), suggesting that these variables may be not as important for older adults' participation in political organisations as they are for formal volunteering in later life.

As already mentioned, the analyses showed that attending clubs was positively associated with formal volunteering and participation in political organisations. In this respect it seems necessary to note that the interaction between the migration indicator variables used in this study and attending clubs highlighted that this association is especially relevant for European foreign-born's political participation. This is consistent with previous research with older adults that has shown that those who are willing to join a political organisation may first need to know other members who are involved with it (Dury et al. 2020). The results from our study suggest therefore that social contacts generated while attending clubs could be important for European foreign-born older adults' political participation.

Limitations

The results from this study should be interpreted with caution due to a number of limitations. First, although civic engagement is a multidimensional concept including multiple types of activities (Serrat et al. 2021), we have only used measures on formal volunteering and political participation, which limits the extrapolation of these results to civic activities that may follow different patterns among foreign and native-born older adults (e.g. voting or informal helping behaviours). Second, due to insufficient statistical power, we used both dependent variables as dichotomous variables, even though there is information about frequency in the data. Consequently, we cannot distinguish between levels of involvement in terms of time spent or frequency of participation. Third, given that the data analysed here is cross-sectional, we cannot infer any direction of causality in the findings, such as for example the relationship between marital status and volunteering or between attending clubs and civic engagement. Fourth, the respondents who stated that they were politically engaged were relatively few, which could cause low statistical power and mask existing associations. Fifth, only those who speak the national language(s) of the countries where the interviews were conducted were eligible to participate in SHARE. This may imply a selection bias of more educated and socially included subgroups of foreign-born. Finally, civic engagement could show variations according to geographical contexts. Further studies analysing these influences are therefore needed.

Conclusions

Despite these limitations, our study shows that European foreign-born older adults volunteer less and engage less in political organisations than their native counterparts. The results of this study also stress that socio-structural and social capital variables are associated with civic engagement among native-born, European foreign-born and non-European foreign-born older adults. Finally, the results highlight that age-upon-migration plays a role in predicting civic engagement among foreign-born older adults. However, because SHARE is not a migration-astute survey, the analyses presented here for the foreign-born group are only the first step in putting the civic engagement of older migrants on the agenda of social gerontology. Future research on this group's civic engagement must therefore consider not only the heterogeneity of older migrants (Warnes et al. 2004), but also the array of migration indicator variables that scholars who focus on migrants' civic engagement tend to focus on.

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ORIGINAL INVESTIGATION

Family care during the first COVID-19 lockdown in Germany: longitudinal evidence on consequences for the well-being of caregivers

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Abstract
We examine changes in the well-being of family caregivers during the early phase of the COVID-19 pandemic in Germany, using data from the German Socio-Economic Panel (SOEP) and the SOEP-CoV study. The COVID-19 pandemic posed an extraordinary challenge for family caregivers, as care recipients are a high-risk group requiring special protection, and professional care services were severely cut back. The specific situation of the COVID-19 pandemic allows us to re-examine the caregiver stress process model. Using first difference regression models, we analyse changes in general life satisfaction and depressive symptoms (PHQ-4 score) among family caregivers between 2019 and spring 2020, differentiating by care intensity and duration of the care episode. Caregivers show similar changes in well-being as non-caregivers: a simultaneous increase in depressive symptoms and life satisfaction between 2019 and 2020. However, our results reveal heterogeneity within the group of family caregivers as we find differences according to caregiving dynamics and intensity. Among the group of continuing caregivers, high-intensity caregivers experience a larger increase in life satisfaction, and low-intensity caregivers a smaller increase in life satisfaction, compared to non-caregivers. Our results therefore provide some support for the role enhancement hypothesis for continuing caregivers with high time commitment.

Keywords Corona pandemic · Depression · First difference regression · Informal care · Life satisfaction · SOEP-CoV

Introduction

Approximately 8 million people in Germany (11.5% of the adult population) provide help, support or care ('family caregivers' in the following) for a partner, parent or other family members (or sometimes neighbours or friends) suffering from poor health, disability or age-related frailty (Rothgang and Müller 2022). Unlike professional care providers, who are usually trained and employed for their care services, family caregivers are typically untrained and unpaid (Lilly et al. 2007; Van Houtven 2015). However, the German welfare system relies heavily on the care services provided by family caregivers; although a small number of people are cared for by professional care providers in nursing homes, most care-dependents receive care from family members or friends in their own home (Destatis 2020). However, only 31.5% of family caregivers reside with their care recipients (Ehrlich and Kelle 2019). While providing family care can be a rewarding task (e.g. Moen et al. 1995), research mainly supports the notion that family caregiving operates as a stressor

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and impacts negatively on the well-being of caregivers (e.g. Kaschowitz and Brandt 2017; Sacco et al. 2020).

The COVID-19 pandemic posed an extraordinary challenge to family caregivers. Care recipients, and most family caregivers themselves, were at an increased risk of severe sickness from COVID-19 due to their higher age, impaired health and/or existing chronic conditions (Fischer and Geyer 2020; Schilling et al. 2021). During the first wave of the pandemic, the death toll was especially high among the old (60–79 years) and very old (80 years and older) (Schilling et al. 2021). As testing possibilities were not widely available and a vaccine had not yet been developed, high insecurity existed in how to manage the situation and protect the elderly population. Common strategies included isolating the elderly, cutting professional care services, and suspending access to nursing homes for new patients (RKI, 2021; Rothgang et al. 2020). These measures constrained family caregivers' formal and informal support networks. Building on the stress process/role strain framework (Moen et al. 1995; Pearlin et al. 1990), the spread of COVID-19 was an additional stressor in the relationship between family care and well-being, leading to an increase in the care burden, stress and emotional strain of family caregivers. However, according to the role enhancement theory (Moen et al. 1995), the COVID-19 pandemic could also positively affect the well-being of caregivers; feeling that they perform an even more crucial role for their care recipient and society may have contributed to increased self-esteem and a strengthened sense of identity.

There has been little research on whether and how the pandemic has affected the well-being of family caregivers using a longitudinal approach and detailed information on caregiving characteristics (for an exception, see Ehrlich et al. 2022). Therefore, our study addresses whether—and if so to what extent—the well-being of family caregivers was affected during the first wave of the COVID-19 pandemic, and what differences exist with regard to family care dynamics (new caregiver, continuing caregiver) and intensity (low- vs. high-intensity care). We investigate two well-being outcomes: general life satisfaction and depressive symptoms (PHQ-4 score).

In answering this research question, our study contributes to the literature in two major ways. First, it allows to re-examine whether the relative strengths of prominent theories in the area of family care and well-being also hold true during the COVID-19 outbreak and subsequent containment measures. Second, previous studies addressing the well-being of family caregivers during the COVID-19 pandemic have mainly used caregiver-specific, cross-sectional or non-probability data (e.g. Brandt et al. 2021; Budnick et al. 2021; Rodrigues et al. 2021), have not been able to detect causal relationships within a representative sample, have not focused on specific sub-groups of caregivers (Whitley et al. 2021 only include co-residing caregivers) or have not accounted for family care intensity (Ehrlich et al. 2022). In contrast, our study uses data from the German Socio-Economic Panel (SOEP) and its special Corona study, SOEP-CoV (2020, www.soep-cov.de), which took place during the first lockdown in spring 2020 and in the period immediately afterwards. The SOEP is a longitudinal household study relying on probability samples, which enables the examination of changes in the well-being of caregivers between 2019 and the first wave of the pandemic in 2020, differentiating along care dynamics and intensity.

Theory and previous research

Family caregiving and well-being

Family care is a broad concept which refers to both care provided in legally recognised relationships and care in other forms of relationships such as biological, step and adopted families, and families by choice. The most important attribute of family caregiving is not necessarily a familial relationship, but rather a familial commitment between caregiver and care recipient (Freedman and Wolff 2020). Fulfilling this commitment can occur at any point during the life course (Moen et al. 1994) and is expressed in the caregiver's attention to the care recipient's social, psychological, emotional and physical needs (Knijn and Kremer 1997).

Two main scenarios of how family care might impact on individuals' well-being have been proposed. According to the role strain perspective and the caregiver stress process model, family care provision leads to negative well-being outcomes as "[…] there is a fixed quantity of time, energy, and commitment available for role-related responsibilities [and the] […] role of caregiving is taken on in addition to ongoing family and nonfamily obligations, producing the very real possibility of overload and strain, and consequently psychological distress" (Moen et al. 1995, p. 260). The caregiver stress model predicts the same outcome, albeit through a slightly different mechanism; family care can transform "from the ordinary exchange of assistance among people standing in close relationship to one another to an extraordinary and unequally distributed burden" (Pearlin et al. 1990, p. 583). Family caregiving is "potentially a fertile ground for persistent stress" that negatively affects individuals' well-being (Pearlin et al. 1990, p. 583). Stress and strain related to family care tasks may arise from 'caring for' the care recipient, but also from 'caring about' and observing a loved one suffering from poor health, disability or age-related frailty (Bobinac et al. 2010; Bom et al. 2019).

The role enhancement approach takes a contrasting perspective from the negative implications of caregiving proposed by the role strain persepctive and the stress process model. According to the role enhancement perspective, family caregiving can be perceived as rewarding, increasing the subjective well-being of family caregivers. As "[s]ocial integration, in the form of multiple roles, augments an individual's power, prestige, resources, and emotional gratification, including social recognition and a heightened sense of identity", the family caregiver role is associated with benefits to well-being (Moen et al. 1995, p. 260).

Previous longitudinal research analysing probability-based population data mainly supports the role strain and stress process perspectives; transitioning into family care is associated with increasing depressive symptoms (Coe and Van Houtven 2009; Hiel et al. 2015; Kaschowitz and Brandt 2017; Kaschowitz and Lazarevic 2020; Marks et al. 2002; Zwar et al. 2020) and decreasing quality of life (Rafnsson et al. 2017; Sacco et al. 2020) or life satisfaction (Gerlich and Wolbring 2021). However, there is also research showing a positive relationship, or no relationship at all (e.g. Hajek and König 2016; Leigh 2010). Furthermore, variation exists according to caregiving duration and intensity. While empirical studies show a decline in well-being after the *transition into* family care (e.g. Sacco et al. 2020; Zwar et al. 2020), they yield inconclusive answers on if and how the well-being of the caregiver may change over the longer course of the care episode. Although Lacey et al. (2019) and Sacco et al. (2020) found that continuing caregivers are worse-off in terms of well-being than non-caregivers, they did not observe an additional decline in well-being over time. However, Coe and Van Houtven (2009) have shown that continuing care is associated with losses in well-being. Furthermore, studies demonstrate that the negative effect of family care on well-being tends to be stronger for caregivers providing more hours of care (Chen et al. 2019; Hirst 2005; Sacco et al. 2020). In summary, previous research provides mixed results on the relationship between family caregiving and the well-being of caregivers. Therefore, heterogeneity in family caregiving needs to be considered, especially with respect to care intensity and dynamics.

Family caregiving during the COVID-19 pandemic

A general lockdown with stay-at-home orders was in place in Germany starting from 22 March 2020, which was extended twice until the beginning of May (Naumann et al. 2020). This included a closure of schools, kindergartens, and almost all public and leisure facilities. People were told to stay at home but could leave the home for walks and outdoor activities. Meetings with others were only allowed outdoors and with no more than one member of another household (Bundesregierung 2020). The effects of the COVID-19 pandemic and the related containment measures on individuals' well-being and mental health varied for different groups in society, depending not only on their current socio-economic and health status, but also on their coping strategies (Zacher and Rudolph 2021; Möhring et al. 2021). For family caregivers, it seems likely that the "stress process" and "role strain" dominated during the first wave of the COVID-19 pandemic, rather than the role enhancement perspective. Family caregivers predominantly provide care for frail or elderly people at particularly high risk of severe disease in cases of COIVD-19 infection (especially at the beginning of the pandemic when vaccination was unavailable). Moreover, many family caregivers are elderly and thus also belonged to high-risk groups (Fischer and Geyer 2020). Thus, family caregivers faced increased stress during the first wave of the pandemic from protecting themselves and their care recipients from COVID-19 infection (Gilligan et al. 2020). At the same time, though social-distancing measures had eased by the end of the first pandemic wave, a cure or vaccine was still not available and family caregivers might still have felt the need to reduce social contacts.

Furthermore, the family care situation also changed during the COVID-19 pandemic; the availability of professional care services was restricted, leading to a shrinking of formal support possibilities for family caregivers. During the first COVID-19 lockdown, outpatient services were completely or partially cancelled for tasks that could be fully or partially taken on by relatives living in the household (Räker et al. 2021). In care homes, admission stops were widely implemented (Ott 2020; RKI 2021; Rothgang et al. 2020). As a result of social-distancing practices, family caregivers' informal support networks were also impaired (Eggert et al. 2020). This likely led to more unmet support needs, more individual care hours and more stress (Gilligan et al. 2020; Raiber et al. 2022; Verbakel et al. 2018); about 25% of family caregivers in Germany expressed a need for more support during the COVID-19 pandemic (Klaus and Ehrlich 2021).

Empirical results from the UK support the notion of a lowering of the well-being of family caregivers during the Corona pandemic (Whitley et al. 2021 for caregivers who look after a household member), and the first empirical results for Germany show that the pandemic was associated with increased feelings of loneliness among continuing caregivers (Ehrlich et al. 2022). Taken together, these theoretical considerations and empirical results lead us to the formulation of our first hypothesis: *family caregivers will have experienced a larger decline in well-being (more depressive symptoms, less life satisfaction) during the early phase of the COVID-19 pandemic compared to 2019 than those not providing family care.* (Hypothesis 1a).

However, the well-being of family caregivers might also not have changed—or even increased—during the pandemic, as contextual changes (induced by the pandemic) and containment measures were able to provide relief for them. First, short-time work and work-from-home options may have helped to alleviate role overload and strain resulting from conflicts between jobs and caregiving (Ehrlich et al. 2020; Ehrlich 2023). Second, especially during the first phase of the pandemic in the first half of 2020, the performance of (professional) caregivers was greatly appreciated in the public. The increased social recognition and the feeling of fulfilling a socially crucial task under adverse conditions may have translated into a heightened sense of identity, which in turn enhanced well-being (Gray and Pattaravanich 2020). Recchi et al. (2020) identified an improvement in well-being in the general population in France during the early phase of the pandemic and speculated that it was due to social comparisons with those who were worse off: people in need of intensive care or dying from COVID-19. Those social comparisons might have been even more relevant for family caregivers, who compared the situation of their care recipient living at home with the situation of persons in care homes where many COVID-19 outbreaks took place with high death tolls among residents (Kohl et al. 2021) and social contacts were widely cut-off (Räker et al. 2021). With these considerations, we formulate a second contrasting hypothesis: *Those who provided family care will have experienced no change, or an increase in well-being (depressive symptoms, life satisfaction) during the early phase of the COVID-19 pandemic compared to 2019* (Hypothesis 1b).

Therefore, we expect effect heterogeneity within the group of family caregivers, stemming from differences in the intensity of care provision and the dynamics over time. The effect of the pandemic and the containment measures might especially vary between those who had already been providing family care before the pandemic and those who took up family care responsibilities during the pandemic. Räker et al. (2021) note that the pre-existing coping resources of caregivers can help master the pandemic situation and maintain pre-care well-being levels. Therefore, the group of *continuing family caregivers* is more likely to have had strategies to handle the burden and stress from care provision that could also help them cope with the adverse conditions during the pandemic. Consequently, for continuing family caregivers, increased social recognition and a heightened sense of identity might be relevant. Furthermore, continuing caregivers might have already adapted their well-being levels and might not, therefore, have experienced a further decline (Lacey et al. 2019; Sacco et al. 2020). New family caregivers probably did not have such strategies (yet). This would have been especially severe in a situation with reduced or no support from out- and inpatient care services. Therefore, we expect that *the relationship between family care provision and well-being is moderated by the dynamics of family care provision; the decline in well-being (more depressive symptoms, less life satisfaction) will have been more severe for new family caregivers* (Hypothesis 2a), *while continuing family caregivers will have experienced no change, or even an increase in well-being* (Hypothesis 2b).

As described above, the greater the care intensity, i.e. the higher the number of care hours provided, the more negative the effect on the well-being of caregivers (Chen et al. 2019; Hirst 2005; Sacco et al. 2020; Verbakel et al. 2018). Again, transferring these results to the pandemic situation, and the partial or complete suspension of informal and/or formal support, the burden for those providing intensive care might have been even stronger, and the related loss in well-being even greater than in pre-pandemic times. Especially during the lockdown in 2020, support and care provided by neighbours and friends increased temporary (Ehrlich and Kelle 2022). This caregiving tasks—most probably provided due to geographical proximity—may have included sporadic help with household tasks or grocery shopping. Therefore, it is crucial to distinguish care intensity categories. Therefore, we assume that *the relationship between family care provision and well-being is moderated by care intensity, with a stronger decline in well-being (more depressive symptoms, less life satisfaction) the more hours of family care provided (high-intensity family caregiving)* (Hypothesis 3).

Data and methods

We examined the impact of the COVID-19 pandemic on the well-being of family caregivers using data from the 2019 annual wave of the German Socio-Economic Panel (SOEP, Goebel et al. 2019) and the SOEP-CoV study. The SOEP-CoV sample is a sub-sample of the SOEP that was surveyed between 30 March and 28 June 2020. All SOEP households with a valid telephone number were contacted by telephone, and one adult person in the household was asked to participate in the survey. Half of the calls were made in the late afternoon or evening (51% in total) to ensure that the on-site working population could be reached. The analytic sample is balanced, only including respondents who participated in both the SOEP annual wave 2019 and SOEP-CoV 2020: a total of N = 6694 adult persons with a mean age of 53.1, and 51% women (weighted numbers). Complete information on all focal variables is available for 91% of our analytic sample. We used the multivariate imputation by chained equations (mice) algorithm by van Buuren and Groothuis-Oudshoorn (2011) to multiply imputed missing values. Online Appendix B presents further information on the nonresponse patterns.[1]

The two outcome variables are general life satisfaction and depressive symptoms. General life satisfaction is asked on an 11-point Likert scale (0 completely dissatisfied, …, 10 completely satisfied). Depressive symptoms are measured by the PHQ-4, a standard instrument for measuring depression

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[1] A detailed description of the handling of nonresponse and imputation is given in the electronic supplementary material for this article, see Online Appendix B.

and anxiety consisting of four items with a 4-point scale (1 never, …, 4 every day), added to a sum score (e.g. Löwe et al. 2010). The related question is: "In the last two weeks, how often have you been bothered by any of the following problems? (1) having a lack of interest or pleasure in your activities, (2) feeling down, depressed or hopeless, (3) feeling nervous, worried or on edge, (4) feeling unable to stop or control your worry." The central explanatory variable in our study is family care provision. Respondents are asked in the annual SOEP waves and in the SOEP-CoV study: *"What is a typical day for you? How many hours do you spend on the following activities on a typical weekday: care and support for individuals in need of care?"*. In line with previous research (e.g. Hirst 2005; Sacco et al. 2020), we consider family care in three categories: 1) no family care (0 h per weekday), 2) low-intensity family care (between 1 and 2 h per weekday, i.e. up to 10 h of family care per week), 3) high-intensity family care (more than 2 h per weekday, i.e. more than 10 h of family care per week). Figure A1 in the Online Appendix includes the mean values of depressive symptoms scores and general life satisfaction in 2019 and 2020 along care categories (with 95% confidence intervals and for N = 6694 individuals). As covariates, we include changes in *employment status* (categories: employment, unemployment and non-employment, including retirement and housekeeping) and changes in *concerns about caregivers' own financial situation* (categories: very concerned, somewhat concerned, not concerned at all). Thereby, we control changes in the employment or financial situation that might impact individuals' well-being. Weighted sample statistics for the analytic (balanced) sample for 2019 and 2020 and for the analytic (balanced) sample 2018 and 2019 are given in Appendix Table A1 and split up along caregiver categories in Appendix Table A2. The proportion of missing values in each focus variable is given in Appendix Table A3.

To test our hypotheses and gain insights into the impact of changes in family care at the start of the pandemic in spring 2020 compared to 2019, we estimate first difference models with a balanced panel of 2019 and 2020. First difference models only analyse change (within effects) while controlling for group differences and unobserved heterogeneity on the individual level (Allison 2009).[2] We proceed in three steps. First, we estimate separate models for non-caregivers, new family caregivers (who took on care responsibilities shortly before or during the onset of the pandemic), and continuing family caregivers (who had been providing care before the pandemic). Note that caregiving status is defined *stable over time* so that individuals do not change the classification between the two survey years. We model the general change between 2019 and 2020 with a period dummy for 2020 for non-caregivers, new caregivers and continuing caregivers. For *each of these groups* our models take the following form:

$$\begin{aligned} y_{it} =& a_i + \gamma_1 T_{it} + \gamma_2 EMPLOY_{it} \\ &+ \gamma_3 CONCERNS_{it} \\ &+ \gamma_4 T_{it} CARE_i + \gamma_5 EMPLOY_{it} CARE_i \\ &+ \gamma_6 CONCERNS_{it} CARE_i + \varepsilon_{it} \end{aligned}$$

Here, y_{it} maps the outcome variable of person i at time t, a_i constitutes the individual specific intercept, T_{it} the survey year, $EMPLOY_{it}$ is the employment situation of i at t and $CONCERNS_{it}$ maps the concerns about the (non-)caregiver's financial situation at year t. ε_{it} is the error term of the model which is normally distributed with mean zero and variance σ^2. γ_k are the parameters to be estimated. $EMPLOY_{it}$ $CONCERNS_{it}$ y_{it}

Second, to test whether changes in depressive symptoms and life satisfaction scores are significantly different between non-caregivers, new and continuing family caregivers, we use fully interacted models with the three groups non-caregivers, continuing caregivers, new caregivers ($CARE_i$). The change scores between 2019 and 2020 in depressive symptoms and life satisfaction are then interacted by these categories. The related model equation is

$$\begin{aligned} y_{it} =& a_i + \gamma_1 T_{it} + \gamma_2 EMPLOY_{it} \\ &+ \gamma_3 CONCERNS_{it} \\ &+ \gamma_4 T_{it} CARE_i + \gamma_5 EMPLOY_{it} CARE_i \\ &+ \gamma_6 CONCERNS_{it} CARE_i + \varepsilon_{it} \end{aligned}$$

Third, we integrate care intensity in the analysis by categorising caregivers in six groups: continuing low-intensity caregivers, continuing high-intensity caregivers, new low-intensity caregivers, new high-intensity caregivers, continuing caregivers switching from high- to low-intensity, and continuing caregivers switching from low- to high-intensity care (see Appendix Table A4). Again, these groups are operationalized as stable over time. We then use fully interacted models including only caregivers categorised in these six groups ($CAREINT_i$). The change scores between 2019 and 2020 in depressive symptoms and life satisfaction were again interacted by these categories. The related model equation is

$$\begin{aligned} y_{it} =& a_i + \gamma_1 T_{it} + \gamma_2 EMPLOY_{it} \\ &+ \gamma_3 CONCERNS_{it} \\ &+ \gamma_4 T_{it} CAREINT_i \\ &+ \gamma_5 EMPLOY_{it} CAREINT_i \\ &+ \gamma_6 CONCERNS_{it} CAREINT_i + \varepsilon_{it} \end{aligned}$$

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[2] The first-difference estimator is obtained by a pooled ordinary least squares estimation for a regression of $y_{it} - y_{it-1}$ on $x_{it} - x_{it-1}$. Alternatively, our first difference approach may be denoted as change score approach.

Table 1 First difference regression results from separated Models 1–3 and combined fully-interacted Model 4 on depression scores (Betas), 2019–2020

	Model 1: non-caregivers	Model 2: new caregivers	Model 3: continuing caregivers	Model 4a: new versus non-caregivers	Model 4b: continuing versus non-caregivers	Model 4c: new versus continuing caregivers
Year						
2020 (Ref.: 2019)	0.65* [0.03]	0.74* [0.15]	0.46* [0.15]	0.09 [0.14]	− 0.19 [0.15]	0.28 [0.20]
Employment (Ref.: employed)						
Unemployed	0.14 [0.17]	− 0.87 [0.66]	− 0.67 [0.72]	− 1.01 [0.61]	− 0.81 [0.75]	− 0.20 [0.94]
non-employed	− 0.10 [0.11]	− 0.25 [0.45]	0.43 [0.62]	− 0.15 [0.42]	0.53 [0.63]	− 0.68 [0.74]
Concerned about own econ. Situation (Ref.: not at all)						
Somewhat	0.39* [0.06]	0.55* [0.27]	0.22 [0.27]	0.16 [0.25]	− 0.17 [0.28]	0.33 [0.36]
Very	1.19* [0.11]	2.00* [0.45]	1.69* [0.44]	0.81 [0.43]	0.50 [0.46]	0.31 [0.60]
R squared	0.08	0.11	0.08	0.08	0.08	0.08
Sample size (individuals)	5,838	359	291	6488	6488	6488

Standard errors from pooled results are given in brackets. N = 206 persons stopped caregiving from 2019 to 2020. Sample size is the mean of the group sizes after multiple imputation

*$p < 0.05$. First difference analysis from m = 20 multiply imputed data sets

Note that our approach differs from a Difference-in-differences (DiD) design as the Corona pandemic was experienced by all sample members, i.e. there is no “control group” in our design. As a robustness check, we also analysed the data from a balanced panel for 2018–2019 with the same statistical strategy as for the 2019–2020 data (see Online Appendix C). Of course, this does not eliminate the problem of the missing control group; therefore, differences we find between 2019 and 2020 might have other causes than the pandemic.

We used the statistical software R (version × 64 3.6.2); the packages ‘Hmisc’ (Harrell 2022), ‘weights’ (Pasek 2021) and ‘diagis’ (Helske 2021) for descriptive statistics, the package ‘mice’ (van Buuren et al. 2022a, b) for multiple imputation, and the package ‘plm’ for regression analysis (Croissant et al. 2022).[3]

Results

Differences according to caregiving dynamics

Before we turn to the first difference regression models, we examine the sample composition as presented in the weighted sample statistics in Appendix Table A2. These descriptive statistics show some compositional differences between the three groups of non-caregivers, new caregivers who started caregiving in 2020, and continuing caregivers who provided care in 2019 and 2020. Compared to non-caregivers, continuing caregivers concentrated more in the higher age group of 61 years and older, and new caregivers in the middle age group of 41–60 years. While new caregivers had a similar female share as non-caregivers, the share of women was higher among continuing caregivers (67% female as compared to 50% among non-caregivers). The share of non-employment was higher among continuing caregivers (44% as compared to 35% among non-caregivers in 2019) and the share of unemployment higher among new caregivers as compared to non-caregivers (10% as compared to 4% among non-caregivers). Financial concerns were higher among new caregivers. However, the amount of *change over time* in employment status and concerns about financial situation were similar in the three groups except for a higher rate of transition to non-employment, including retirement, among continuing caregivers.

Tables 1 and 2 show the results of first difference regression models for 2019 and 2020. We began by testing changes in depressive symptoms between 2019 and 2020 for non-caregivers, continuing caregivers and new caregivers. Did individuals providing family care during the early phase of the COVID-19 pandemic experience a larger change or a smaller change than those not providing family care, or no difference, compared to 2019 (Hypotheses 1a and 1b)? For individuals who did not provide family care, our analysis reveals a significant overall increase in the depressive symptoms score of 0.65 scale units in 2020 compared to 2019 (Table 1, Model 1). Those who started providing family care between

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[3] The source code and further information on the data and methods is available at the GitHub link: https://github.com/bieneSchwarze/familyCareDuringCOVID19Lockdown

Table 2 First difference regression results from separated Models 1–3 and combined fully-interacted Model 4 on life satisfaction (Betas), 2019 – 2020

	Model 1: non-caregivers	Model 2: new caregivers	Model 3: continuing caregivers	Model 4a: new versus non-caregivers	Model 4b: continuing versus non-caregivers	Model 4c new versus continuing caregivers
Year						
2020 (Ref.: 2019)	0.19* [0.02]	0.19* [0.10]	0.13 [0.11]	0.01 [0.10]	– 0.06 [0.11]	0.06 [0.15]
Employment (Ref.: employed)						
Unemployed	– 0.03 [0.12]	0.31 [0.45]	– 0.64 [0.51]	0.34 [0.45]	– 0.61 [0.53]	0.95 [0.67]
Non-employed	0.02 [0.08]	0.60* [0.29]	0.24 [0.43]	0.58 [0.29]	0.22 [0.44]	0.36 [0.52]
Concerned about own econ. Situation (Ref.: not at all)						
Somewhat	– 0.33* [0.04]	– 0.47* [0.19]	– 0.20 [0.20]	– 0.14 [0.18]	0.13 [0.20]	– 0.27 [0.27]
Very concerned	– 0.89* [0.07]	– 1.06* [0.30]	– 0.67* [0.32]	– 0.17 [0.29]	0.22 [0.44]	– 0.39 [0.43]
R squared	0.04	0.07	0.04	0.04	0.04	0.04
Sample size (individuals)	5838	359	291	6488	6488	6488

Standard errors from pooled results are given in brackets. N = 206 persons stopped caregiving from 2019 to 2020. Sample size is the mean of the group sizes after multiple imputation

*$p < 0.05$. First difference analysis from m = 20 multiply imputed data sets

2019 and spring 2020 had a significantly increased depressive symptoms score of 0.74 scale units in 2020 (Table 1, Model 2), and those who were already providing family care before the pandemic had a significantly increased depression score of 0.46 scale units in 2020 (Table 1, Model 3). Between 2018 and 2019, in contrast, there was a significant decrease in depression score among non-caregivers and continuing caregivers (see Models 1–3 in Appendix Table C2).

Models 4a–c contrast the three groups in paired comparisons based on a fully interacted regression. This means we can directly test whether changes in depressive symptoms and life satisfaction are significantly different between non-caregivers, new and continuing caregivers by adding interactions of each variable in the model with the three groups. Differences in change scores between (non-)caregivers are non-significant, indicating that increases in depressive symptoms between all three groups were similar. This was different between 2018 and 2019, when new caregivers experienced a significant increase in depressive symptoms compared to the reference group of non-caregivers (coefficient of 0.23* in Model 4a Appendix Table C2).

For general life satisfaction, our analysis shows a significant increase of 0.19 scale units in spring 2020 compared to 2019 for those who did not provide family care (Table 2, Model 1). The results for new and continuing caregivers also show a slight increase in life satisfaction of 0.19 and 0.13 scale units respectively, albeit non-significant for continuing caregivers (Table 2, Models 2–3). This is contrary to the development between 2019 and 2018 with a significant decline in life satisfaction in all three groups (see Models 1–3 in Appendix Table C3). Differences in change scores between non-caregivers, continuing caregivers and new caregivers are again non-significant in 2019–20 (Table 2, Models 4a–c), same as for 2018–2019 (see Models 4a–c in Appendix Table C3).

Differences according to care intensity

For the multivariate analyses on differences according to caregiving intensity, caregivers were categorised in six groups depending on changes or stability in intensity as described above: continuing low-intensity caregivers, continuing high-intensity caregivers, new low-intensity caregivers, new high-intensity caregivers, continuing caregivers switching from high- to low-intensity, and continuing caregivers switching from low- to high-intensity care (see Appendix Table A4).

Figure 1 shows selected beta coefficients from fully interacted models for the interactions of caregiving group*year 2020 (regression models are included in Appendix Table A5). These conditional effects show whether a change in well-being of a specific group of caregivers significantly deviated from non-caregivers. Note that the values apply with the reference categories set to ‘employed’ and ‘no financial worries’. The different types of caregivers did not significantly differ from non-caregivers in changes in depression scores (Fig. 1, left panel). Continuing low-intensity caregivers had a significantly smaller increase in life satisfaction than non-caregivers, while continuing high-intensity caregivers had a significantly larger increase in life satisfaction than non-caregivers (Fig. 1, right panel).

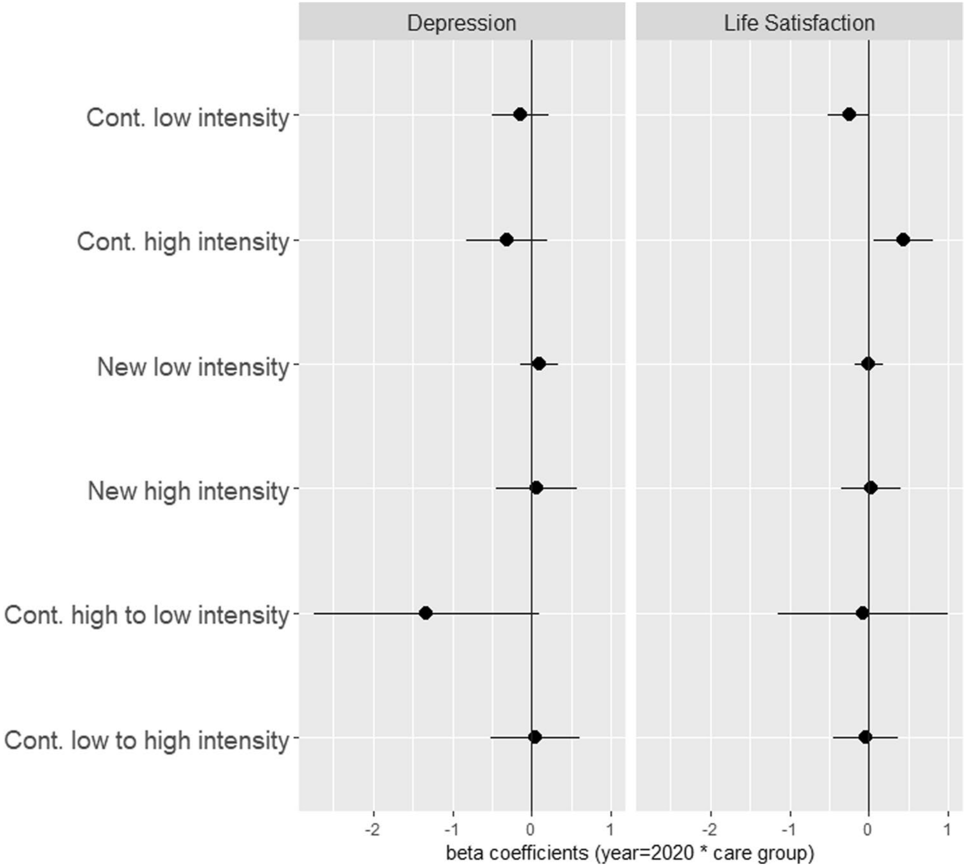

Fig. 1 Coefficient plot for the first difference regression results on depression and life satisfaction (Betas), 2019–2020. *Notes*: Beta coefficients from regression models 1 and 2 in Appendix Table A5. Controlled for changes in employment (reference category: employed) and worries about financial situation (reference category: no worries)

Discussion

Viewing these results in light of our Hypotheses, we arrive at the following conclusions. Our conflicting Hypotheses 1a and 1b assuming a decline or increase in well-being of family caregivers between 2019 and 2020 compared to non-caregivers are neither confirmed nor refuted. Everybody, non-caregivers and caregivers alike, showed significant increases in life satisfaction and simultaneously (partly significant) increases in depressive symptoms. Increases in depression were larger for new caregivers who started family caregiving during or shortly before the first wave of the pandemic in 2020, and smaller for those who had continuing provided care already in 2019 and 2020, compared to non-caregivers. However, differences between the three groups are non-significant.

Our findings point to heterogeneity within the group of caregivers. While changes in well-being between 2019 and 2020 among caregivers are very much in line with changes in the general population, variation within the group of caregivers, especially due to care intensity, is striking—and partly contrary to our expectations. We assumed stronger negative effects from the pandemic for those providing high-intensity care (Hypothesis 3). In fact, increases in life satisfaction were largest for continuing high-intensity caregivers.

Conclusion

Our study is the first, to the best of our knowledge, to examine relationships in the well-being of family caregivers in response to the first wave of the COVID-19 pandemic with detailed information on family care dynamics and intensity and appropriate data, sample and methods. The results on changes in depression scores and general life satisfaction of family caregivers over the course of the first COVID-19 lockdown show temporal and within-group differences regarding family care dynamics (new caregivers vs. continuing caregivers) and family care intensity (high- vs. low-intensity caregivers). While the changes in well-being between 2019 and 2020 among caregivers resemble those among non-caregivers, differences emerge in the group of continuing caregivers according to care intensity. Caregivers providing intensive care of more than two hours per day show a larger increase in life satisfaction than non-caregivers, while the opposite applies to low-intensity caregivers with two or less hours of care-provision per day. This difference might be due to the divergent care arrangements of these two groups. Continuing high-intensity caregivers are presumably primary caregivers or co-residential caregivers, as both caregiver types are associated with a higher number of average care hours (Ehrlich and Kelle 2019; Räker et al.

2020; Schneekloth et al. 2016). Low-intensity caregivers presumably receive help from a private or professional support network, are secondary caregivers, or are extra-residential caregivers – caregiver types that are all associated with a lower number of average care hours (Ehrlich 2018; Ehrlich and Kelle 2019; Schneekloth et al. 2016). Therefore, the latter group might be more negatively affected by containment measures, which greatly altered their care arrangements and restricted contact with persons outside their own household in the first phase of the COVID-19 pandemic. Furthermore, continuing high-intensity caregivers could be more resilient to the adverse conditions during the pandemic, having already become accustomed to the care situation before the onset of the pandemic in 2020. This group may have also benefited from the increased social reputation of care work during the first lockdown in the early phase of the pandemic, gaining increased self-esteem and a strengthened sense of identity—as predicted by role enhancement theory (Moen et al. 1995).

From a theoretical perspective, our study demonstrates that prominent theories on family care and well-being also have some predictive power during the COVID-19 outbreak and its subsequent containment measures. The results support the notion that family caregiving and the group of family caregivers are heterogeneous, presumably also due to differences in the ability to develop coping strategies (Haley and Pardo 1989; Seltzer and Li 2000; Townsend et al. 1989). The increase in life satisfaction among continuing high-intensity caregivers is in line with the role enhancement perspective. These caregivers may have felt a greater appreciation of their role as a family caregiver than before the pandemic. From a practical perspective, the situation of continuing low-intensity caregivers during the first wave of the pandemic, when professional care services were severely cut back, underlines the necessity of further expanding such options instead of cutting them, especially options that temporarily and flexibly reduce the care burden for family caregivers (Raiber et al. 2022; Stadler 2021).

However, our study has limitations. Generally, the association between family caregiving and the well-being of family caregivers might be endogenous; more resilient individuals might be more likely to take on care provision. Empirical research does not clearly support this "healthy caregiver hypothesis" (Fredman et al. 2010; Roth et al. 2015). Besides, the unexpectedness of the COVID-19 pandemic in early 2020 restricts the possibility for a selection effect in any direction; caregivers could not 'opt-out' of caregiving considering the difficulties ahead, and admission stops in care homes in 2020 further restricted opportunities to pass on care responsibilities to professional care services. Furthermore, with our first difference design, we focused on within variation, doing our best to account for unobserved heterogeneity, e.g. in terms of general health conditions and character traits. Unfortunately, we could not integrate information on the family caregiver's support network, as this information is not available for all family caregivers. Moreover, the SOEP does not provide full information on when caring episodes began, so we could not integrate the exact duration of care episodes. Furthermore, due to this study's small case numbers, gender-sensitive analyses were not applicable, although effects might be gendered (Swinkels et al. 2019; Zwar et al. 2020).

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ORIGINAL INVESTIGATION

Retirement's impact on health: what role does social network play?

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Abstract

While a large body of literature investigates the bidirectional relationship between retirement and health, few have analyzed the mechanism through which retirement affects health which will provide important policy instrument insights. Using three waves of National Social Life, Health, and Aging Project, we examine the mediating role of the social network in the relationship between retirement and health in USA. We address the endogeneity and reverse causality through panel instrumental fixed-effect methods. We apply both single and parallel mediation analyses to identify the potential mechanism by which social network characteristics mediate the impact of retirement on health. Findings reveal that retirement adversely affects physical and mental health outcomes, and a considerable portion of these effects are explained by social network changes post-retirement. Specifically, 58% of reduction in the probability of reporting good physical health and 4.5% of increment in chances of having depression symptoms post-retirement can be explained by shrinkage in the size of social network in retirees. Using parallel mediation identification to account for dependencies among social network features, we find that social network size induces 79.5% reduction in probability of reporting good physical health and 18.6% increase in probability of having depression in retirees as compared to non-retirees. Findings in this paper suggest that investing in social network of the elderly can buffer the adverse health effect of retirement and can be an effective policy target for promoting healthy aging.

Keywords Retirement · Physical and mental health · Social network · Mediation

JEL Classification I12 · J26

Introduction

In the USA, population aging so-called silver tsunami causes deep social and political transformations, challenging society in many aspects. The continuing reduction in ratio of workers to retirees causes serious concerns about Social Security benefit sustainability, and growing of elderly population due to improvement in longevity increases the burden on medical care and pension systems. In particular, Social Security paid out more benefits than it collected in taxes in 2018, and recent prediction by Social Security Administration shows the trust will be depleted by 2034.[1]

These concerns prompt a series of policies such as increasing the Social Security retirement age and Medicare eligibility age. The effectiveness of increasing retirement age depends on an implicit assumption that late retirement is good for health or at least does not harm health. Retirement is a life-changing event that can improve or deteriorate elderly's health both physically and mentally (Nishimura et al. 2018; Dave et al. 2008; Coe and Lindeboom 2008). Therefore, the precise identification of the causality impacts of retirement on the elderly's health is needed for effective policy design, implementation, and evaluation.

However, establishing the causal effects of retirement on health is empirically challenging for a couple of reasons. First, existing evidence suggests a reverse causal relationship between health and labor supply decisions and second, the existence of unobserved confounding factors that influence both health and retirement decisions simultaneously such as work environment and genetics.

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[1] Social Security Administration Annual Report.

Furthermore, as a life-changing event, retirement significantly alters retirees' daily routines, social contact, and social activities (i.e., Barnett et al. 2012; Eibich 2015). If retirement affects social network while social network significantly impacts individual's health (Cohen 2004), social network might be a health policy instrument that can be used to promote elderly's health, i.e., minimizing the negative impact of post-retirement's life changes on retiree's health through maintaining and fostering retirees' social capital.

However, disentangling the causality between health and social network suffers similar identification problem because the formation of social network is not random (Manski 1993; Moffitt et al. 2001; Brock and Durlauf 2001): individuals' unobserved heterogeneity simultaneously affects both health production and social network formation. People who have lower discount rates and put more value for future benefits are more likely to invest in health and social network that results in better health and more social capital in the future. Meanwhile, healthy individuals have more energy and time to socialize with others and enrich their social network. As a result, a model that examines the causality of retirement and social network on retirees' health outcomes will need to address the endogeneity problem that may cause inconsistent estimations.

The literature has applied various identification methods to address the aforementioned empirical challenges in investigating the relationship between retirement and health but has not reached consistent findings (e.g., Kofi Charles 2004; Neuman 2008; Coe and Lindeboom 2008; Coe and Zamarro 2011; Gorry et al. 2018; Insler 2014). The most recent studies (e.g., Gorry et al. 2018; Insler 2014) used instrumental-variable (IV) and fixed-effect (FE) methods with early and regular pension benefit eligible ages as instruments to deal with the endogeneity in the retirement status.

It is still hard to compare results across studies since they use different retirement definitions such as not working for pay and working less than 1200 h per year. Those definitions do not necessarily capture the effect of complete retirement (i.e., not working at all both for pay and for free) on health precisely.[2] Furthermore, to the best of our knowledge, there is no empirical evidence on the social network pathway through which retirement affects health.

The chief goal of this study is to identify the mediatory impact of social network on the subsequent health effect of retirement using the egocentric social network and health information available in the National Social Life, Health and Aging Project (NSHAP) survey (discussed in detail in later section). For this purpose, we first investigate the retirement impact on health and address the endogeneity issue by employing the panel structure of NSHAP.[3] In particular, we tackle the endogeneity caused by unobservables and individual's heterogeneity by using eligibility age for full Social Security benefits as an instrumental variable for retirement status as well as applying fixed-effect methodology. Furthermore, we restrict our sample to pre-retirement healthy individuals to minimize the potential inconsistency induced by reverse causality and potential weak instrument problem (i.e., people might retire in other time in the life span, not necessarily at the eligibility age for Social Security benefits). Lastly, we highlight the importance of investigating the causal relationship between retirement and health and the mediatory role of social network for public policy intervention to promote healthy aging.

Review of literature

Health on retirement

On top of the numerous factors that affect retirement decision, such as Social Security eligibility, financial resources, and health insurance, health is believed to be a crucial determinant. The empirical findings are consistent in supporting this conclusion. By modeling the endogenous health dynamics within a structural model of retirement, Bound et al. (2010) find that healthy people are unlikely to retire unless they have a sizable financial resource. It is more likely for those who are in poor health to retire before being eligible for any pension benefits. Capatina (2015) indicates four channels by which health affects an individual's labor supply: productivity, medical expenditures, available time, and mortality. She states that productivity and time lost to sickness are the main channels by which health affects labor supply. Similarly, Gustman and Steinmeier (2018) demonstrate that improving the overall health of the population would delay retirement by one year. Moreover, McGarry (2004) shows that the impact of changes in health on retirement expectations is much greater than financial variables.

Retirement on health

Recently, researchers have paid more attention to the effect of retirement on health outcomes. Several studies show a significant health improvement after retirement (e.g., Charles 2002; Bound and Waidmann 2007; Johnston and Lee 2009; Neuman 2008; Coe and Lindeboom 2008; Coe and Zamarro 2011; Insler 2014), while others find that retirement significantly deteriorates health (e.g., Dave et al. 2008;

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[2] Dave et al.'s study (2008) is the only study on US data which considers not working as the definition of retirement (using Health and Retirement Study dataset) and exploits the panel nature of data.

[3] The NSHAP has not been exploited in the literature of retirement and health studies.

Behncke 2012). Recently, a systematic review (Nishimura et al. 2018) points out that different methodology utilized is a key factor for explaining the mixed results in the literature as well as the choice of wide ranges of control variables. For example, in a study using UK data, Behncke (2012) employs a nonparametric matching approach and finds no impact of retirement on depression along with a negative impact on self-reported health. However, by using Regression Discontinuity Design, Johnston and Lee (2009) indicate that retirement lowers depression for a sample of men who do not have an educational degree in UK.[4] Besides, different norms, labor market, and economic incentives embedded in the Social Security and pension system across different countries may also contribute to the inconsistency in empirical findings in the literature.

Even if we only compare the studies on US data, the findings are still mixed. For example, in terms of subjective well-being, by using Social Security normal retirement age as an instrumental variable, Kofi Charles (2004) finds that retirement has a positive effect on subjective well-being, while Dave et al. (2008) find no effect. For the self-reported health, most findings show that the probability of reporting good health increases after retirement (e.g., Neuman 2008; Coe and Lindeboom 2008; Calvo et al. 2011; Nishimura et al. 2018), whereas some reports the opposite (Dave et al. 2008). In the case of physical health, Dave et al. (2008) report retirees are more likely to suffer from difficulties in their physical activities, while other studies declare there is a positive association between retirement and physical health for women but none for men (Neuman 2008; Nishimura et al. 2018). In regard to mental health, some studies claim that retirement does not affect depression (Neuman 2008; Coe and Lindeboom 2008), while others find that retirement is associated with higher depression (Nishimura et al. 2018; Li et al. 2021).

The role of social network

A few studies investigate how retirement changes the social life and social network of retirees (e.g., Comi et al. 2020; Patacchini and Engelhardt 2016; Börsch-Supan and Schuth 2014; Barnett et al. 2012). Social network is defined as a "web of social relationships surrounding an individual and the characteristics of those ties" (Berkman et al. 2000), which are generally characterized in terms of structure, quality, and function. Social network structure refers to the number of people in the network and the level of contact an individual has with the other network members.

An important function of a social network is to provide social support, especially emotional and instrumental support, to members of the network that eventually influence mental and physical health (especially for those older individuals) (e.g., Israel 1982; Cohen 2004; Ronconi et al. 2012; Petrou and Kupek 2008; Fiori and Jager 2012; Litwin and Shiovitz-Ezra 2010; Allen et al. 2014). Social network members can provide social support and companionship for day-to-day adaptation to new life of retirees that will contribute to better health. According to Berkman and Syme (1979), individuals who have larger social networks are more likely to have better health, especially when the network members are frequently contacting each other (Terhell et al. 2007). Social network involvement might include negative social interaction in which social network members behave in hurtful and inconsiderate ways that result in worse health (Krause and Rook 2003). Noticeably, studies found that positive social interactions and social support happen much more frequently than do negative interactions (Rook 1998).

In a recent study on 11 European countries, Comi et al. (2020) report major changes in the structure of the social network upon retirement. They conclude retirees make stronger ties with family members, while they lose ties with friends and colleagues. In a similar study on the same countries, Börsch-Supan and Schuth (2014) find early retirement reduces the size and intensity of relationships in retiree's social network, which leads to significant early cognitive aging. In the US study, researchers Patacchini and Engelhardt (2016) find similar results on the negative impact of retirement on size and density of social network.

The effect of retirement on social network is an empirical hypothesis. On the one hand, retirement reduces social interactions because of losing co-workers and work-related networks and thus shrinks the size of social network (Sugisawa et al. 1997). On the other hand, people would have more time to do voluntary works, participate in different types of social activities, and make new connections to expand their social networks (Barnett et al. 2012).[5] No matter which direction the impact is, retirement will lead to social network changes and subsequently may impact retirees' health. Therefore, it is needed to investigate the empirical evidence of social network's mediation effect in the pathway between retirement and health to understand whether social network is a viable channel to invest on for healthy aging promoting policies.

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[4] There are many other studies based on the evidence of other countries such as Korea, Japan, Canada, and European countries.

[5] Recently, several studies attempt to investigate how social network impacts retirement decision making (van den Berg et al. 2010; Harkonmäki et al. 2006). Findings show that social support can buffer the effect of main factors of early retirement decision such as poor health, low job satisfaction, and work pressure (van den Berg et al. 2010).

Data and variables

Data

In our empirical analysis, we use data from the National Social Life, Health, and Aging Project (NSHAP), which is conducted by National Opinion Research Center (NORC) at the University of Chicago. This is a population-based panel study of the US elderly with specific purpose to investigate connections between health and social factors. The first wave of the NSHAP includes a sample of 3,005 adults aged 57–85 years old (born between 1920 and 1947) who were interviewed in 2005 or 2006. Wave 2 consists of 2261 Wave 1 respondents who were re-interviewed in 2010 or 2011. Wave 2 also includes the cohabiting spouses and romantic partners of Wave 1 respondents in addition to Wave 1 non-interviewed respondents. In total, wave 2 includes 3400 respondents. Wave 3 constitutes of 4777 individuals who were interviewed in wave 2 in addition to a new cohort born between 1948 and 1965 (baby boomers).[6] The construction of the subsample used in our study will be explained in Sect. 3.5.

Health variables

As outcome variables, we consider both physical and mental health measures available in NSHAP. Physical health: We examine the overall physical health based on the respondent's answer to the question "would you say your physical health is excellent, very good, good, fair, or poor?" The response is coded on scale from 1 to 5. Higher values of self-reported physical health correspond to better health. The physical health outcome in the analysis is an indicator variable equal to one if respondent reports excellent or very good health status (Coe and Lindeboom 2008).

Depression The NSHAP includes a depression scale introduced by Center for Epidemiologic Studies (CES), which is based on a cumulative summation over response scores to eleven questions. Respondents were asked about the frequency of certain feelings in the past week (e.g., "how often did you feel depressed in the past week?"). Certain feelings include: Depressed, Restless, Difficult, Poor appetite, Everything was an effort, Happy, Lonely, People were unfriendly, Enjoyed life, Sad, and Being disliked. There are four possible responses: "rarely or none of the time" (score: 1); "some of the time" (score: 2); "occasionally" (score: 3); and "most of the time" (score: 4).[7]Higher values of CESD represent more depression symptoms and worse mental health. A score of 16 is considered as a standard cutoff point (Radloff 1977), meaning that scores greater than 16 denote the existence of depression symptoms. Using this cutoff point, we define a dichotomous variable for depression in which value one indicates the existence of depression symptoms, and zero otherwise.

Anxiety NSHAP includes seven questions related to anxiety symptoms defined by Hospital Anxiety and Depression Scale (HADS). Respondents were asked about the frequency of feeling anxiety symptoms (i.e., tense, something awful about to happen, restless, worried, relaxed, frightened, and panic) in the past week. The range of answer to these questions are similar to the CES-D depression. Hence, we calculate the anxiety score by summation over the response scores to the seven questions. The higher values of anxiety variable demonstrate worse mental health.[8] Score 8 is considered as cutoff point such that scores below 8 show no symptoms of Anxiety (Zigmond and Snaith 1983). Anxiety variable in our analysis is an indicator variable with value one indicating presence of anxiety symptoms.

Social network variables

NSHAP includes the respondent's egocentric social network. An egocentric social network includes an ego (the respondent) and a set of members. In NSHAP, respondents could name up to five people that immediately surround them in the past 12 months, but respondents were also asked to denote if they had more than five members in their networks. Also, NSHAP contains frequency of contacts among members including the respondent. Frequency of contacts are collected by asking respondents "how often do you talk to the person cited?" The responses range "have never spoken to each other (0)," "less than once a year (1)," "once a year (2)," "a couple of times a year (3)," "once a month (4)," "once every two weeks (5)," "once a week (6)," "several times a week (7)," "every day (8)." In NSHAP, respondents are asked to describe type of their relationship with each member in the network (e.g., partner, family, friend, coworker, etc.).

Based on available information about social network in NSHAP, we construct the most frequent examined network characteristics in the social network literature: size of social network, frequency of contacts, and diversity of ego's network (Carolan 2013). Size is defined as number of members in the respondent's social network. We construct an index

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[6] We use sample weights for all the analyses.

[7] The answer scores to positive notion questions (e.g., "How often did you feel happy in the past week?") are reversed to be consistent in measuring depression.

[8] Anxiety questions are asked in the leave-behind questionnaire, and around 2600 respondents have answered these questions in each wave. Therefore, the subsample for investigating the anxiety impact has the lowest sample size.

for measuring frequency of contacts by summation over the scores of ego's frequency of contacts (i.e., scores range from 0 to 8) with members and normalize it with the size of network. This normalization makes the frequency measure less dependent on the size. To illustrate this, consider ego1 who has one member in her social network and every day is in contact with that person as compared to ego2 who has 8 members in his network and is in contact with them less than a day per year. In terms of the frequency of contacts, without normalization, these two have the same frequency of contacts (i.e., 8).

Based on varieties of relationship types in NSHAP, we define 8 categories: partner, parent, child, family, friend, neighbor, coworker, and others (i.e., minister, priest, or other clergy, psychiatrist, psychologist, counselor, or therapist, caseworker/social worker, and house-keeper/home healthcare provider). We utilize the Index of Qualitative Variation (IQV) (Knoke and Yang 2008) to construct the diversity measurement of social network. For the i-th respondent with N members in the network, where members are classified into K categories, the IQV is defined as follows:

$$\mathrm{IQV} = \frac{1 - \Sigma_{j=1}^{k} P_j^2}{\frac{k-1}{k}} \quad (1)$$

In which P_j is the percentage of members of network in the j-th category. The IQV is a standardized measure ranging between 0 and 1, where 0 indicates all N members are in one category and 1 indicates members are equally dispersed across K categories.

Retirement and control variables

NSHAP contains demographic and socioeconomic information such as gender, age, ethnicity, marital status, educational attainment, income, and employment status (i.e., currently working, retired, disabled, unemployed, homemaker, or other). Dichotomous indicator is defined to be 1 for retirement if the respondent reports retired and not working, the indicator is 0 otherwise.[9] We focus on full retirement to capture the largest effect that retirement can have on health. The NSHAP also includes respondent's health behaviors like smoking and drinking. Particularly, respondents were asked whether they smoke cigarettes currently and how many cigarettes they smoke per day, whether they currently drink alcohol and the number of drinks they consume per day. In our empirical analysis, we control for these observable characteristics (e.g., age, income, marital status, cigarette smoking, and alcohol consumption).[10]

Sample selection

We restrict the sample to subsample of healthy individuals before retirement event. Although we lose many observations, we immune our findings from potential simultaneity problem between retirement and health. There are several advantages for us to focus on pre-retirement healthy individuals: first, it is less likely that health causes retirement for these individuals (i.e., reverse causality is minimized). Second, the inconsistency induced by unobservable confounding factors that simultaneously influence both health and retirement is also minimized. Third, this sample selection strategy also protects our estimations from weak instrument inconsistency (more details will be provided in "Empirical methodology" section).

Likewise, this subsample selection helps minimize the inconsistency caused by the possible endogeneity of social network as well. Remarkably, social network involvement might not only be disturbed by health problems, but also be changed by retirement. Focusing on the subsample of healthy individuals before retirement guarantees bad health does not interfere the social network changes. In particular, individuals are defined as healthy if they report good, very good, or excellent as their self-reported physical and have depression and anxiety score less than 16 and 8, respectively.[11] Consequently, our pre-retirement healthy subsample includes 1,160 individuals. Hence, we sacrifice the variation in observations for the sake of validity of results and preventing inconsistency in the estimations.

Summary statistics

Table 1 provides data description and summary statistics of the variables in the selected subsample of pre-retirement healthy individuals and compares retirees versus non-retirees. According to Table 1, 45% of sample are retired who are on average significantly older than non-retirees (i.e., 70 years old vs. 66 years old).[12] The mean of self-reported physical health depicts that on average retired people are in worse health condition as compared to non-retirees. Table 1 also indicates retirees on average experience higher levels of depression and anxiety symptoms than non-retirees do.

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[9] Respondents were asked: "Are you retired?" possible answers: Yes, No, refused. "Are you currently working?" possible answers: Yes, No, refused. A respondent is considered as retired if the answer to the former question is yes and the latter question is no.

[10] Age is entered to the models linearly.

[11] CESD score lower than 16 implies no depression symptoms exist (Radloff 1977). Also, anxiety scores below 8 indicates no anxiety is diagnosed (Zigmond and Snaith 1983)

[12] This is according to our definition of retirement.

Table 1 Summary statistics and data description of subsample of study

	Not-retired	Retired	Difference	Min[a]	Max[b]
Employment status					
Retirement	0	1	− 1	0	1
Health outcomes					
Physical health	3.89	3.51	0.38***	1	5
	(0.76)	(1.00)	(0.08)		
Depression	12.88	13.93	− 1.05***	11	29
	(1.96)	(3.16)	(0.23)		
Anxiety	2.39	3.48	− 1.08***	0	14
	(2.23)	(3.18)	(0.25)		
Demographics					
Age	66.24	69.95	− 3.70***	57	90
	(6.01)	(6.02)	(0.61)		
Female	0.46	0.44	0.02	0	1
	(0.50)	(0.50)	(0.05)		
Married	0.73	0.67	0.06	0	1
	(0.44)	(0.47)	(0.05)		
White	0.85	0.83	0.02	0	1
	(0.36)	(0.38)	(0.04)		
Asian	0.05	0.05	− 0.01	0	1
	(0.21)	(0.23)	(0.02)		
High education	0.75	0.74	0	0	1
	(0.44)	(0.44)	(0.04)		
High income	0.88	0.81	0.06*	0	1
	(0.33)	(0.39)	(0.03)		
Health behaviors					
Alcohol consumption	0.69	0.59	0.09**	0	1
	(0.46)	(0.49)	(0.05)		
Number of drinks	1.3	1.09	0.22	0	15
	(1.51)	(1.16)	(0.15)		
Smoking cigarette	0.11	0.09	0.02	0	1
	(0.31)	(0.28)	(0.03)		
Social network					
Size[c]	9.46	9.52	− 0.05	2	18
	(3.08)	(3.18)	(0.31)		
Frequency of contacts[d]	14.85	15.63	− 0.79	2	31.3
	(5.15)	(5.65)	(0.53)		
Diversity[e]	0.67	0.64	0.03	0	0.95
	(0.19)	(0.21)	(0.02)		
Observations	633	537			

This table reports the summary statistics of the subsample of healthy (healthy in self-reported physical and mental health, no depression, and no anxiety) individuals before retirement. Retired refers to individuals who reported retired and not working

[a] Min denotes the minimum values of each variable

[b] Max denotes the maximum values of each variable

[c] Size refers to the number of members in the individual's social network

Table 1 (continued)

[d] Frequency refers to the frequency of contacts with members of one's social network

[e] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV). Standard deviations are in parentheses. For some variables, the actual sample size is less due to missing information and because some of the variables are in the leave-behind questioners

Asterisks present that the difference between the retired and non-retired samples is statistically significant as follow: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

According to this table, on average, retirees have lower income as compared to non-retirees. With regard to health behaviors, retirees drink alcohol less than non-retirees on average, whereas no significant difference exists between these two groups in terms of smoking. While retirees on average seem to have larger social network with higher frequency of contacts and lower diversity in their network as compared to non-retirees' social network, no significant differences exist on these characteristics among the two groups.

Some limitations in the data set prevent us from a comprehensive investigation of the effects of social network. In particular, we have no information about the geographical distance between respondents and members, the form of communication between social network members whether it is by mail, internet, in person, or by phone. Also, the lack of detailed information on health condition and labor status of the social network members deprives the opportunity for examination of potential interactive and spillover social effects. Moreover, although health insurance is a key variable in late life that influences both health and retirement decision, we exclude it from our empirical analysis due to the lack of variations in the sample. Particularly, more than 80% of the sample have health insurance in the first two waves.

Empirical methodology

Retirement and health

For simplicity, consider the following linear specification of health as a function of retirement in Eq. (2):

$$H_{it} = \alpha_0 + cR_{it} + \alpha_2 X_{it} + \mu_i + \epsilon_{it} \tag{2}$$

$$R_{it} = \delta_0 + \delta Z_{it} + \delta_2 X_{it} + \mu_i + \nu_{it} \tag{3}$$

where H_{it} is the health status of individual i at time t and R_{it} is retirement status of individual i at time t. X_{it} denotes

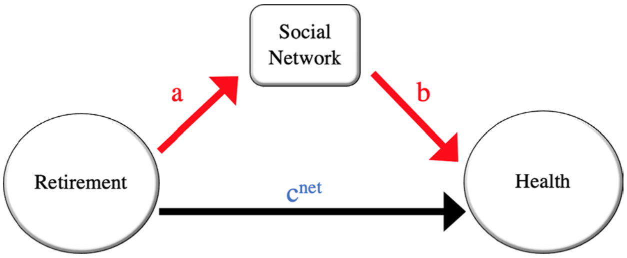

Fig. 1 Single mediation model of social network on the relationship between retirement and health

time-variant observable characteristics such as age, income, marital status, and health behaviors. μ_i indicates time-invariant unobservable characteristics of individuals such as genetics, family background, and time preferences. ϵ_{it} and v_{it} are i.i.d error terms. We are interested in consistent estimation of c, which is a challenging task due to reasons discussed earlier, i.e., the reverse causal relationship between health and labor supply decision, and the existence of unobserved confounding factors that influence both health and retirement decision simultaneously.

To account for endogeneity in retirement (Angrist and Keueger 1991; Cameron and Trivedi 2005), we apply Instrumental Variables (IV) strategy by using eligibility age for full entitlement Social Security benefits (i.e., 65 years old; $Z_{it} = 1(\text{Age} \geq 65)$) as instrument (see Appendix for more details and the first-stage estimation results).

In addition, addressing the heterogeneity effect is also essential. Due to different job characteristics and socio-economic background, some individuals may experience better health after retirement, whereas others may experience no changes or deterioration on health upon retirement. Besides, heterogeneity in health investment behaviors might be another source of variations in health after retirement (Grossman 1972). According to Grossman's model, health is both investment and consumption goods. Upon retirement, with no incentive to invest in health to increase productivity and thus earnings, individuals may not sufficiently invest in their health, which lead to poor health post-retirement. However, health as a consumption good directly enters the utility function and retirees may invest more in it, which results in better health post-retirement.

Failing to consider these individual heterogeneity leads to inconsistent estimation of retirement's impact on health. We exploit the panel nature of data and apply individual fixed-effects (FE) method that controls for all unobserved time-invariant heterogeneity across individuals (Wooldridge 2010; Cameron and Trivedi 2005). Although using IV can help to minimize the endogeneity issue, full retirement age for eligibility of Social Security benefit might be a weak instrument because individuals retire all the time during the life span (i.e., even after full retirement age).[13] To avoid the inconsistency of estimations, we restrict the sample to pre-retirement healthy individuals. For healthy individuals before retirement, retirement is less likely to be endogenous. Therefore, we capture the causality of retirement on subsequent health by applying the FE-IV approach in Eqs. (2) and (3) to the subsample of healthy individuals before retirement.

Mediation effect of social network

We are particularly interested in the mediation effect of social network on post-retirement changes in health. According to Fig. 1, two pathways exist for retirement to influence health. One is the direct effect, which refers to the pathway from retirement to health without passing through social network. The other one is the indirect effect, which refers to the pathway from retirement to health through social network. If retirement alters the social network characteristics (e.g., lost the contact with colleagues or raising opportunity to engage in different social activities), and social network impacts individual's health, then social network would be a health policy instrument that can be used for intervention in promoting elderly's health.

The corresponding econometric model is as follows[14]:

$$\begin{aligned} \text{SNW}_{it} &= \alpha_0 + aR_{it} + \alpha_1 X_{it} + \mu_i + v_{it} \\ H_{it} &= \beta_0 + c^{\text{net}} R_{it} + b\text{SNW}_{it} + \beta_1 X_{it} + \mu_i + \epsilon_{it} \end{aligned} \tag{4}$$

where SNW_{it} refers to a specific social network characteristic (i.e., size, frequency of contacts, or diversity), and the rest of the variables are as defined previously. v_{it} and ϵ_{it} present the i.i.d error term in each equation, respectively.

According to Baron and Kenny (1986), the multiplication of a and b is the social network mediation on the health impact of retirement, and c^{net} is the direct impact of retirement on health holding social network variable constant. Therefore, the summation of c^{net} and $a \times b$ indicates the total effect of retirement on subsequent health. To tackle the endogeneity problem, we apply the FE-IV approach to each equation using the subsample of pre-retirement healthy individuals.

From a policy perspective, it would be interesting to know if any of the social network characteristics drives the mediation more than the others. Parallel mediation analysis

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[13] For instance, including individuals who retired after 65 years old due to health problems results in overestimation of retirement's impact on health.

[14] The mediation analysis models first introduced by Baron and Kenny (1986) and developed further with less restrictive assumptions in later years, i.e., Zhao et al. (2010). We follow the revised mediation analysis by Zhao et al. (2010).

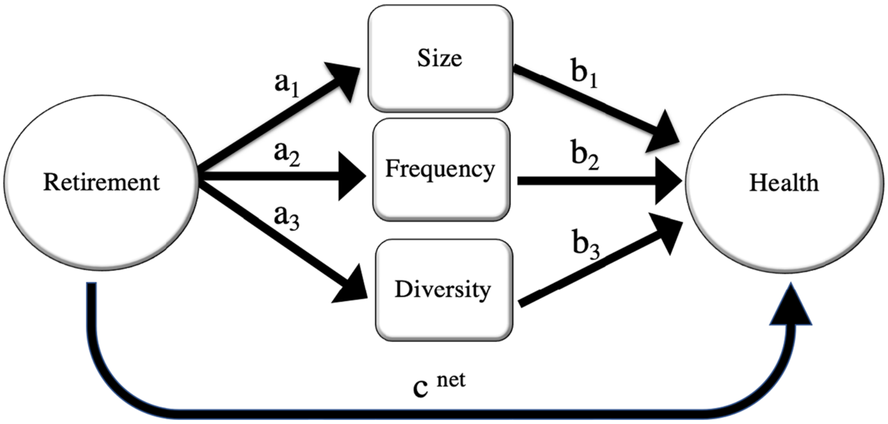

Fig. 2 Parallel mediation model of social network on the relationship between retirement and health

presented in Fig. 2 is a method to compare magnitudes of the indirect effects while allows for the correlations among the mediators. As shown in Fig. 2, the absence of any arrows linking the mediators (i.e., social network characteristics) assumes no causality link exists between them.

The corresponding econometric model is defined as follows:

$$\begin{bmatrix} \text{Size}_{it} \\ \text{Frequency}_{it} \\ \text{Diversity}_{it} \\ H_{it} \end{bmatrix} = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} + \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ c^{\text{net}} \end{bmatrix} R_{it} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ b_1 & b_2 & b_3 \end{bmatrix} \begin{bmatrix} \text{Size}_{it} \\ \text{Frequency}_{it} \\ \text{Diversity}_{it} \end{bmatrix} + \begin{bmatrix} \alpha_0 \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \mathbf{X}_{it} + \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \mu_i + \begin{bmatrix} v_{0it} \\ v_{1it} \\ v_{2it} \\ v_{3it} \end{bmatrix} \tag{5}$$

or,

$$\mathbf{Y} = \beta + \mathbf{a}R_{it} + \mathbf{B}\text{SNW}_{it} + \boldsymbol{\alpha}\mathbf{X_{it}} + \mathbf{l_4}\mu_i + v \tag{6}$$

where all variables are similar to those defined previously in Eqs. (3) and (2). Size_{it} refers to social network size of individual i at time t, Frequency_{it} indicates the frequency of contacts of individual i with members of her social network at time t, and Diversity_{it} refers to diversity index (i.e., IQV) for an individual i at time t.

According to Fig. 2, we have three different indirect effects of retirement on health such that each one passes through one social network characteristic ($a_1 \times b_1$, $a_2 \times b_2$, and $a_3 \times b_3$). The sum of the three indirect effects and the direct effect of retirement gives the total effect of retirement on health. Similar to single mediation analysis, we implement the FE-IV approach to each equation on the subsample of pre-retirement healthy individuals to address endogeneity.[15] All the analysis are done using STATA 14[16](StataCorp 2015).

Table 2 FE-IV estimation of total impact of retirement on subsequent health outcomes

	Physical health	Depression	Anxiety
Retirement	− 0.093*** (0.04)	0.220*** (0.04)	0.113*** (0.03)
Observations	1101	1098	1008

Each cell presents the total effect of retirement on corresponding health outcomes using the fixed-effect instrumental variable estimation method. In all analyses, we control for health behaviors, age, marital status, and income levels. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all these four health outcomes. The health outcomes are binary variables. Table 7 in Appendix reports the detailed estimation results. Robust individuals-clustered standard errors are in parenthesis. *** indicate the significant at the 1% level

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[15] The direct effect of retirement on health cannot be consistently estimated by IV without also instrumenting social networks, since controlling for social networks necessarily invalidates the instrument. To address the possible endogeneity of retirement w.r.t. social network, we have performed exogeneity test. The p-value of the exogeneity test (H0: retirement is exogenous) w.r.t size, frequency of contacts, and diversity of social network is 0.001, 0.21, and 0.19, respectively. As the test results show, we have failed to reject the exogeneity of retirement w.r.t. frequency of contacts and diversity of social networks. However, the null hypothesis regarding the exogeneity of retirement w.r.t. the size of the social network variable was rejected. That is, there might be a potential endogeneity of retirement w.r.t. the size of social network. To investigate the impacts of the possible endogeneity of retirement w.r.t. the size of social network on our results, we have followed the causal mediation analysis framework developed by Dippel et al. (2019) to estimate the mediatory effect of social network size under the assumption that both treatment and mediator are endogenous. This method needs a further assumption that the unobserved confounding variables that cause the retirement and the social network size are independent of the confounders that cause the social network size and health (called partially confounding condition). In our study, this assumption is likely to hold because our sample is pre-retirement healthy older adults. Using this method, the mediatory impact of social network remains the same with larger magnitude. The results are available upon request.

[16] We mainly used the XTIVREG command in STATA.

Empirical results

Total effect of retirement

The first set of analysis examines the total impact of full retirement on subsequent health. Table 2 presents the total effect of retirement on self-reported physical health, depression, and anxiety by FE-IV estimation of Eqs. (3) and (2) as the first stage.[17] This evidence shows, in line with previous findings Dave et al. (2008), that retirement generates a significant adverse effect on physical health, depression, and anxiety in elderly. However, the primary focus of this study is to reveal how social network can mediate the effect of retirement on subsequent health.

Single mediation analysis

Estimation results of the single mediation model (i.e., Fig. 1) are shown in Table 3. Each panel of the table provides results for a specific health outcome, and each row presents the coefficient estimation of equations in system (4) considering one specific social network feature as the mediator variable.

Table 3 Single mediation analysis: FE-IV estimation of mediatory impact of social network characteristic on retirement's effect on physical health, depression, and anxiety

	Retirement impact on SNW	Social Network impact on Health	Mediation impact of SNW	Direct effect of retirement on health
	a	b	$a \times b$	c^{net}
Physical health				
Size[d]	− 4.032***	0.013**	− 0.054***	− 0.039
	(0.323)	(0.006)	(0.001)	(0.052)
Frequency[e]	− 2.392***	0.003	− 0.007***	− 0.085**
	(0.504)	(0.004)	(0.000)	(0.042)
Diversity[f]	− 0.035*	0.015	− 0.001***	− 0.092**
	(0.021)	(0.084)	(0.000)	(0.038)
Observations	1101			
Depression				
Size	− 4.044***	− 0.003	0.010***	0.211***
	(0.323)	(0.005)	(0.001)	(0.048)
Frequency	− 2.404***	0.002	− 0.005***	0.226***
	(0.504)	(0.004)	(0.000)	(0.038)
Diversity	− 0.036*	0.110	− 0.004***	0.225***
	(0.021)	(0.080)	(0.000)	(0.036)
Observations	1098			
Anxiety				
Size	− 4.247***	− 0.000	0.001*	0.111***
	(0.344)	(0.005)	(0.001)	(0.038)
Frequency	− 2.486***	0.000	− 0.001***	0.113***
	(0.503)	(0.003)	(0.000)	(0.028)
Diversity	− 0.044**	0.039	− 0.002***	0.114***
	(0.021)	(0.059)	(0.000)	(0.026)
Observations	1008			

Each row reports the fixed-effect Instrumental Variable estimation results of equations corresponding to Fig. 1

[d] Size refers to the number of members in the individual's social network. [e] Frequency refers to the frequency of contacts with members of one's social network. [f] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV). The sample is limited to pre-retirement healthy individuals in all these four health outcomes. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. Tables 8, 9, 10 and in Appendix report the detailed estimation results. Robust individuals-clustered standard errors are in parenthesis. The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

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[17] Table 5 in Appendix presents the first-stage estimation results.

We first explain how retirement affects social network features. In Table 3, "a" refers to the estimation of retirement's impact on the size, frequency, and diversity of social network (corresponding to "a" in Fig. 1), separately. The result shows that retirement significantly reduces the size of social network, frequency of contacts (Sugisawa et al. 1997), and the diversity in one's network.

The second column in the table reports the estimated impact of social network characteristics on the health outcomes—after controlling for the time-invariant effects. Larger social network is associated with higher probability of reporting good physical health, while has no impact on depression and anxiety, holding everything else constant. Frequency of contacts and diversity in network do not impact any of the health outcomes (i.e., $b = 0$), holding all else constant.[18] Even if social network does not generate a significant direct impact on health, it could still perform as a mediator on the impact of retirement on health. As a matter of fact, according to a recent study Zhao et al. (2010), it is not necessary to have a significant a or b to establish a mediation effect; instead, the distribution of their products matters for the existence of mediation effect (also, Hayes 2017). We obtain the empirical distribution of $a \times b$ using bootstrapping to calculate the standard errors and find that it is significant at the 95% level.

The third column displays the mediatory effect of social network features on the path from retirement to health. As we see, the social network plays a significant mediatory role with the highest impact of size in comparison with the other two features. Remarkably, size shrinkage explains 58% (i.e., $\frac{0.054}{0.093} * 100$) of reduction in probability of reporting good physical health caused by retirement, frequency of contacts explains around 7.5% of it, with a small mediatory contribution of diversity.

Depression: social network size reduction explains $\frac{0.010}{0.22} * 100 = 4.5\%$ of increment in probability of having depression symptoms upon retirement. However, the other two features of social network, the frequency of contacts and diversity, have a small mediatory impact on depression upon retirement. Thus, the size of retiree's social network explains the highest adverse effect of retirement on depression as compared to the other two features.

Anxiety: social network size marginally increases the probability of having anxiety symptoms in retirees. Interestingly, findings show that reduction in frequency of contacts and diversity upon retirement significantly contribute to the mitigation of anxiety. This can be explained by the concept of social anxiety in elderly and negative impact of social network involvements that is discussed earlier. Social anxiety implies elderlies in contact with others often feel they are a burden on the life of people surrounding them. However, the impact of frequency of contacts and diversity on reducing probability of having anxiety symptoms upon retirement is small. The direct impact of retirement on anxiety dominates the mediatory effect of social network characteristics and leads to overall higher anxiety symptoms in retirees as compared to non-retirees. There might be other hidden factors that fuels the impact of retirement on anxiety such as financial fears and lifestyle changes.

The last column of Table 3 shows that the direct effect of retirement is significant on all health outcomes ($c^{\text{net}} \neq 0$) except physical health, while the mediator is social network size. The nonzero direct impact of retirement on health might be due to all the other mechanisms through which retirement might influence health such as financial hardships, health insurance coverage, and lifestyle changes.

In summary, simple mediation analysis suggests social network as a significant channel that influences various health outcomes upon retirement. In the next section, we consider the mediatory effects of all three social network features simultaneously in the model.

Parallel mediation analysis

According to Fig. 2, retirement is modeled to exert its effect on health through 4 pathways. One pathway is direct, from retirement to health without passing through any of the proposed social network mediators, and the other three pathways are indirect, each through one feature of social network. The estimation results corresponding to Fig. 2 (i.e., system of equations in (5)) are shown in Table 4. These parallel analyses shed more light on the social network mechanism for the post-retirement decline in health.

In the first row of Table 4, we see that retirement significantly decreases probability of reporting good physical health, ceteris paribus—holding social network variables and all other explanatory variables constant. The mediation coefficient estimation of social network size implies that retirees are likely to report worse physical health than non-retirees due to a smaller social network size at the same levels of frequency of contacts and diversity. Particularly, size shrinkage explains 79.5% of reduction in the chance of reporting good physical health among retirees, while holding frequency of contacts and diversity constant. In contrast, retirees are estimated to have better physical health in comparison with non-retirees through the effect of retirement on the frequency of contacts/diversity, holding size, and everything else constant. In contrast to single mediation analysis, the parallel mediation analysis reflects that with the same social network size and diversity, higher

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[18] In Appendix, Table 6 shows a significant impact of social network on health outcomes using OLS estimation, which ignores the existence of time-invariant confounding, i.e., unobservable time-invariant confounding are the factors affecting both social network and health.

Table 4 Parallel mediation analysis: FE-IV estimation of mediatory impact of social network characteristics on retirement's effect on physical health, depression, and anxiety

Health outcomes	c^{net}	Mediation effects			Total indirect effect
		Size[a]	Frequency[b]	Diversity[c]	
		$a_1 \times b_1$	$a_2 \times b_2$	$a_3 \times b_3$	
Physical health	– 0.030***	– 0.074***	0.009***	0.003***	– 0.062***
	(0.002)	(0.001)	(0.000)	(0.000)	(0.001)
Depression	0.198***	0.041***	– 0.013***	– 0.006***	0.023***
	(0.002)	(0.001)	(0.000)	(0.000)	(0.001)
Anxiety	0.107***	0.009***	– 0.002***	– 0.002*** (0.000)	0.005***
	(0.001)	(0.001)	(0.000)		(0.001)

Each row reports the fixed-effect Instrumental Variable estimation results of equations corresponding to Fig. 2

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV). The sample is limited to pre-retirement healthy individuals in all these four health outcomes. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. Tables 11, 12, and 13 in Appendix report the detailed estimation results. Robust individuals-clustered standard errors are in parenthesis

*** indicates significant at the 1% level

frequency of contacts is associated with higher chance of reporting good physical health. It reflects the importance of considering the correlation between the social network features in the analysis rather than assessing them in isolation from the other related features. Overall, the adverse mediatory effect of size dominates the impact of the other two features of social network. Therefore, the indirect and direct impact of retirement reduces the probability of reporting good physical health by 6.2% and 3%, respectively.

As expected, retirees are more likely to experience depression symptoms by 19.8% than non-retirees. Overall, we observe similar patterns in direct and indirect effects of depression to physical health. In particular, about 18.6% increase in probability of having depression symptoms after retirement is explained by the reduction in the size of social network, holding frequency of contacts and diversity constant. Within the parallel mediation framework, the impact of retirement on depression through social network is more than 10%$\left(\frac{0.023}{0.22} * 100 = 10.5\%\right)$.

In parallel mediation analysis, smaller social network size is associated with higher chance of having anxiety symptoms post-retirement, holding the frequency of contacts and diversity of network constant. The size of social network contributes to higher chances of anxiety in retirees by 7.9% $\left(\frac{0.009}{0.113} * 100 = 7.9\%\right)$, whereas the frequency of contacts and diversity estimation show similar effects to single mediation analysis in the parallel system.

Comparing the mediatory effects of social network features across health outcomes, we find that size of social network generates the largest effect in comparison with the other two features for health outcomes. According to the last column of Table 4, retirement decreases the chance of reporting good physical health and increases the probability of having depression and anxiety symptoms through its influence on social network features. These results imply that adverse health impacts post-retirement can be curbed by improving social network of retirees.

Discussion

Different conceptual theories in psychology and sociology address how social network influences health or vice versa (e.g., Israel 1982), while no study empirically investigates the effect of health on social network. Yet, health might be a potential factor affecting network formation since the formation of social network is not random (Moffitt et al. 2001; Brock and Durlauf 2001). For instance, healthier people are more likely to participate in social activities and have more social connections. Besides, individuals' heterogeneity, such as time preferences and personality, might simultaneously contribute to the extent of social network involvement and health conditions. For example, extrovert people are more likely to participate in different social activities, meanwhile they are less likely to have depressive symptoms.

However, the severity of endogeneity between health and social network formation is less severe in older adults as compared to younger adults. According to socioemotional selectivity theory (SST) (Carstensen 1991), as people age, they focus on enriching and maintaining the existing relationships rather than investing in new ones. That is, the effect of unobservables on the older adults' health is less likely to influence their social network formation, meaning that unobservable confounding factors are not significant matter of endogeneity between health and social network in this population. In addition, in this study, the social network and health are not measured at the same time. There is a temporal exogeneity between social network and health. Respondents were asked about their social network in the last 12 months, while the health-related questions were asked at the moment of the interview. Therefore, it is less likely that their current health influences the social network characteristics within the past year. As we limit the sample to healthy individuals before retirement event, we further assure that health does not interfere the changes in social network upon retirement as well (i.e., no reverse causality). However, we acknowledge that this study is limited by lack of information for developing a valid and relevant instrument for social network to sufficiently tackle the endogeneity of health and social network.

Policy implications

Evidence provided by this study has important policy implications. The key message in this study is that considering the health challenges caused by population aging, social capital (in the form of social network) is a key policy instrument for health promotion in the elderly. Investing in the social capital of the elderly may help to curb the negative health effect post-retirement, even if the retirement eligibility age remains unchanged.

Enriching social network in elderly may also help to ameliorate the depression symptoms after retirement. Our finding indicates that a large portion (i.e., 4.5% in single mediation analysis and 18.6% in parallel mediation estimation) of increase in the chance of having post-retirement depression symptoms happens due to a reduction in social network size.

Therefore, interventions that target promoting different aspects of the elderly's social capital buildup are promising ones to allocate resources into, aiming to improve elderly's health. Particularly, the government can improve health of the elderly by investing in their social capital. For example, one effective policy is to provide education on technologies that can minimize social network size shrinkage in retirees. Also, the government can directly provide subsidies to promote the elderly's social capital enrichment, for instance, by organizing community elderly activities targeting groups that share similar prior occupations, or by providing funding to stimulate community participation through voluntary organizations and community groups.

Conclusions

In this study, we investigate how retirement can impact health through altering social network characteristics, including size, diversity, and frequency of contacts. First we estimate the health impact of retirement using the FE-IV method with Social Security benefits eligibility age as instrument for retirement on pre-retirement healthy individuals in NSHAP data set. Then, we investigate the mediatory role of social network on the health impact of retirement. We investigate the mediatory effect of social network characteristics in single and parallel mediation model specifications, separately. The parallel analysis has the advantage of accounting for possible dependence and correlation between different social network features, while single analysis considers one social network feature at a time.

Estimations reveal a statistically significant negative effect of retirement on physical health, depression, and anxiety. Findings uncover that retirees not only have fewer members in their social network but also have less frequent contacts with members as compared to non-retirees. Due to the association of social network and health, differences in social network of retirees and non-retirees explain a substantial amount of disparities in health outcomes between the two groups. Our findings indicate that a considerable portion of retirement's impact on health is mediated by social network changes.

In particular, single mediation identification suggests that 58% of reduction in the chances of being in good physical health and 4.5% of increment in the probability of having depression post-retirement can be explained by the reduction in social network size, whereas, in the parallel identification, holding the other social network features constant, the corresponding portions of the effects of social network size reduction on negative physical health outcome and depression upon retirement become 79.5% and 18.6%, respectively. We find similar impact of social network size reduction on chances of having anxiety with lower magnitude of the effect. Moreover, with the same social network size, retirees who have higher frequency of contacts/diversity experience lower chances of anxiety, which can be explained by social anxiety concept in elderly.

We find social network changes due to important lifestyle change after retirement and can be utilized as an effective policy instrument to buffer the adverse health outcomes of retirement. Social network based interventions that target social capital buildup in older adults might be desirable for healthy aging. For instance, the government can provide subsidies for organizing and establishing different community events to stimulate social capital buildup for the elderly. Understanding the underlying mechanisms of how social network can mediate the adverse effect of retirement on health calls for more detailed information about the structure of social network of the elderly. This will be investigated in a future project as more social network data become available.

There are some limitations to this study. First, the exact retirement time is not identifiable since the survey wave time gap is five years. Therefore, we assume respondents retired within the past five years (if they reported retired status in the current wave and not reported as retired in the previous wave). Second, this study is limited by a lack of information for developing a valid and relevant instrument for the social network to sufficiently tackle the endogeneity of health and social network. Third, we restrict the sample to pre-retirement healthy individuals to address the potential endogeneity problem. Therefore, our findings might likely be conservative in the effect magnitude since our analysis does not quantify the effects of retirement on those who are not healthy before retirement. At last, the NSHAP dataset includes no information on health and labor status of social network members. Therefore, we could not examine the potential interactive and spillover social effects.

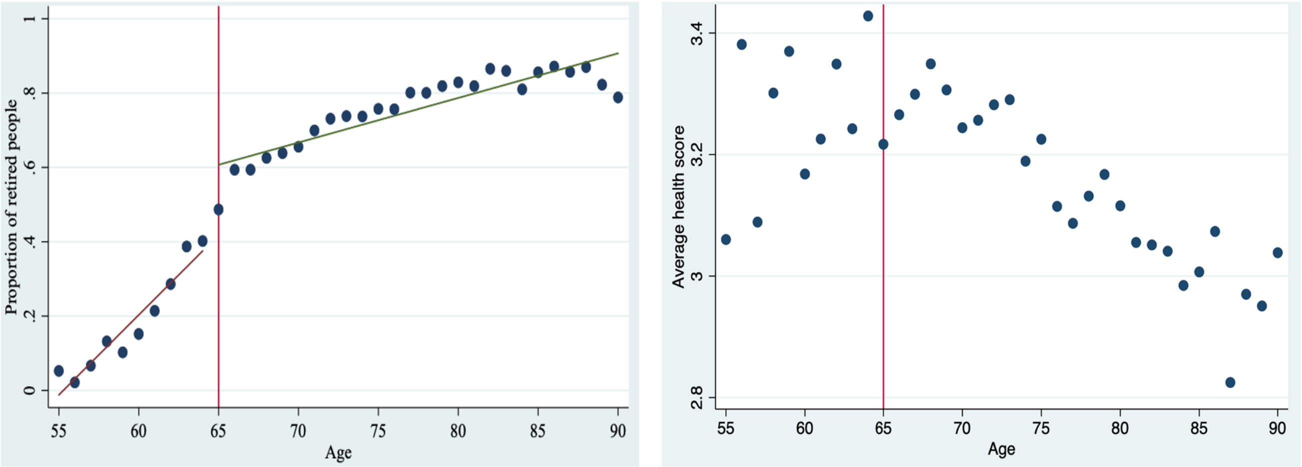
Appendix

Instrumental variable method

To be a valid instrument, an instrument must be correlated to retirement (endogenous regressor) and related to health outcomes only through the effect on retirement (i.e., corr $(Z_{it}, \epsilon_{it}) = 0$). Well-documented literature exists about the sharp changes in retirement behavior around this age (e.g., Coile and Gruber 2000; Ruhm 1995), which confirms this cutoff point should have the power to predict retirement decision. It is worth mentioning that an individual's health outcomes do not change substantially by officially turning one year older, even though health gradually declines as people aged.

Empirical findings using NSHAP also provide evidence for the discrete changes in retirement decision around the eligibility age for full Social Security benefits. Figure 3a presents the jump in retirement behavior at 65 years old, while Fig. 3b confirms the self-reported health does not necessarily decrease around this point. Therefore, eligibility age for full Social Security benefits is a valid and relevant instrument. Fixed-effect regression estimation of equation (3) as the first stage shows that reaching 65 years old is significantly associated with a 34-percentage-point increase in retirement for the pre-retirement healthy individuals subsample. Table 5 presents the first-stage estimation results.

See Tables 6, 7, 8, 9, 10, 11, 12 and 13.



(a) Retirement behavior on different ages

(b) Average self-report health on different ages

Fig. 3 Retirement and health behavior of different ages. Higher health score means better self-report health

Table 5 First-stage results of FE-IV estimations

	Dep var: Retirement			
	Physical health	Mental health	Depression	Anxiety
Instrument (full Social Security entitlement age indicator)[a]	0.342***	0.345***	0.346***	0.333***
	(0.04)	(0.04)	(0.04)	(0.05)
Age	0.011***	0.010***	0.011***	0.010***
	(0.00)	(0.00)	(0.00)	(0.00)
Income	0.006	0.008	0.008	0.016
	(0.01)	(0.01)	(0.01)	(0.02)
Married[b]	0.009	0.004	0.006	− 0.007
	(0.03)	(0.03)	(0.03)	(0.03)
Number of drinks	− 0.003	− 0.003	− 0.004	− 0.006
	(0.01)	(0.01)	(0.01)	(0.01)
Smoking cigarette	− 0.033	− 0.025	− 0.046	− 0.033
	(0.05)	(0.05)	(0.05)	(0.05)
Constant	− 0.568***	− 0.523***	− 0.563***	− 0.529**
	(0.19)	(0.20)	(0.19)	(0.21)
Observations	1101	1080	1098	1008
F_statistics	60.27	57.19	61.65	52.14

This table reports the first stage results of FE-IV estimation of retirement on health outcomes in subsample of healthy individuals before retirement

Robust individuals-clustered standard errors are in parenthesis

[a] The indicator is 1 if the individuals is 65 years old or older, and 0 otherwise

[b] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all these four health outcomes

*** indicates significant at the 1% level

Table 6 Ordinary Least Square estimation of impact of social network characteristics on health outcomes

	Physical health	Depression	Anxiety
Size[a]	0.012**	− 0.014***	− 0.005
	(0.006)	(0.004)	(0.003)
Frequency[b]	− 0.009**	0.004	0.001
	(0.004)	(0.003)	(0.002)
Diversity[c]	− 0.053	0.113**	0.029
	(0.079)	(0.057)	(0.045)
Age	− − 0.004*	0.008***	0.004***
	(0.002)	(0.002)	(0.001)
Female	0.052	0.043*	0.045**
	(0.032)	(0.023)	(0.018)
High education[d]	0.076**	− 0.018	− 0.032
	(0.035)	(0.025)	(0.020)
Income	0.039**	− 0.015	0.006
	(0.017)	(0.012)	(0.010)
Married[e]	0.061	− 0.045*	0.039*
	(0.038)	(0.027)	(0.021)
Number of drinks	0.030***	− 0.007	− 0.002
	(0.011)	(0.008)	(0.006)
Smoking cigarette	0.008	0.019	0.010
	(0.051)	(0.036)	(0.028)
Constant	0.731***	− 0.396***	− 0.250**
	(0.191)	(0.136)	(0.108)
Observation	1101	1098	1008

This table reports the OLS estimation results of social network characteristics on different health outcomes

Robust individuals-clustered standard errors are in parenthesis

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Education levels equal to some college or higher is considered as high education

[e] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all these four health outcomes

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 7 FE-IV estimation of total impact of retirement on health outcomes

	Physical health	Depression	Anxiety
Retirement[a]	– 0.093**	0.220***	0.113***
	(0.04)	(0.04)	(0.03)
Age	– 0.087*	0.064	0.059*
	(0.05)	(0.04)	(0.03)
Income	– 0.014	0.014	0.037**
	(0.02)	(0.02)	(0.02)
Married[b]	0.103	– 0.263***	– 0.060
	(0.07)	(0.07)	(0.06)
Number of drinks	0.035**	– 0.022*	0.002
	(0.01)	(0.01)	(0.01)
Smoking cigarette	0.069	– 0.141*	– 0.083
	(0.10)	(0.08)	(0.09)
Constant	0.549***	0.241***	– 0.006
	(0.08)	(0.08)	(0.06)
Observations	1101	1098	1008

This table reports the fixed-effect Instrumental Variable estimation of retirement on health outcomes. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise

[a] Retirement is 1 if the individual reports retired and not working, and 0 otherwise

[b] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all these four health outcomes. Robust individuals-clustered standard errors are in parenthesis

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 8 Single mediation analysis: FE-IV estimation of mediatory impact of social network characteristic on retirement's effect on physical health

	Size[a]	Physical health	Frequency[b]	Physical health	Diversity[c]	Physical health
Retirement	– 4.032***	– 0.039	– 2.392***	– 0.085*	– 0.035	– 0.092**
	(0.391)	(0.060)	(0.484)	(0.048)	(0.022)	(0.045)
Age	– 0.868**	– 0.082	– 0.700	– 0.085	0.005	– 0.086
	(0.381)	(0.057)	(0.506)	(0.055)	(0.022)	(0.056)
Income	0.349*	– 0.019	0.265	– 0.015	0.006	– 0.014
	(0.210)	(0.024)	(0.260)	(0.024)	(0.012)	(0.024)
Married[d]	0.806	0.092	3.439***	0.092	0.092***	0.101
	(0.602)	(0.069)	(0.744)	(0.070)	(0.034)	(0.070)
Number of drinks	0.191	0.033**	0.173	0.035**	0.000	0.035**
	(0.138)	(0.016)	(0.170)	(0.016)	(0.008)	(0.016)
Smoking cigarette	– 0.210	0.075	– 0.168	0.073	0.095**	0.071
	(0.820)	(0.094)	(1.014)	(0.094)	(0.046)	(0.095)
Size		0.013**				
		(0.006)				
Frequency				0.003		
				(0.004)		
Diversity						0.015
						(0.083)
Constant	7.877***	0.443***	11.678***	0.513***	0.568***	0.540***
	(0.740)	(0.108)	(0.914)	(0.104)	(0.041)	(0.098)
Observations	1101	1101	1101	1101	1101	1101

This table presents the fixed-effect Instrumental Variable estimation results of single mediation equations corresponding to Fig. 1. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. For instance, column 2 presents the estimation result of retirement on the size of social network and column 3 presents the estimation of retirement and size of social network on physical health

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study. Robust individuals-clustered standard errors are in parenthesis

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 9 Single mediation analysis: FE-IV estimation of mediatory impact of social network characteristic on retirement's effect on Depression

	Size[a]	Depression	Frequency[b]	Depression	Diversity[c]	Depression
Retirement	− 4.044***	0.211***	− 2.404***	0.226***	− 0.036*	0.225***
	(0.392)	(0.052)	(0.485)	(0.043)	(0.022)	(0.040)
Age	− 0.873**	0.064	− 0.701	0.062	0.004	0.060
	(0.378)	(0.045)	(0.503)	(0.043)	(0.021)	(0.043)
Income	0.318	0.014	0.198	0.013	0.005	0.013
	(0.211)	(0.021)	(0.261)	(0.021)	(0.012)	(0.021)
Married[d]	0.833	− 0.261***	3.623***	− 0.271***	0.085**	− 0.273***
	(0.612)	(0.061)	(0.757)	(0.062)	(0.034)	(0.062)
Number of drinks	0.177	− 0.023	0.173	− 0.023*	− 0.001	− 0.023
	(0.139)	(0.014)	(0.172)	(0.014)	(0.008)	(0.014)
Smoking cigarette	− 0.203	− 0.118	− 0.174	− 0.117	0.097**	− 0.128
	(0.823)	(0.083)	(1.018)	(0.083)	(0.046)	(0.083)
Size		− 0.003				
		(0.005)				
Frequency				0.002		
				(0.004)		
Diversity						0.110
						(0.073)
Constant	7.952***	0.260***	11.721***	0.214**	0.579***	0.176**
	(0.743)	(0.095)	(0.919)	(0.091)	(0.041)	(0.086)
Observations	1098	1098	1098	1098	1098	1098

This table presents the fixed-effect Instrumental Variable estimation results of single mediation equations corresponding to Fig. 1. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. For instance, column 2 presents the estimation result of retirement on the size of social network and column 3 presents the estimation of retirement and size of social network on depression

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study. Robust individuals-clustered standard errors are in parenthesis

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 10 Single mediation analysis: FE-IV estimation of mediatory impact of social network characteristic on retirement's effect on anxiety

	Size[a]	Anxiety	Frequency[b]	Anxiety	Diversity[c]	Anxiety
Retirement	− 4.247***	0.111***	− 2.486***	0.113***	− 0.044**	0.114***
	(0.408)	(0.043)	(0.497)	(0.034)	(0.022)	(0.032)
Age	− 0.528*	0.064*	− 0.407	0.061*	0.007	0.059*
	(0.316)	(0.037)	(0.435)	(0.036)	(0.020)	(0.036)
Income	0.387*	0.037**	0.158	0.037**	0.007	0.037**
	(0.220)	(0.017)	(0.269)	(0.017)	(0.012)	(0.017)
Married[d]	0.799	− 0.060	2.988***	− 0.061	0.116***	− 0.065
	(0.650)	(0.051)	(0.793)	(0.051)	(0.035)	(0.051)
Number of drinks	0.103	0.002	0.095	0.002	− 0.005	0.002
	(0.145)	(0.011)	(0.177)	(0.011)	(0.008)	(0.011)
Smoking cigarette	− 0.142	− 0.083	− 0.249	− 0.083	0.091*	− 0.086
	(0.863)	(0.068)	(1.052)	(0.068)	(0.047)	(0.068)
Size		− 0.000				
		(0.005)				
Frequency				0.000		
				(0.003)		
Diversity						0.039
						(0.063)
Constant	7.916***	− 0.004	12.287***	− 0.010	0.560***	− 0.028
	(0.773)	(0.077)	(0.943)	(0.075)	(0.042)	(0.071)
Observations	1008	1008	1008	1008	1008	1008

This table presents the fixed-effect Instrumental Variable estimation results of single mediation equations corresponding to Fig. 1. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. For instance, column 2 presents the estimation result of retirement on the size of social network and column 3 presents the estimation of retirement and size of social network on anxiety

Robust individuals-clustered standard errors are in parenthesis

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 11 Parallel mediation analysis: FE-IV estimation of mediatory impact of social network characteristics on retirement's effect on physical health

	Size[a]	Frequency[b]	Diversity[c]	Physical Health
Retirement	− 4.032***	− 2.392***	− 0.035	− 0.030**
	(0.391)	(0.484)	(0.022)	(0.003)
Size				0.018**
				(0.008)
Frequency				− 0.004
				(0.005)
Diversity				− 0.083
				(0.091)
Age	− 0.868**	− 0.700	0.005	− 0.080
	(0.381)	(0.506)	(0.022)	(0.056)
Income	0.349*	0.265	0.006	− 0.019
	(0.210)	(0.260)	(0.012)	(0.024)
Married[d]	0.806	3.439***	0.092***	0.109
	(0.602)	(0.744)	(0.034)	(0.071)
Number of drinks	0.191	0.173	0.000	0.032**
	(0.138)	(0.170)	(0.008)	(0.016)
Smoking cigarette	− 0.210	− 0.168	0.095**	0.083
	(0.820)	(1.014)	(0.046)	(0.095)
Constant	7.877***	11.678***	0.568***	0.498***
	(0.740)	(0.914)	(0.041)	(0.112)
Observations	1101	1101	1101	1101

Note: This table presents the fixed-effect Instrumental Variable estimation results of parallel mediation equations corresponding to Fig. 2 with physical health as the outcome variable. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. Columns 2–4 present the FE-IV estimation of social network variables on the retirement, corresponding to the paths in Fig. 2

Robust individuals-clustered standard errors are in parenthesis

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 12 Parallel mediation analysis: FE-IV estimation of mediatory impact of social network characteristics on retirement's effect on depression

	Size [a]	Frequency[b]	Diversity[c]	Depression
Retirement	− 4.044***	− 2.404***	− 0.036*	0.200***
	(0.392)	(0.485)	(0.022)	(0.003)
Size				− 0.010
				(0.007)
Frequency				0.005
				(0.004)
Diversity				0.152*
				(0.080)
Age	− 0.873**	− 0.701	0.004	0.060
	(0.378)	(0.503)	(0.021)	(0.044)
Income	0.318	0.198	0.005	0.015
	(0.211)	(0.261)	(0.012)	(0.021)
Married[d]	0.833	3.623***	0.085**	− 0.287***
	(0.612)	(0.757)	(0.034)	(0.063)
Number of drinks	0.177	0.173	− 0.001	− 0.022
	(0.139)	(0.172)	(0.008)	(0.014)
Smoking cigarette	− 0.203	− 0.174	0.097**	− 0.134
	(0.823)	(1.018)	(0.046)	(0.083)
Constant	7.952***	11.721***	0.579***	0.168*
Observations	1098	1098	1098	1098

This table presents the fixed-effect Instrumental Variable estimation results of parallel mediation equations corresponding to Fig. 2 with depression as the outcome variable. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. Columns 2-4 present the FE-IV estimation of social network variables on the retirement, corresponding to the paths in Fig. 2

Robust individuals-clustered standard errors are in parenthesis

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

Table 13 Parallel mediation analysis: FE-IV estimation of mediatory impact of social network characteristics on retirement's effect on anxiety

	Size[a]	Frequency[b]	Diversity[c]	Anxiety
Retirement	− 4.247***	− 2.486***	− 0.044**	0.107**
	(0.408)	(0.497)	(0.022)	(0.004)
Size				− 0.002
				(0.006)
Frequency				0.001
				(0.003)
Diversity				0.047
				(0.068)
Age	− 0.528*	− 0.407	0.007	0.063*
	(0.316)	(0.435)	(0.020)	(0.036)
Income	0.387*	0.158	0.007	0.037**
	(0.220)	(0.269)	(0.012)	(0.017)
Married[d]	0.799	2.988***	0.116***	− 0.067
	(0.650)	(0.793)	(0.035)	(0.052)
Number of drinks	0.103	0.095	− 0.005	0.003
	(0.145)	(0.177)	(0.008)	(0.011)
Smoking cigarette	− 0.142	− 0.249	0.091*	− 0.087
	(0.863)	(1.052)	(0.047)	(0.068)
Constant	7.916***	12.287***	0.560***	− 0.028
	(0.773)	(0.943)	(0.042)	(0.082)
Observations	1008	1008	1008	1008

This table presents the fixed-effect Instrumental Variable estimation results of parallel mediation equations corresponding to Fig. 2 with anxiety as the outcome variable. Instrument is a dummy variable with value 1 if individual is older than 65 years old, and 0 otherwise. Columns 2-4 present the FE-IV estimation of social network variables on the retirement, corresponding to the paths in Fig. 2

Robust individuals-clustered standard errors are in parenthesis

[a] Size refers to the number of members in the individual's social network

[b] Frequency refers to the frequency of contacts with members of one's social network

[c] Diversity refers to diversity in the types of relationships in individual's social network that is measured by Index of Qualitative Variation (IQV)

[d] Married is a dummy variable that takes value of 1 if individual is married, and 0 otherwise. The sample is limited to pre-retirement healthy individuals in all health outcomes in this study

The significance level is defined as follows: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level

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ORIGINAL INVESTIGATION

Patterns and correlates of old-age social exclusion in the Balkan states

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Abstract

Social exclusion (SE), or the separation of individuals and groups from mainstream society, is associated with poor health and wellbeing, yet a substantial number of older people are socially excluded. There is increasing agreement that SE is multidimensional, comprising among others social relations, material resources, and/or civic participation. However, measuring SE is still challenging as exclusion may occur in more than one dimension, whereas its sum does not reflect the content of SE. To account for these challenges, this study provides a typology of SE and describes how SE types differ from each other in terms of severity and risk factors. We concentrate on Balkan states, which are among the European countries with the highest prevalence of SE. Data come from the European Quality of Life Survey ($N=3030$, age 50+). Latent Class Analysis revealed four SE types: low SE risk (50%), material exclusion (23%), material and social exclusion (4%), and multidimensional exclusion (23%). A higher number of dimensions from which a person is excluded are associated with more severe outcomes. Multinomial regression further revealed that lower levels of education, lower subjective health, and lower social trust increase the risks of any SE type. Younger age, unemployment, and not having a partner are associated with specific SE types. This study is in line with the limited evidence that different types of SE exist. Policies designed to reduce SE should take account of the different SE types and specific associated risk factors in order to enhance the impact of interventions to reduce social exclusion.

Introduction

Social exclusion (SE)—or exclusion from mainstream society—is a significant societal problem as it threatens social cohesion, reduces an individual's health and well-being, and increases loneliness (Dahlberg et al. 2022) and mortality (Dahlberg and McKee 2018; Lee 2021; Lennartsson et al. 2021; Sacker et al. 2017). The issue of SE is even more significant for older people (Dahlberg et al. 2020), as they have a higher risk of being socially excluded and to be excluded for a longer duration than younger age groups (Scharf and Keating 2012). Interventions to reduce SE have had a limited effect, partly because of inadequate scientific understanding of the different manifestations of SE (Byrne 2005; Walsh et al. 2017) and partly because of a narrow definition of SE, which leaves certain groups of excluded people undetected. For example, EU policies defined SE until recently mainly in terms of poverty, material deprivation, or living in a household with very low work intensity (European Commission 2010). However, scholars converge in their opinion that SE should be defined in broader terms to include, among other things, exclusion from social relations and exclusion from welfare state entitlements (Barry 1998; Burchardt et al. 1999; Walsh et al. 2017; Van Regenmortel et al. 2018), and the EU definition now also includes social deprivation (Eurostat 2021).

The number of studies on SE has grown steadily over the last few years, and while definitions depend on the scientific discipline and context (Walsh et al. 2017), SE is increasingly perceived as '… a complex and multi-dimensional process. It involves the lack or denial of resources, rights, goods and

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services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole' (Levitas et al. 2007). Based on this definition and on the international literature, Walsh and others (2017) developed an old-age exclusion framework consisting of six dimensions and many subdimensions, which are a key part of this study, namely material resources, social relations, services, civic and political participation, and neighbourhood and communities.

The multidimensionality of SE raises the question of whether different manifestations exist, or combinations of dimensions from which a person is excluded, and whether they differ in severity (Levitas et al. 2007). However, little is known about SE types, their risk factors, and severity. While it is assumed that 'deep exclusion' or the simultaneous exclusion from many domains may result in more 'severe negative consequences for quality of life, well-being and future life-changes' (Levitas et al. 2007, p. 9), there is not much evidence to support this claim. The aim of this study is therefore to (1) identify different types of SE among people living in countries with high risks of SE and (2) to evaluate associations between SE types, risk factors, and well-being outcomes.

This study focusses on the Balkans, a specific geographical area in the south-east of Europe consisting of states with similar histories of totalitarian regimes and poor welfare state entitlements. Not surprisingly, the Balkans are among the countries in Europe with the highest risks on many dimensions of SE (Sumil-Laanemaa et al. 2021; Morgan et al. 2021) and between 20 and 48% of the people aged 60 + living in Balkan states is socially excluded according to EU definitions (Eurostat 2021). This study further focusses on the individual aspects of SE, since variations in macro-level variables are most likely limited.

Literature

A fundamental issue in debates about SE is whether exclusion is associated with individuals' specific preconditions (risk factors) or whether it is the social structure that excludes people from mainstream society (drivers). Another factor that is sometimes discussed is the degree to which exclusion is a voluntary act of the individual (self-exclusion). However, while people say they choose for SE to escape from social pressures or to relax (Lay et al. 2020), it may be difficult to determine whether it is truly voluntary (Barry 1998; Victor et al. 2008; Weldrick and Grenier 2018, Lay et al. 2020).

Literature on risk factors of SE indicates that age, gender, education, household size, and partner status are among the most frequently observed (e.g. Burholt and Aartsen 2021; Sumil-Laanemaa et al. 2021; Myck et al. 2021). Educational attainment and migrant status are related to multiple forms of exclusion (Scharf et al. 2005). The level of material resources in one generation affects material exclusion in the next generation via intergenerational transmission of (dis) advantages (Peruzzi 2015). Transitions during the life course, such as from employee to retiree, and events, such as the loss of a spouse, can lead to exclusion from social and material resources (Dewilde 2003). Health and functioning are important conditions for various forms of, for example, civic and social participation (Sacker et al. 2017), and lack of trust as requirement for social engagement, can lead to social disengagement (Rapolienė and Aartsen 2021). Important factors at the meso-level are a lack of a sense of belonging to a neighbourhood, and living in a deprived area, both of which are related to increased levels of exclusion (Prattley et al. 2020; Dahlberg and McKee 2018). Gender is a cross-cutting factor which may moderate the many potential associations between risk factors and SE (Aartsen et al. 2021), potentially leading to a disproportionately higher chance that older females become socially excluded (Dahlberg et al. 2020).

Recent findings suggest that SE is a dynamic construct as people can move in and out states of SE, although there is a tendency for exclusion to increase over the course of life as exclusion from one dimension increases the risk of exclusion from other dimensions (Scharf et al. 2021; Dahlberg 2021). Evidence further suggests that the dimensions of exclusion are connected (Scharf et al. 2021; Dahlberg 2021). Exclusion from one dimension increases the risk of exclusion from other dimensions. People are not necessarily excluded from all dimensions simultaneously. And while in theory a myriad of combinations of dimensions can exist, certain combinations are more prevalent than others, whereas other combinations hardly occur. For example, in the empirical studies in Belgium (Van Regenmortel et al. 2018) and the UK (Becker and Boreham 2009) only a limited number of combinations, or types of SE, are observed.

In line with previous empirical research, we thus anticipate a limited number of SE types. Risk factors are selected based on their expected relation with SE type, and we expect that older age, female gender, a low degree of urbanisation, no partner, low subjective health, a low level of education, migrant status, no employment, and low trust in other people and in the parliament are associated with an increased risk of any SE type. In line with life course theories on the cumulation of (dis)advantages (e.g. Ferraro et al. 2009), we expect a linear association between the number of dimensions from which a person is excluded, and the severity of SE. Severity will be expressed in terms of loneliness and mental well-being, as loneliness and well-being are associated with all domains of SE (Dahlberg et al. 2022; Precupetu et al. 2019).

Methods

Research design

This cross-sectional study is based on data from the European Quality of Life Survey (EQLS) from 2016, which was, at the time of the study, the most recent data collected (Eurofound 2018). EQLS is a repeated cross-sectional survey of people aged 18 + living in private households. The objective is to improve the living and working conditions of European citizens. The survey examines both the objective circumstances of people's lives, such as employment, income, education, housing, family, and health, as well as subjective questions about, for example, life satisfaction and the perceived quality of the society in which people live. Data were collected by means of computer-assisted face-to-face interviews at respondents' homes. The interviewers adhered to a set of rules governing their conduct and the confidentiality of the project. Survey participation was based on voluntary informed consent that was verbally obtained (Eurofound 2018).

Our study sample ($N = 3030$) consists of older people living in Balkan states, including Bulgaria (20% of the study sample), Romania (18%), Albania (17%), Montenegro (11%), Macedonia (17%), and Serbia (18%). We selected people aged 50 + to retain sufficient power and to acknowledge that socially excluded individuals have a higher risk of mortality (Holt-Lunstad et al. 2010). The average age of our study sample is 64 (SD = 9.3). Slightly more than half of the sample (56%) are female.

Measurements

The operationalisation of SE is based on the conceptual framework by Walsh and others (2017) who distinguish six different domains of exclusion, i.e. social relations, material and financial resources, services amenities and mobilities, civic participation, neighbourhood and community, and socio-cultural aspects. Several subdimensions are defined for each domain, and these are used to guide the selection of variables in our analytical models. All domains are included, except for socio-cultural aspects. These aspects refer to macro-social characteristics of a society which cannot be examined in a collection of countries with similar macro-social contexts. Furthermore, the previous practices in the measurement of old-age SE are adhered to, in which multiple indicators per dimension are used and in which the multidimensionality is preserved (Levitas et al. 2007; Kneale 2012; Van Regenmortel et al. 2018).

SE domains and subdimensions The domains included in our SE variable are (1) civic participation, (2) services, (3) financial resources, (4) neighbourhood, and (5) social relations, and for each domain three subdimensions were selected (Table 1). To avoid very sparse tables and in accordance with general practice (Nylund-Gibson and Choi 2018), all indicators are dichotomised into 1 (indicative for inclusion) and 0 (indicative for exclusion). In this study,

Table 1 Initial selection of SE dimensions and subdimensions and thresholds for exclusion

Dimension	Subdimension	Indicative of exclusion
Civic participation	Participation in church and/or social clubs at least once a month	No
	Feeling left out of society	(Strongly) agree
	Participation in political activities in the last year	No
Services	Can afford to see a general practitioner (GP), family doctor or health-care services	Only with (great) difficulty
	Having been online in the last year	No
	Satisfaction with the GP	Scale score 6 or lower out of 10 (max)
Financial resources	Being able to make ends meet	Only with (great) difficulty
	Being able to keep the home adequately warm	No
	Material deprivation*	At least 3 out of 5 items cannot be afforded
Neighbourhood	Feeling safe when walking alone after dark	No
	Feeling close to people in the area where they life	Neither agree nor (strongly) disagree
	Access to banking facilities, transport, culture, green area, and grocery stores	Rather or very difficult
Social relations	Contact with family and relatives at least once a month	No
	Contact with neighbours and friends at least once a month	No
	Satisfied with family life	Scale score 6 or lower out of 10 (max)

*Material deprivation is measured by asking whether the respondent is able to afford the following items: paying for a week's annual holiday, replacing worn-out furniture, affording a meal with meat/chicken/fish every second day if desired, buying new rather than second-hand clothes, having friends or family for a drink or meal once a month *civic participation* includes (1) participation in church and/or social clubs at least once a month (1 = yes/0 = no), (2) feeling left out of society (neutral or (strongly) disagree = 1/(strongly) agree = 0), and (3) participation in at least one of the six following political activities in the last year: attended a meeting of a trade union, a political party or political action group; attended a protest or demonstration; signed a petition, including an e-mail or online petition; contacted a politician or public official; commented on a political or social issue online; boycotted certain products (1 = at least one activity/0 = else). Exclusion from *services* includes (1) can afford general practitioner (GP), family doctor or healthcare services (1 = yes/0 = only with (great) difficulty); (2) have been online in the last year (1 = yes/0 = no); and (3) satisfaction with the GP. For satisfaction with the GP, a scale was developed based on the following four items: quality of the facilities, expertise and professionalism of staff, personal attention, and being informed or consulted about health care. Response categories ranged from 1 to 10 with higher scores indicating higher satisfaction (Cr. alpha = 0.92). The scale was dichotomised using an arbitrary cut-off of 7 into satisfied (1 = 7 or higher) and not satisfied (0 = lower than 7). For exclusion from *material resources*, the following categories were selected (1) being able to make ends meet (1 = yes/0 = only with (great) difficulty); (2) being able to keep the home adequately warm (1 = yes/0 = no); and (3) material deprivation. Material deprivation is measured by asking whether the respondent is able to afford the following items: paying for a week's annual holiday, replacing worn-out furniture, affording a meal with meat/chicken/fish every second day if desired, buying new rather than second-hand clothes, having friends or family for a drink or meal once a month (1 = four or five items can be afforded/0 = three or fewer items can be afforded). For *neighbourhood exclusion, the following categories* were selected (1) feeling safe walking alone after dark (1 = yes/0 = no); (2) feeling close to people in the area where they life (1 = (strongly) agree/0 = neither agree or disagree and (strongly) disagree); and (3) access to banking facilities, transport, culture, green area, and grocery stores. Scores relating to access to facilities reflect the average score on each item, which are dichotomised into 1 (rather or very easy) and 0 (rather or very difficult). Exclusion from *social relations* includes (1) having contact with family and relatives at least once a month (1 = yes/0 = no); (2) having contact with neighbours and friends at least once a month (1 = yes/0 = no); and (3) satisfaction with family life. Response categories for satisfaction with family life ranged from 1 to 10 with higher scores indicating higher satisfaction. The scale was dichotomised using an arbitrary cut-off of 7 into satisfied (1 = 7 or higher) and not satisfied (0 = lower than 7).

Risk factors of SE We also selected a wide range of potentially relevant risk factors of SE, which have been observed in previous studies and were available in the data: degree of urbanisation, partner status, subjective health, level of education, migrant status, employment status, trust in people and trust in parliament, age, and gender. *Urbanisation* is a categorical variable describing the area in which people live, with the following categories (1) the open countryside, (2) a village/small town, (3) medium to large town, (4) city or city suburb. *Partner status* is based on legal marital status, which is dichotomised into 0 = no partner (including the categories widowed, separated, divorced, and never married) and 1 (married). *Subjective health* is based on the question ‘In general, how is your health?’ and has 5 response categories. The response categories were recoded so that higher scores indicate better subjective health. *Level of education* is based on the International Standard Classification of Education (ISCED) and has nine categories, ranging from 0 (low education) to 8 (high education). *Migrant status* is a dichotomous variable indicating whether a person is born in another country than the surveyed country (1 = yes/0 = no). *Employment status* is based on a 12-category variable, which are recoded into employed (1 = employed/employed but on paid leave) and unemployed (0 = retired, unemployed, no paid work, unable to work due to long-term illnesses). *Trust in people* is assessed by asking people whether they agree with the statement ‘Do you trust other people?’, with response categories ranging from 1 (you cannot be too careful) to 10 (most people can be trusted). *Trust in the parliament* is assessed by asking people whether they agree with the statement ‘Do you trust the parliament in your country?’ with response categories ranging from 1 (do not trust at all) to 10 (trust completely). Age reflects the number of years lived and gender is a dichotomous variable with (1) for male and (2) for female.

Outcomes of SE Loneliness was measured with a single-item statement ‘Over the last two weeks I felt lonely’ with six response categories recoded so that higher scores indicate greater loneliness. Mental well-being was assessed using the World Health Organization Wellbeing Index (WHO-5 scale) which has adequate validity (Topp et al. 2015). The WHO-5 scale consists of the following five questions: (1) I have felt cheerful and in good spirits, (2) I have felt calm and relaxed, (3) I have felt active and vigorous, (4) I woke up feeling fresh and rested, and (5) my daily life has been filled with things that interest me. Answers refer to the last 14 days and response categories ranged from 1 (all the time) to 6 (none of the time). The internal consistency for these five items was also high in our sample (Cr. alpha = 0.93). The response categories have been recoded so that higher scores indicate higher well-being, and an average score has been calculated.

Analytical strategy

The study examines whether different manifestations or types of SE exist, whether these types differ in severity, and how they are associated with potential risk factors. Analyses were conducted in three subsequent steps. In the *first step,* SE types were identified by means of Latent Class Analysis (LCA). LCA is a statistical clustering technique that organises the whole sample of heterogeneous people into smaller, more homogenous subgroups of people (Hagenaars and McCutcheon, 2002) with similar manifestations of social exclusion. Each subgroup represents a different SE type. The decision on the number of SE types with LCA was based on a combination of formal statistics and on the theoretical meaningfulness of the different SE types. The formal statistical tests include fit indices (smallest Bayesian information criterium (BIC), and smallest adjusted BIC (adj. BIC)), high classification quality (that is an entropy close to 1), and parsimony (based on the Vuong-Lo-Mendell-Rubin Likelihood Ratio test for K-1 versus K classes; Jung and Wickrama 2008). These tests make LCA superior to the more traditional cluster techniques such as K-means, which do not provide such statistics (Magidson and Vermunt 2002). The second criterium, that is the theoretical meaningfulness of the different subtypes, has decisive importance if the various formal statistics suggest different numbers of SE types. Two parameters are important to decide on the meaningfulness of SE types, i.e. the conditional probability and the latent class probability. The conditional probability is the probability that a person with a specific SE type will be at a specific level of the various dimensions, e.g. will have social resources, or material resources, or any other dimension of SE, given the SE type to which he or she belongs. Latent class probabilities reflect the prevalence of each SE type. For reasons of parsimony, dimensions with similar conditional probabilities across the SE types are excluded, as these dimensions discriminate poorly between the SE types. For each person in the sample, the most likely SE type was identified, saved, and merged with the datafile for the analyses in steps 2 and 3. The LCA was conducted with MPlus version 8.4 (Muthén and Muthén 1998–2017).

The *second step* evaluates whether the average level of mental well-being and loneliness differed by SE type, by means of an ANOVA, and in the *third step* we examined multivariate associations between the potential risk factors of SE by means of a multinomial regression with SE types as dependent variable and low SE risk as reference group. Urbanisation and subjective health were treated as categorical variables with more than two categories in the model, and gender, partner status, migrant status, and employment as dichotomous variables.

Results

The basic characteristics of the study sample are presented in Table 2. The proportion of males is below the EU average in all countries, except Montenegro, which may reflect the relatively large gender gap in life expectancy, with women living longer than men in many of the Balkan states (https://stat.link/042196). Compared to the other EU countries, people in Balkan states have lower education (except in Bulgaria), lower employment rates (except in Montenegro), are less often migrants (except in Serbia), have lower trust in other people or the parliament, and slightly lower subjective health (except in Bulgaria). The prevalence of living with a partner is higher in all Balkan states, except in Romania, where it is closer to the EU average. Overall, people in Balkan states are, or feel, more often excluded than in other EU countries in almost all dimensions, except contact with family (more often contact in Albania, Montenegro, Macedonia, and Serbia), contact with neighbours and friends (more often contact in Bulgaria, Albania, Montenegro, and Serbia), and, in some of the Balkan states, more people feel safe walking alone after dark (Montenegro, Macedonia, and Serbia) than in the other EU countries.

The results of the latent class analysis are presented in Table 3. As is often the case with LCA, the formal fit statistics were not unequivocal about the number of SE types. As can be seen in Table 3, the (adjusted) BIC indicates that the best model includes five types of SE (smallest BIC), whereas the accuracy of classifying people in the right SE type is highest when a two-SE-type solution is chosen. The most parsimonious model distinguishes three SE types. The decisive factor for determining the number of SE types was the solution that gave the most nuanced description of SE, while at the same time preserving parsimony. This was the model with four SE types. The conditional probabilities and latent class sizes are given in Table 4. Table 4 can be interpreted as follows: the third row of the full model suggests that people in type I have a high probability of feeling included in society ($p=0.81$), whereas people with SE type II have a low probability of feeling included in society ($p=0.26$). For people with SE type III and IV the proportions are round 0.50, indicating an equal proportion of people who feel included in society as people who do not feel included. From the second row of the full model, it follows that the probability of participating in a social or religious organisation is rather similar for the four SE types. A similar reasoning can be followed for the indicators participation in political activities, being online in the last year, and feeling safe when walking alone after dark. To further optimise the model fit, all indicators that did not discriminate between the four SE types were removed from the 4-class solution.

Table 2 Descriptive characteristics of study sample by Balkan states and EU* average

	Bulg.	Rom.	Alb.	Monten.	Maced.	Serbia.	EU*
Mean Age (range 50–95)	65.4	66.1	63.0	60.2	64.3	62.6	65.3
Gender (% Male)	41.1	35.1	43.9	52.9	46.3	47.9	56.9
Mean level of education (range 0–8)	3.5	2.6	2.9	3.1	2.5	1.4	3.2
Partner status (% with partner)	56.1	54.4	79.9	61.7	68.8	65.3	55.6
Being employed (%)	29.2	15.5	16.8	30.6	22.8	29.3	29.8
Urbanisation							
Open countryside (%)	0.0	0.2	6.2	2.9	3.4	1.6	12.5
Village/small town (%)	52.2	58.6	43.9	43.9	39.7	46.1	42.5
Medium to large town (%)	16.0	23.0	9.4	43.6	31.3	40.1	24.4
City or city suburb (%)	31.8	18.2	40.5	9.5	25.5	12.2	20.5
Migrant status (%)	1.0	0.5	0.6	9.0	3.3	12.2	8.8
Mean subjective health (0–5, 5 = high)	3.4	2.9	3.2	3.3	3.3	3.2	3.4
Mean trust in other people (1–10, 10 = high)	3.9	4.8	2.6	4.2	2.9	4.2	5.0
Mean trust in the parliament (1–10, 10 = high)	3.4	4.0	4.3	3.2	3.9	5.3	4.7
Indicators of the SE types (% yes)							
Participation in social and religious organisations	17.9	42.0	24.7	37.0	36.4	41.6	50.7
Feeling included in society	57.6	70.8	78.2	64.5	62.6	55.0	78.0
Participation in political activities	14.2	7.2	14.2	17.6	15.1	19.4	26.8
Can afford health-care facilities	79.7	57.3	65.2	54.1	89.4	68.2	80.4
Being online in the last year	5.8	3.9	8.1	12.0	11.1	11.5	10.6**
Satisfied with GP	70.7	77.0	76.1	51.1	70.0	58.2	81.2
Being able to make ends meet	58.8	53.7	41.6	72.1	75.0	61.3	82.5
Being able to keep the house warm	73.9	75.8	49.0	83.3	84.7	83.5	89.5
Being able to afford at least four out of five items	45.3	39.1	27.4	50.8	42.9	53.0	76.8
Feeling safe walking alone after dark	72.7	79.6	81.6	86.9	90.6	88.7	83.8
Feeling close to the people in the area	78.2	68.6	87.1	59.4	77.4	55.7	71.2
Easy access to facilities	67.1	52.2	58.3	63.5	66.5	56.7	69.5
Contact with family and relatives at least once per month	84.8	77.7	88.1	96.5	89.4	92.5	88.8
Contact with neighbours and friends at least once per month	94.8	88.2	93.9	97.7	88.7	97.1	93.1
Satisfied with family life	57.0	67.5	77.0	63.5	66.9	70.4	77.0
N	593	556	513	346	523	499	16.265

Bulg. = Bulgaria, Rom. = Romania, Alb. = Albania, Monten. = Montenegro, Maced. = FYR of Macedonia,

GP, General practitioner

*EU Average of all other countries in the EQLS that are part of the EU, **52.8% missing observations

Table 3 Fit statistics and proportions of SE types based on the most likely class membership

# Class	BIC	Adj. BIC	L-ratio for *K*-1 versus *K*	Entropy	Proportions for the SE types				
					I	II	III	IV	V
2	47,590.49	47,491.99	0.00	0.71	0.52	0.48			
3	47,477.35	47,328.01	0.00	0.65	0.52	0.24	0.24		
4	47,422.84	47,222.66	0.68	0.69	0.51	0.22	0.18	0.09	
5	47,394.96	47,143.94	0.23	0.62	0.34	0.24	0.21	0.17	0.04
Trimmed model	34,346.13	34,196.79		0.73	0.50	0.23	0.04	0.23	

This trimmed model had a lower (adjusted) BIC and higher entropy (last row Table 3).

The latent class probabilities (first row Table 4) indicate for the trimmed model that the prevalence of people with SE type I, II, III, and IV is 50, 23, 4, and 23 per cent, respectively. Based on the conditional probabilities, Type I is labelled as '*Low SE risk*', as the probability of exclusion was low for all indicators. Type II is characterised by

Table 4 Proportions SE types based on most likely class membership and conditional probabilities ($N = 3030$)

		Full model				Trimmed model			
		I	II	III	IV	I	II	III	IV
Proportions based on most likely class membership	Total sample	0.51	0.22	0.18	0.09	0.50	0.23	0.04	0.23
Civic participation (% yes)									
Participation in social or religious organisations	(0.32)	0.35	0.40	0.28	0.23				
Feeling included in society	(0.64)	0.81	0.26	0.43	0.69	0.81	0.26	0.60	0.72
Participation in political activities	(0.14)	0.18	0.15	0.07	0.09				
Access to services (% yes)									
Can afford health-care facilities	(0.69)	0.84	0.54	0.49	0.57	0.84	0.56	0.59	0.57
Being online in the last year	(0.07)	0.09	0.08	0.04	0.04				
Satisfied with GP	(0.46)	0.47	0.26	0.43	0.61	0.74	0.43	0.69	0.84
Material resources (% yes)									
Being able to make ends meet	(0.59)	0.92	0.37	0.29	0.18	0.93	0.31	0.45	0.23
Being able to keep the house warm	(0.74)	0.96	0.54	0.50	0.54	0.96	0.55	0.59	0.51
Being able to afford at least four out of five items	(0.40)	0.73	0.10	0.11	0.05	0.78	0.11	0.21	0.04
Neighbourhood (% yes)									
Feeling safe walking alone after dark	(0.82)	0.89	0.76	0.68	0.78				
Feeling close to the people in the area	(0.71)	0.75	0.45	0.55	0.94	0.75	0.48	0.58	0.91
Easy access to facilities	(0.60)	0.72	0.46	0.44	0.55	0.72	0.45	0.55	0.55
Social resources (% yes)									
Contact with family and relatives at least once per month	(0.86)	0.91	1.00	0.23	0.94	0.92	0.87	0.00	0.90
Contact with neighbours and friends at least once per month	(0.93)	0.95	0.99	0.59	0.96	0.97	0.96	0.00	0.95
Satisfied with family life	(0.66)	0.81	0.36	0.40	0.71	0.82	0.32	0.41	0.75

SE types I = Low SE risk, II = Material exclusion, III = Exclusion from material resources and social relations, IV = Multidimensional exclusion, GP = General Practitioner

exclusion from material resources, but not exclusion from other dimensions. Type II is labelled '*Material exclusion*'. Type III was mainly characterised by having no contact with family, relatives, neighbours, and friends, and a low quality of family life. The probability that people can afford to buy new items as well as being able to make ends meet was also low. Type III is therefore labelled '*Exclusion from material resources and social relations*'. Type IV is characterised by low feelings of societal inclusion, low satisfaction with the GP, low levels of material resources, disconnection from neighbours, and low access to services. In addition, while people in this type are not excluded from social relations, the satisfaction with family life is low. Type IV is therefore labelled '*Multidimensional exclusion*'.

By means of a subsequent ANOVA, we observed significant differences in severity of SE pertaining to loneliness across the four SE types ($F = 203.12$, df = 3, $p < 0.01$). The lowest levels of loneliness were observed in people with low SE risk ($M = 1.97$, 95% CI = 1.91–2.04), followed by people excluded from material resources ($M = 2.46$, 95% CI = 2.34–2.59), people excluded from material and social resources ($M = 3.40$, 95% CI = 3.05–3.75), and the highest average level of loneliness was observed among people with multidimensional exclusion ($M = 3.58$, 95% CI = 3.46–3.69). Significant differences were also observed in the severity of SE pertaining to mental well-being across the four groups ($F = 164.30$, df = 3, $p < 0.01$), with highest levels of well-being observed in people with low SE risk ($M = 4.21$, 95% CI = 4.16–4.26), followed by people excluded from material resources ($M = 3.60$, 95% CI = 3.50–3.69), and people excluded from material resources and social relations ($M = 3.25$, 95%CI = 3.00–3.51). People excluded from multiple dimensions have the lowest mental well-being ($M = 3.11$, 95% CI = 3.03–3.20) (results not in a table).

Finally, we estimated a multinomial model where potential risk factors of SE were regressed on SE types, with low SE risk as reference category. Several risk factors appeared to be significantly associated with some or all SE types (Fig. 1). Low education, low trust in parliament, living in a medium to large town as compared to living in the city, and lower subjective health increase the odds of being excluded, irrespective of the type of SE. Being younger, unemployed, and having low trust in other people is additionally associated with an increased risk of exclusion from material resources; being male and living without a partner is additionally associated with a higher risk from material and social resources, and being younger, unemployed, and

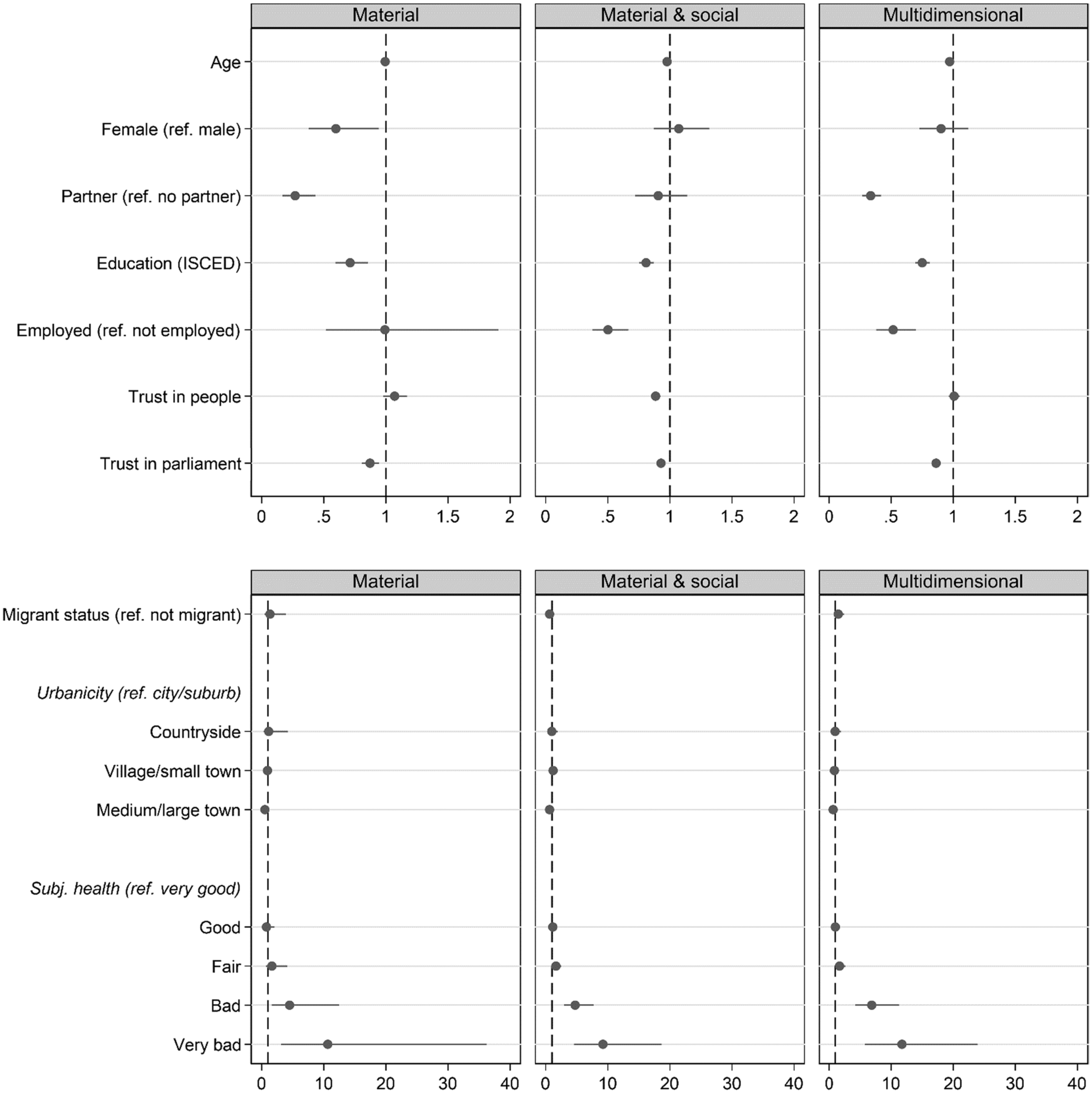

Fig. 1 Plot of the parameter estimates and 95% confidence intervals (CI) for the multinomial regression of SE type on the study variables (N=3030). Note that the x-axis of the upper two figures is different from the lower two figures due to the large CI's for the small groups

living without a partner is additionally associated with a lower risk of multidimensional exclusion.

Discussion

This study provides evidence of the existence of different types of SE and indicates various factors that are associated with SE in older people living in countries with high SE prevalence. An estimation has been made of the prevalence of each SE type, and a broad range of risk factors and outcomes of SE have been investigated. The study finds that half of the people aged 50+ in Balkan states are not excluded from mainstream society, which also means that half of the 50+ population in the Balkan states are excluded from one or more dimensions of SE. There is evidence for four types of SE: low risk of exclusion (observed for 50% of the 50+ people in our sample), exclusion from material resources (23%), exclusion from material resources and social relations (4%), and exclusion from material resources, neighbours, and society, with low satisfaction with the family and general practitioner, here referred to as multidimensional exclusion (23%). All our proposed risk factors, except migrant status, have been found to be associated with some or all SE types, although not all in the expected direction. Low education, low trust in the parliament, living in a medium to large town as compared to living in the city, and lower subjective health are associated with all types of SE; being unemployed is only associated with material and multidimensional exclusion; living without a partner is only associated with exclusion from material and social resources, and multidimensional exclusion; and lower trust in other people is only associated with exclusion from material resources.

In contrast to our expectations, it was observed that, compared to older-old people, younger-old people have an increased risk of exclusion from material resources and multidimensional exclusion. One explanation for this is that older people may own a mortgage-free property and do not need to pay rent, making it easier to make ends meet (Age Platform Europe 2018). An alternative explanation for this may be that it is not age per se but being unemployed which increases the risk for exclusion from material resources (Matkovic 2006). It is unclear whether it is the exclusion from material resources that drives the significant association between multidimensional exclusion and age. This would need further investigation.

Also in contrast with our expectation is that it is men, and not women, that have an increased risk of material and social exclusion, although no gender differences for material exclusion or multidimensional exclusion are observed, which is in line with studies in the UK (Scharf et al. 2005) and Australia (Miranti and Yu 2015). It is unclear why men in Balkan states are at increased risk of material and social exclusion, and any explanation would be speculative. It may be, for example, that prevailing gender norms surrounding social roles leave men more vulnerable to SE than women. The male breadwinner norm is still dominant in Balkan countries, and those who cannot conform to expectations likely withdraw from social relations and/or are stigmatised, leading to a common experience of being excluded from both material resources and social connections.

In line with previous claims and findings that SE leads to lower well-being (Walsh et al. 2017; Sacker et al. 2017), this study finds that the higher the number of domains from which a person is excluded, the higher their loneliness and the lower their well-being. Hence, exclusion from multiple domains is the most severe form of SE. As can also be seen in the sparse number of empirical studies, while many manifestations of SE may exist, only a limited number are observed, even in countries with high SE risks. It is apparent that domains of exclusion tend to cluster around three types of SE: material exclusion, social and material exclusion, and exclusion from many domains simultaneously, or multidimensional exclusion. It was also observed that factors associated with SE are partly specific, only affecting one or two types of SE, and partly generic, affecting all types of SE, suggesting qualitative differences in the (origins of) SE.

There are limitations to this study. Firstly, the selection of SE indicators is confined to variables available in the data used, meaning that the most ideal indicators could not always be selected. Secondly, cross-sectional data were used, which makes it impossible to separate drivers, risk factors, indicators, and outcomes of SE (Macleod et al. 2019). However, distinguishing between the various associated factors is not so relevant to the purpose of this study. Thirdly, data were combined from six countries. Although all those countries had a relatively high degree of SE—similar welfare regimes, and comparable histories in respect of the many transformations in economic structures, labour markets, and political institutions (Precupetu et al. 2019)—variations and different patterns of SE may still exist. A hierarchical or multilevel LCA can take this regional or country-level variation into account (Pirani 2013). However, since the study only has 6 level-2 units, and because 50 or more level-2 units are recommended for an accurate estimation of standard errors (Maas and Hox 2005), a multilevel LCA was not conducted.

Despite its limitations, this study has contributed to a deeper understanding of SE in several important ways. Firstly, while a large variation of different manifestations of SE might be expected, evidence suggests that the number of SE types is limited, even in countries with a high SE risk. Thinking in types of SE helps to reduce the inherent complexity of a multidimensional concept, which makes it easier to develop strategies to reduce SE. Secondly, there appears to be generic and specific risk factors of the SE types, and SE types differ in severity, which makes each SE type qualitatively distinct. Thirdly, SE types differ in terms of severity, with the number of exclusion dimensions linearly related to higher levels of loneliness and lower levels of mental well-being.

The results of this study emphasise the importance of tailoring policy interventions to the various types or manifestations of SE, while also considering the different risk factors. Policies should continue to address the high levels of material exclusion in Balkan states and in other poorer countries. The range of income-centric policies (e.g. guaranteed minimum income, benefits for those suffering from fuel poverty, disability benefits) could be expanded and better targeted to those in need. In addition to income maintenance policies for older people, preventive strategies should also concentrate on those currently active in the labour market who have a greater risk of low income after retirement. This includes,

Table 5 Parameter estimates for the multinomial regression of SE type on the study variables ($N = 3030$)

	Exp(B)	95% CI		Exp(B)	95% CI		Exp(B)	95% CI	
		Lower	Upper		Lower	Upper		Lower	Upper
	Material versus Low-risk SE			Material and social versus Low-risk SE			Multidimensional versus Low-risk SE		
Age	***0.98***	***0.97***	***0.99***	0.99	0.97	1.02	**0.97**	**0.96**	**0.98**
Female gender	1.07	0.87	1.32	***0.60***	***0.38***	***0.94***	0.90	0.73	1.12
With partner	0.91	0.72	1.14	***0.27***	***0.17***	***0.43***	***0.34***	***0.27***	***0.42***
Education	***0.81***	***0.75***	***0.87***	***0.71***	***0.59***	***0.85***	***0.75***	***0.69***	***0.81***
Migrant status	0.62	0.34	1.14	1.34	0.46	3.91	1.48	0.91	2.40
Being employed	***0.50***	***0.38***	***0.67***	0.99	0.52	1.91	***0.52***	***0.38***	***0.70***
Trust in people	***0.89***	***0.85***	***0.92***	1.07	0.98	1.17	1.01	0.96	1.05
Trust in the parliament	***0.93***	***0.90***	***0.96***	***0.87***	***0.81***	***0.94***	***0.86***	***0.83***	***0.90***
Urbanity (ref is city or suburb)									
Open countryside (%)	0.97	0.49	1.93	1.12	0.30	4.19	0.99	0.50	1.93
Village/small town	1.19	0.92	1.53	0.93	0.54	1.61	0.87	0.67	1.13
Medium to large town	***0.62***	***0.46***	***0.83***	***0.52***	***0.27***	***1.00***	***0.66***	***0.49***	***0.89***
Subjective health (Ref = Very good)									
Good	1.14	0.74	1.75	0.77	0.29	2.06	1.02	0.65	1.60
Fair	***1.64***	***1.07***	***2.51***	1.64	0.65	4.14	***1.69***	***1.09***	***2.62***
Bad	***4.74***	***2.92***	***7.70***	***4.48***	***1.61***	***12.47***	***6.88***	***4.19***	***11.28***
Very bad	***9.22***	***4.55***	***18.67***	***10.64***	***3.13***	***36.20***	***11.74***	***5.76***	***23.93***

Bold and italic numbers indicate that $p < 0.05$

for example, people working in the grey economy, persons with fragmented work trajectories, and those who experience long-term unemployment. Exclusion from material resources and social relations, as well as multidimensional exclusion, highlights the importance of implementing the principles of active ageing, especially when creating socially supportive environments for older people. Programmes to sustain extended social relationships in the community, such as intergenerational interaction programmes, supporting communities or clubs that centre on specific activities that bring people together, could be particularly beneficial. Such programmes could expand spheres of sociability beyond close relationships and help secure a social network that withstands disruptive life events such as the death of a partner, separation, or divorce. A broader social sphere may lessen the exclusive reliance on close family members that is typical in familistic welfare states.

In conclusion, while opinions increasingly converge about what SE encompasses and its different manifestations, more needs to be done. Firstly, the indicators for different dimensions vary across studies, which compromises the comparability of SE across countries and welfare states. Having said that, since SE is a relative concept, defining who is included or excluded depends on what is normal in a particular society, which implies that the threshold of each indicator can only be defined at a societal level. Secondly, many studies are cross-sectional which makes it impossible to separate risk factors, indicators, and outcomes of SE. There needs to be more research into macro-level drivers, such as state benefits for compensating exclusion from material resources or health-care services, and into cultural, gendered, or ageistic norms about older peoples. That requires longitudinal data and cross-national comparisons, and an analytical method that can handle these data. Hierarchical longitudinal LCA may be a good candidate for these types of analyses.

Appendix

(See Table 5).

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Declarations

Competing interests The authors declare that there is no conflict of interest.

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ORIGINAL INVESTIGATION

Unmet healthcare needs among the population aged 50+ and their association with health outcomes during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic led to unprecedented levels of subjective unmet healthcare needs (SUN). This study investigates the association between SUN in 2020 and three health outcomes in 2021—mortality, cancer, and self-assessed health (SAH), among adults aged 50 years and older, using data from the regular administration of the Survey of Health, Ageing and Retirement in Europe and from the two special waves administered in 2020 and 2021 regarding COVID-19. Three types of SUN were surveyed: care foregone due to fear of contracting COVID-19, pre-scheduled care postponed, and inability to get medical appointments or treatments demanded. We resort on the relative risk and the logistic specification to investigate the association between SUN and health outcomes. To avoid simultaneity, 1-year lagged SUN variables are used. We found a negative association between SUN and mortality. This result differs from the (scarce) previous evidence, suggesting that health systems prioritised life-threatening conditions, in the pandemic context. In line with previous studies, we obtained a positive association between SUN and worse health, in the case of cancer, though it is statistically significant only for the global measure of SUN (any reason). The higher chances of reporting cancer among those exposed to SUN might mean delayed cancer diagnosis, confirming that healthcare foregone was truly needed for a timely diagnosis. The association between SUN and poor or fair SAH is positive but not statistically significant, for the period analysed.

Keywords Unmet needs · Mortality · Cancer · Self-assessed health · COVID-19 · SHARE

Introduction

Self-reported unmet healthcare needs, also known as subjective unmet needs (SUN) (Allin et al. 2010), have become an essential indicator of access to healthcare (Allin and Masseria 2009; EXPH 2017; Thomson et al. 2019). Factors associated with SUN are widely explored by now, namely in European countries. Individuals with low income, worse health, of younger ages, immigrants, unemployed, and women tend to present higher levels of SUN for general healthcare (Baert and De Norre 2009; Israel 2016; Röttger et al. 2016; Fjaer et al. 2017). Lack of private health insurance might lead to an increased risk of SUN (Connolly and Wren 2017), while it seems irrelevant whether persons are registered at public or private primary care providers (Lindström et al. 2018). Differently, higher levels of trust (Lindström et al. 2017) and social capital in general (Quintal et al. 2019) are negatively associated with SUN. At the country level, unmet needs for medical care seem to be higher in countries with larger income inequalities (Israel 2016) as well as in countries where out-of-pocket payments weigh more on total health expenditure (Chaupain-Guillot and Guillot 2015).

Although access to healthcare merits investigation on its own, a strong concern with unmet needs stems from the possibility of unmet healthcare needs leading to a deterioration of the individuals' health (Aragon et al. 2017). Contrasting with the numerous studies on predictors of SUN, empirical analyses of the health implications of SUN are much scarcer particularly in Europe, but also elsewhere. Existing

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evidence suggests that SUN in the past cause a worsening in self-assessed health (SAH) in the present. One study obtained this evidence for Canada (Gibson et al. 2019) and two others for Korea (Ko 2016; Kim et al. 2019), considering one-year or two-year lagged SAH. Some studies used mortality, instead, as the health outcome variable, concluding that unmet needs were associated with increased mortality in a five-year follow-up period for the case of Sweden (Lindström et al. 2020) and a three-year follow-up period for the case of Chinese elderly (Zhen et al. 2015). However, in the latter study, unlike in the previous ones, unmet needs concerned assistance in performing activities of daily living and not specifically healthcare. An early study by Alonso et al. (1997) also found that unmet healthcare needs were associated with an increased risk of mortality for the elderly (Spain). Nonetheless, in this study, direct questions about unmet needs were not available. Hence, the authors considered that individuals with bad health, who reported no visits to/from a physician in the previous twelve months, had unmet healthcare needs. Besides SAH and mortality, an association between SUN in one period and worse health, measured by chronic conditions as well as activity limitations, in the following period, was obtained by Gibson et al. (2019). Using a broader health outcome variable, some studies produced evidence of a negative relationship between SUN and health-related quality of life (Ko 2016; Ju et al. 2017; Gibson et al. 2019). Finally, a few studies focused on specific clinical outcomes mostly related with mental health, such as Lasalvia et al. (2005), Gaugler et al. (2005), and more recently Stein et al. (2019). These studies too found a negative association between unmet needs and good health, but needs were assessed in a different way, adapting the Camberwell Assessment of Need, consisting of health and social needs across various domains.

Previous evidence further suggests that the magnitude of the association between SUN and health-related quality of life is more pronounced in economically vulnerable groups (Ju et al. 2017). There is also evidence that the magnitude of the association between SUN and SAH is bigger for unmet needs due to economic reasons rather than any other reasons, and smaller in the case of mild symptoms (Ko 2016). In light of these results, it is possible that more educated individuals are more capable of identifying milder conditions for which healthcare can be foregone without serious health consequences. On the other hand, poorer individuals might not have the means to meet healthcare needs even when they recognise them as serious needs.

All the above studies used data collected before the COVID-19 pandemic. The pandemic created a totally different panorama, with a massive reduction in healthcare utilisation (Moynihan et al. 2021). Before the pandemic, surveys and analyses of unmet healthcare needs were mainly concerned with barriers to access to healthcare, particularly related to costs and waiting times. With the outbreak of COVID-19, health systems reallocated healthcare resources to COVID-19 patients, leading to the cancellation and/or postponement of many planned treatments. Patients themselves, either due to fear of infection or to avoid burdening health services, have restrained demand. Measures as lockdowns and stay-at-home orders have also affected healthcare utilisation (Moynihan et al. 2021). Using data from a special wave of the Survey of Health, Ageing and Retirement in Europe (SHARE), the SHARE Corona Survey launched in 2020 (SC1), some studies have addressed unmet healthcare needs in the first months of the pandemic. Some of the usual predictors of SUN were found in these studies such as being female, having poor health and a bad economic situation (Smolić et al. 2021). Another study reports that the impact of economic vulnerability was stronger among those who were in poor health before the outbreak (Arnault et al. 2021). At the country level, postponed medical care is associated with more stringent governmental anti-COVID-19 measures (Jiskrova et al. 2021). Comparisons with previous analyses of unmet needs must be however cautious because some of the unmet needs, in SC1, were assessed by asking individuals if their appointments were cancelled/postponed. Thus, in this case, unmet needs can only be observed among those individuals with scheduled appointments. However, irrespective of which factors are associated with unmet healthcare needs and of any limitation that might apply, one important question remains: what are the health implications of these unmet needs which emerged during the pandemic?

Bergeot and Jusot (2022) investigated the effect of unmet needs during the first wave of the pandemic on health outcomes (fear of falling, falling, fatigue, dizziness) up to one year after, relying on data from the two special waves of the SHARE Corona surveys collected in 2020 and 2021 (SC1 and SC2, respectively). These authors found a positive association between SUN in 2020 and all outcomes in 2021.

In the current study, we too take advantage of the data collected in the special waves of the SHARE Corona Survey, SC1 and SC2, to assess the association of unmet healthcare needs reported in 2020 with health outcomes reported in 2021, among the general population, aged 50 years or above. As in most studies analysing the association between SUN and health, two main health outcomes here analysed are SAH and mortality. In addition, we also analyse the association between SUN in 2020 and cancer incidence in 2021. Our health outcomes thus differ from those analysed by Bergeot and Jusot (2022).

A usual difficulty in linking SUN with health outcomes lies in the subjectivity of this measure. Individuals who value health more or who have higher expectations towards health services might be more prone to report unmet needs (Ko 2016). Hence, SUN might not represent true unmet needs given that they are based on respondents' perceptions of need and are not based on evidence regarding the effectiveness of healthcare foregone (Gibson et al. 2019). In the context of the pandemic, because we are dealing with the cancellation/postponement of, or non-attendance to, planned appointments, one might say that most self-reported unmet healthcare needs are clinician-validated (Allin et al. 2010). Nonetheless, overuse and waste in the healthcare sector is well documented (Mafi and Parchman 2018), meaning that even clinician-validated SUN might not represent true unmet needs. There are already claims that not all healthcare foregone during the pandemic was necessary and that the pandemic context was an opportunity to reduce waste (Moynihan et al. 2020; Sorenson et al. 2020). There are mixed signals about the impact of the pandemic on the health of patients suffering from conditions not related with COVID-19. On the one hand, there is evidence of excess population mortality, in addition to deaths from COVID-19 (Lai et al. 2020) and increases in out-of-hospital cardiac arrests and contacts with emergency phone lines (Marijon et al. 2020; Perlini et al. 2020). On the other, it seems that cuts in healthcare utilisation were stronger for less severe forms of illness (Moynihan et al. 2021). The research about the association between unmet needs, in 2020, and health outcomes such as SAH and mortality, in 2021, might shed some light on this issue.

With the present study we aim to contribute to the very scarce literature on the association between SUN and health, especially in European countries. In addition, as frequent users of healthcare, older people were at an increased risk of unmet needs during the pandemic. Hence, we also aim to contribute to a more comprehensive understanding of the consequences of the pandemic, due to healthcare foregone, for the health of older patients suffering from conditions not necessarily related with COVID-19.

Materials and methods

Data

Data for this study come from the SHARE project. SHARE is a longitudinal study that includes eight ordinary waves of biennial surveys starting at 2004 and finishing at 2018/2019 (Börsch-Supan et al. 2013). The target population of SHARE consists of all persons aged 50 years or older who at the time of the interview had their domicile in a country that was part of the SHARE project (28 countries, including all European Union countries, except Ireland, plus Switzerland and Israel). The multidisciplinary, cross-national and longitudinal database contains individual-level data on health, demographic and socio-economic status, household structure, and social networks, for more than 123,000 individuals (*SHARE webpage*). Furthermore, it includes two special waves, one from 2020 and another from 2021, designed and applied to collect data about the social, health and economic impact of the COVID-19 pandemic (Scherpenzeel et al. 2020). Notwithstanding the differences among countries, the most frequently used sampling methodology is stratified multistep random sampling. Although the individual participation rate varies from country to country, the overall participation rate is found to be systematically above 45% for every wave (Bergmann et al. 2019).

The special data sets collected in 2020 (SC1) and 2021 (SC2) (Börsch-Supan 2022a, b), covering the pandemic period, are the main data contributors for this analysis (the information about the specificities of SC1 and SC2 can be found in the SHARE Corona Release Guide, available at https://share-eric.eu/fileadmin/user_upload/Release_Guides/SHARE_Corona_Survey_Release_Guide.pdf). Both surveys were designed to collect data reflecting the living context brought about by the COVID-19 crisis. In both surveys, data were collected via computer-assisted telephone interview between June and August 2020 (SC1) and, one year later, between June and August 2021 (SC2). Despite the change from face-to-face-interviewing to telephone interviews, this was done in a way to minimise the drop of the retention rates between waves. Most countries hence achieved or even surpassed their retention rates from before the pandemic (Bergmann et al. 2022). The topics covered by SC1 and SC2 were essentially the same as those of the regular SHARE questionnaire (health and health behaviour; mental health; infections and healthcare; changes in work and in the economic situation; and social networks), but on a shortened version and more oriented to the living situation during the pandemic. SC1 interviewed 57,559 individuals while SC2 interviewed 49,253. However, for our analysis, we are interested in those subjects with valid cases in the two waves, and in those who were interviewed in SC1 and died before the second interview. Our final working database has 48,356 individuals with valid interviews in SC1 and SC2, plus 1199 individuals who were interviewed in 2020 and died before the 2021 interview. These are the sample sizes of the original datasets supplied by SHARE, however, due to the existence of missing values for some of the variables of interest, or to the need to select some sub-populations, the statistical analysis is based on a lower number of observations. Throughout the paper, we will provide the number of cases on which each analysis is based.

Variables

There are three sets of variables—health outcome measures, SUN as measures of exposure, and control variables. Table 1 presents the definition of each variable used in the analysis and the Appendix provides additional information on which waves of SHARE were used, and how, to construct each

Table 1 Definition of variables

Variable	Definition
Health outcome measures (measured in SC2)	
Cancer	= 1 if individual selects, in 2021, from a list of health conditions, the option: "Cancer or malignant tumor, including leukemia or lymphoma, but excluding minor skin cancers"; 0 otherwise
Mortality	= 1 if individual was inquired in the SC1 wave and died afterwards, before SC2 interview; 0 otherwise
SAH Poor|Fair_Pand	= 1 if individual reports self-assessed health, in 2021, as poor or fair; 0 otherwise
SUN as measure of exposure (measured in SC1, at baseline)	
SUN (Fear)	= 1 if individual answers 'yes' to the question "Since the outbreak of Corona, did you forgo medical treatment because you were afraid to become infected by the coronavirus?"; 0 otherwise
SUN (Postponement)	= 1 if individual answers 'yes' to the question "Did you have a medical appointment scheduled, which the doctor or medical facility decided to postpone due to Corona?"; 0 otherwise
SUN (Unavailable care)	= 1 if individual answers 'yes' to the question "Did you ask for an appointment for a medical treatment since the outbreak of Corona and did not get one?"; 0 otherwise
SUN (Global)	= 1 if individual answers 'yes' to any of the questions identified in SUN (Fear), SUN (Postponement) or SUN (Unavailable care); 0 otherwise
Control variables (measured in SC1)	
Male	= 1 if male; 0 otherwise
Age	Age in years
Educ_low	= 1 if individual completed at most basic education (ISCED 1997 codes 0, 1, or 2); 0 otherwise
Educ_med	= 1 individual completed secondary or post-secondary education (ISCED 1997 codes 3 or 4); 0 otherwise
Educ_high	= 1 if individual completed tertiary education (ISCED 1997 codes 5 or 6); 0 otherwise
Income	Monthly equivalent income, before Corona outbreak, in thousand euros
Lives alone	= 1 if individual belongs to a one-person household; 0 otherwise
Big city	= 1 if individual lives in a big city; 0 otherwise
Suburbs	= 1 if individual lives in the suburbs or outskirts of a big city; 0 otherwise
Large town	= 1 if individual lives in a large town; 0 otherwise
Small town	= 1 if individual lives in a small town; 0 otherwise
Rural	= 1 if individual lives in a rural area or village; 0 otherwise
SAH Poor_Pre_Pand[a]	= 1 if individual reports self-assessed health as poor; 0 otherwise
SAH Fair_Pre_Pand[a]	= 1 if individual reports self-assessed health as fair; 0 otherwise
SAH Good_Pre_Pand[a]	= 1 if individual reports self-assessed health as good; 0 otherwise
SAH Very Good_Pre_Pand[a]	= 1 if individual reports self-assessed health as very good; 0 otherwise
SAH Excellent_Pre_Pand[a]	= 1 if individual reports self-assessed health as excellent; 0 otherwise
n_Chronic	Number of chronic conditions (from a list of 17 conditions)
Diabetes	= 1 if individual has diabetes; 0 otherwise
Country C[b]	= 1 if individual lives in country C; 0 otherwise

SC1 SHARE Corona Survey 2020, *SC2* SHARE Corona Survey 2021

[a] In SC1, individuals were asked about their health before the Corona outbreak

[b] *List of countries* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and Switzerland

variable. We analyse the effect of SUN on three health outcomes—cancer, mortality, and poor or fair SAH. Regarding SUN, there are three categories of unmet healthcare needs as shown in Table 1. Healthcare foregone due to fear of infection, SUN (Fear), which includes planned care but also applies to other situations. In the case of planned care, one might say that it represents the concept of clinician-validated SUN (Allin et al. 2010), corresponding to an objective unmet healthcare need. For other situations, SUN (Fear) can be regarded as 'subjective, chosen unmet need' (Allin et al. 2010). SUN (Postponement) fits the previous description of planned care. In the case of SUN (Unavailable care), individuals explicitly sought healthcare, which depends on their perceptions of need and expectations regarding health services. We also consider a global measure of unmet healthcare needs, irrespective of the reasons—SUN (Global). The control variables are defined in Table 1 (see also the Appendix for more details).

Statistical strategy

The main challenges to discerning the effect of SUN on individuals' health status are dealing with unobserved heterogeneity and simultaneity between health status and SUN (Ko 2016; Gibson et al. 2019). One possible strategy to deal with the simultaneity issue is to conceptualize the special waves of SHARE as a prospective cohort study design. The cohort design allows the study of the individuals who have been exposed to SUN, followed over one year, with cancer, poor/fair SAH and mortality as health outcome measures, being compared, at the end of the period, with the group formed by those who have not been exposed to SUN. The 2020 wave (SC1) is the baseline and SC2 is the point where health outcomes are measured. At baseline, the populations selected are those composed of individuals free from the health outcome of interest, therefore, we consider three different baseline cohorts of individuals. In the case of cancer, the baseline population comprises all individuals who never reported cancer by 2020. In the case of SAH, the baseline population is formed by all individuals who reported, in 2020, enjoying very good or excellent SAH before the pandemic. Hence, we analyse the individuals' transitions from a general state of good health (defined by the two upper categories of SAH) to a general state of bad health (defined by the two lowest categories of SAH) and associate these transitions with exposure to SUN. Finally, in the case of mortality, the baseline population encompasses all individuals alive at the baseline.

Supported by the prospective cohort design, we rely on two main statistical approaches to identify the association between SUN and the three health outcomes. Firstly, we estimate the relative risk (RR), which reflects the probability of the health outcome among those exposed to SUN relative to the probability of the health outcome among those not exposed to SUN (Merrill 2015). The RR may be biased due to the presence of confounders, therefore, to reduce the impact of these confounders, we regress the health outcomes observed at the end of the study, in 2021 (SC2), on SUN and on a series of control covariates observed at baseline, in 2020 (SC1). Given the binary nature of all health outcomes, we adopt a logistic specification. Ko (2016) also dealt with the issue of simultaneity between health outcomes and SUN by regressing the health outcomes observed at the end of the observation period on covariates observed at the baseline. The set of control variables included in all models is presented above in Table 1. To investigate the possibility of the individual's socio-economic status influencing the magnitude of the association between SUN and health outcomes, we include in the list of covariates the interaction between SUN (Global) and income and between SUN (Global) and education level.

In all logit specifications, the measure of association between SUN and the health outcome that is estimated, and reported, is the odds ratio (OR). The OR of a given exposure factor is the ratio between the odds of the (health) outcome taking place given that the factor is present and the odds of the (health) outcome occurring given that the factor is absent. Define $P(y=1/x)$ as the probability of the (health) outcome occurring, conditional on covariates $\boldsymbol{x}$. In a logistic model, the probability of the outcome is given by $P_1 = P(y=1|x) = \frac{e^{x'\beta}}{1+e^{x'\beta}}$, and $P_0 = P(y=0|x) = \frac{1}{1+e^{x'\beta}}$. The odds are then defined as $\frac{P_1}{P_0} = e^{x'\beta}$, where $\boldsymbol{x'\beta}$ is a linear function of the covariates ($\boldsymbol{x}$) and parameters ($\boldsymbol{\beta}$). It is straightforward to conclude that for a specific exposure factor E, whose coefficient from the logistic regression is, say, β_2, the corresponding OR is given by $OR_E = e^{\beta_2}$. However, when $\boldsymbol{x'b}$ also includes interaction terms, the interpretation deserves special caution. Assume that $x'b = \beta_0 + \beta_1 x_1 + \beta_2 E + \beta_{12} x_1 * E + \beta_3 d + \beta_{13} dE + \beta_k x_k$, where x_1 and d, are respectively, a continuous and a dummy variable, E is the exposure variable (assumed binary) and $\boldsymbol{x}_k$ is a list of control variables. Then the OR of exposure E is given by $OR_E = e^{\beta_2+\beta_{12}x_1+\beta_{13}d}$, thus depending on the covariates x_1 and d, in addition to the parameters. To estimate the overall OR_E we compute the average response of all individuals. The interaction effect of the continuous variable x_1, that is, the effect of the continuous covariate x_1 on OR_E, is given by the derivative of the OR_E in relation to x_1 $\frac{d}{dx_1}\left(e^{\beta_2+\beta_{12}x_1+\beta_{13}d}\right) = \left(e^{\beta_2+\beta_{12}x_1+\beta_{13}d}\right)*\beta_{12}$. Again, the interaction effect is calculated as the average response of all individuals. To assess the effect of the dummy variable d on the OR_E, we calculate the average effect of $\mathrm{OR}_E(d=1)$–$\mathrm{OR}_E(d=0)$. In summary, we run six logistic regression models. The first three models regress the three health outcome measures (cancer, mortality and SAH Poor|Fair_Pand) on SUN, including, simultaneously, as main covariates the different motives of unmet healthcare needs, along with the control variables presented in Table 1. The second group of models regress the three health outcome measures on SUN (Global), but now including the interaction between income, and education, with SUN Global, in addition to all control variables listed in Table 1. Any dataset case that had a missing value in one variable of interest was dropped from the analysis. We used Stata 16.1 for data processing and statistical analysis. To compute the average OR effects, we used the *margins* instruction available in Stata. Stata do-files are available upon request.

Results

Table 2 displays the prevalence of SUN in both waves, 2020 and 2021. Regarding SUN (Global), there is a clear decrease from 2020 to 2021 of about 12 percentage points (p.p.). Disaggregating by motive, it is noticeable that in both years SUN caused by cancellations/postponements are the most prevalent, followed by fear of getting infected. For the former, the prevalence of SUN falls to less than half in 2021, whereas for SUN due to fear of infection the prevalence in 2021 is about 75% of that in 2020. The prevalence of SUN due to unavailable care is by far the lowest and the more stable in both waves.

Table 3 reports the incidence of SUN in 2021, for two distinct groups: those who reported SUN in 2020 and those who did not.

Considering the new cases of SUN in 2021, the share of such cases related to previous reporting of SUN is between 4 and 4.5 times higher (depending on the motive) when compared to absence of SUN in 2020.

Table 4 displays the prevalence and incidence of the three health outcomes observed in 2021.

The estimates are based on the 48,356 SHARE respondents who participated in both SC1 and SC2. There were some missing values on the outcome measures and on weights, for SC2, and excluding these observations led to sample sizes of 48,046 and 48,150 observations, respectively, for the outcomes Cancer and SAH—these samples were used to create the column "Prevalence" of Table 4. The figures for "Incidence" are based on the full baseline samples (Cancer: 43,693; SAH: 11,396 and Mortality: 49,555 observations). Due to missing values either on one outcome measure or on the weights, at SC2, the final sample is reduced to 42,509 in the case of the cancer baseline and to 11,234 in the case of the SAH baseline. The sample to estimate Mortality comprises all respondents who participated in both SC1 and SC2—48,356, plus those who participated in SC1 and died before the second wave—1199 individuals—amounting to 49,555 observations. The displayed figures are weighted (based on weights from SC2).

As shown in Table 4, the prevalence of cancer in 2021 was 5.07%; however, the incidence was 1.94%. The incidence of cancer in the COVID-19 era is in line with the incidence observed in previous waves of SHARE (own estimates based on all waves of SHARE, available upon request). The prevalence of poor or fair health is 36%, though the new cases for those conditions, in 2021, are 9.46%. The mortality rate was estimated at 2.41%.

Table 5 displays the RR of the health outcomes in 2021 both for the individuals who were and were not exposed to unmet needs in 2020.

As shown in Table 5, the RR for cancer is higher for the exposed to unmet needs (RR greater than one and statistically significant for all motives of SUN). Poor or fair SAH is also higher among those individuals exposed to SUN in 2020 and the difference is statistically significant, except for the case of SUN due to unavailability of care. Differently, in the case of mortality, the RR is higher among the non-exposed to SUN in 2020 (not significant for SUN due to

Table 3 Incidence of subjective unmet healthcare needs (SUN) in 2021

	SUN = YES 2020 (%)	SUN = NO 2020 (%)	*N* (Yes; No)
SUN (Fear)	26.8	6.5	5900; 42,029
SUN (Postponement)	26.8	7.1	12,875; 35,054
SUN (Unavailable care)	20.3	4.5	2508; 45,421
SUN (Global)	38.1	13.5	16,985; 30,944

Estimates are based on the full sample of 48,356 respondents who participated in both SC1 and SC2. There were some missing values on SUN variables, for SC1 and SC2, and on weights for SC2, that had to be excluded, thus leading to a sample size of 47,929 observations. The figures presented are weighted (based on weights from SC2)

Table 2 Prevalence of subjective unmet healthcare needs (SUN) in 2020 and 2021

Type of SUN	2020 (%)	2021 (%)
SUN (Fear)	11.64	8.93
SUN (Postponement)	24.96	11.94
SUN (Unavailable care)	5.40	5.36
SUN (Global)	33.41	21.62
N	57,041	48,868

Prevalence rates are based on the full sample observed in SC1 (57,559) and in SC2 (49,253). There were missing observations on SUN variables and on the weights; excluding them led to a sample size of 57,041 and 48,868 observations for 2020 and 2021, respectively. The displayed prevalence rates are weighted

Table 4 Prevalence and incidence of health outcome variables in 2021

	Prevalence (%)	Incidence (%)
Cancer	5.07	1.94
N	48,046	42,509
SAH Poor|Fair_Pand	36.03	9.46
N	48,150	11,234
Mortality	–	2.41
N		49,555

The figures presented are weighted (based on weights from SC2) and are based on individuals who had valid (non-missing) outcome measures. The "Prevalence" column is based on the full sample and the "Incidence" is based on the baseline populations defined above

Table 5 Unadjusted Relative Risk

	Cancer	Mortality	SAH Poor|Fair_Pand
SUN (Fear)	**1.30** [1.08–1.57]	**0.68** [0.562–0.838]	**1.30** [1.10–1.54]
SUN (Postponement)	**1.32** [1.15–1.51]	**0.77** [0.671–0.881]	**1.16** [1.01–1.32]
SUN (Unavailable care)	**1.61** [1.28–2.05]	0.95 [0.729–1.224]	1.30 [0.99–1.69]
SUN (Global)	**1.32** [1.16–1.51]	**0.69** [0.607–0.782]	**1.23** [1.09–1.38]
N	42,609	49,466	11,308

95% confidence intervals in brackets. In bold, RR statistically significant at 5%

All estimates are based on the full sample for each baseline population (Cancer: 43,693; Mortality: 49,555, and SAH: 11,396 observations). All cases with missing values on any of the unmet measures were dropped, leading to the final sample sizes presented in this table

unavailability of care). We estimated the RR by gender and by age categories and did not find any statistically significant differences.

These univariate estimates suggest that exposure to SUN is associated with all health outcomes considered; however, these results might be biased and influenced by the presence of confounding variables, therefore, we next present the results from the estimation of the multivariate model, controlling for some important independent variables.

Firstly, to check if the baseline populations substantially differ from the whole population, Table 6 presents some descriptive statistics that assist in the characterisation of both.

There are no marked differences between the exposed and the non-exposed, within each baseline population. Because SHARE targets older individuals, it is understandable the absence of great discrepancies. The percentage of individuals reporting fair or poor SAH, before the pandemic, is about 8 p.p. higher among the exposed to SUN (Global) than among the non-exposed, both in whole population and among individuals without cancer up to 2020. The average number of chronic conditions and percentage of individuals with diabetes is also higher among the exposed, for all baseline populations.

As shown in Table 7 (models 1 to 3), for cancer and poor or fair SAH, there is a positive association between

Table 6 Summary statistics of the baseline populations, according to SUN (Global) exposure in 2020

	Whole population			Cancer[a]		SAH Poor|Fair_Pand[b]	
	All	Exposed	Not exposed	Exposed	Not exposed	Exposed	Not exposed
Male (%)	41.7	38.0	43.8	37.5	43.3	38.4	45.1
Age	70.4	70.5	70.4	70.0	69.9	67.6	66.9
Educ low (%)	33.5	31.7	34.5	31.7	34.3	18.2	21.0
Educ med (%)	43.3	42.4	43.8	42.4	44.1	42.2	46.4
Income (€)	1342.7	1375.7	1324.4	1365.9	1333.5	2016.6	1762.5
Lives alone (%)	24.8	26.0	24.2	25.7	23.8	22.9	19.9
Big city (%)	16.6	18.0	15.8	17.8	15.9	17.1	17.6
Suburbs (%)	8.7	9.8	8.1	9.5	8.1	13.4	10.7
Large town (%)	16.0	16.5	15.6	16.5	15.7	15.5	16.3
Small town (%)	23.2	22.7	23.5	22.4	23.4	23.1	23.0
SAH Poor_Pre_Pand (%)	7.0	8.2	6.3	6.9	5.1	–	–
SAH Fair_Pre_Pand (%)	26.6	30.5	24.5	29.3	23.4	–	–
SAH Good_Pre_Pand (%)	43.6	42.1	44.5	43.4	45.4	–	–
SAH Very Good_Pre_Pand (%)	16.1	14.0	17.3	14.7	18.3	72.7	69.7
n_Chronic	2.72	3.17	2.46	2.98	2.30	2.03	1.51
Diabetes (%)	18.2	21.5	16.3	21.0	15.6	10.3	8.0
N	37,409	13,357	24,052	11,261	21,340	2558	5907

These summary statistics were computed based on the samples used to estimate the regression models

[a] The baseline population for cancer are individuals who never reported cancer until 2020

[b] The baseline population for SAH Poor|Fair_Pand are individuals with SAH very good or excellent before the Corona outbreak

Table 7 Association between unmet healthcare needs—SUN (Fear), SUN (Postponement), and SUN (Unavailable care)—and health outcomes—cancer, mortality and poor or fair SAH

	Model 1: cancer		Model 2: mortality		Model 3: SAH Poor|Fair_Pand	
	OR	CI (95%)	OR	CI (95%)	OR	CI (95%)
SUN (Fear)	1.16	[0.934–1.441]	0.782	[0.609–1.004]	1.235	[0.976–1.564]
SUN (Postponement)	1.163	[0.979–1.382]	**0.78**	[0.652–0.934]	0.976	[0.813–1.171]
SUN (Unavailable care)	1.291	[0.963–1.732]	0.948	[0.684–1.313]	1.18	[0.812–1.715]
Male	**1.524**	[1.307–1.777]	**2.817**	[2.408–3.295]	1.023	[0.876–1.194]
Age	**1.022**	[1.012–1.031]	**1.097**	[1.087–1.107]	**1.026**	[1.016–1.037]
Educ_low[a]	0.919	[0.737–1.147]	**1.309**	[1.030–1.663]	**2.054**	[1.641–2.570]
Educ_med[a]	0.912	[0.750–1.110]	1.181	[0.940–1.483]	**1.363**	[1.122–1.656]
Income	0.995	[0.952–1.041]	0.916	[0.802–1.046]	0.918	[0.841–1.002]
Lives alone	0.942	[0.785–1.130]	0.992	[0.836–1.177]	1.111	[0.926–1.334]
Big city[b]	1.014	[0.808–1.273]	0.832	[0.655–1.057]	0.913	[0.725–1.149]
Suburbs[b]	0.757	[0.550–1.042]	0.963	[0.712–1.301]	0.757	[0.576–0.995]
Large town[b]	0.908	[0.718–1.149]	1.011	[0.811–1.261]	0.844	[0.668–1.067]
Small town[b]	0.984	[0.803–1.205]	1.003	[0.831–1.211]	0.818	[0.665–1.007]
SAH Poor_Pre_Pand[c]	**2.48**	[1.604–3.837]	**9.275**	[5.159–16.67]	–	–
SAH Fair_Pre_Pand[c]	**1.534**	[1.052–2.237]	**3.044**	[1.715–5.402]	–	–
SAH Good_Pre_Pand[c]	1.213	[0.851–1.729]	1.466	[0.828–2.596]	–	–
SAH Very Good_Pre_Pand[c]	1.182	[0.811–1.723]	1.132	[0.600–2.135]	**1.258**	[1.056–1.500]
n_Chronic	1.02	[0.972–1.070]	1.037	[0.997–1.078]	**1.422**	[1.347–1.501]
Diabetes	1.028	[0.839–1.259]	**1.211**	[1.023–1.435]	1.192	[0.952–1.494]
N	32,601		37,409		8465	
LogL	−3373.34		−3312.06		−2475.33	
Pseudo R2	0.0285		0.1977		0.1086	

All models include dummies for countries

In bold, OR statistically significant at 5%

Reference categories

[a] Educ_high

[b] Rural

[c] SAH Excellent_Pre_Pand

Table 8 Association between SUN (Global) vs health outcomes and interaction effects

	Model 4: cancer	Model 5: mortality	Model 6: SAH Poor|Fair_Pand
Odds ratio			
SUN (Global)	**1.27** [1.068;1.472]	**0.743** [0.601;0.885]	1.081 [0.897;1.265]
Marginal effects of interaction terms			
Educ_low × SUN (Global)	−0.025 [−0.456;0.506]	0.001 [−0.329;0.329]	−0.374 [−0.843;0.094]
Educ_med × SUN (Global)	0.262 [−0.220;0.744]	0.092 [−0.250;0.435]	−0.109 [−0.575;0.356]
Income × SUN (Global)	−0.045 [−0.194;0.103]	0.024 [−0.112;0.161]	−0.139 [−0.296;0.170]

The coefficients are adjusted for Age, Male, Educ_low, Educ_med, Income, Lives alone, Big city, Suburbs, Large town, Small town, SAH, n_Chronic, Diabetes and country dummies

95% Confidence intervals in brackets. In bold, statistically significant coefficients at 5%

SUN and worse health outcomes, though OR are not statistically significant. In model 2, there is still evidence of a negative association between SUN and mortality, statistically significant for unmet needs due to postponement of care. Individuals who had healthcare postponed in 2020 were 22% less likely to have died by 2021. Regarding the effects of other covariates on outcomes, males are 1.5 and 2.8 times more likely to have reported cancer and died in 2021, respectively. Age is positively associated with all health outcomes. Low education, compared with high education, is positively associated with mortality and poor/fair SAH. In the latter case, the effect is quite pronounced, and even the effect of medium education makes a difference, compared with high education. The associations between poor or fair SAH and both cancer and mortality are statistically significant. In model 2, the magnitude of this association is striking. In model 3, individuals with very good SAH in 2020 were 25% more likely to report poor/fair SAH in 2021 than individuals with excellent health in 2020. Odds ratio for income are slightly lower than one for all outcomes but are not statistically significant, while the area of residence and living alone show mixed signals (also not significant).

Models 4 to 6, shown in Table 8, include, in addition to the covariates from models 1 to 3, the interaction terms between income (or education) and SUN (Global). The main noticeable change is that the association between SUN and cancer becomes statistically significant. Individuals who experienced any kind of SUN in 2020 were 27% more likely to report cancer in 2021. For mortality, there is still a negative (slightly reinforced) association between SUN and this health outcome. For SAH, the OR is greater than one but again not significant. For cancer and SAH, the interaction terms show in general the expected signs (higher education and higher income weaken the association between SUN and worse health) but the coefficients are not statistically significant. Again, for mortality, results are the opposite. If anything, individuals with higher education or higher income, reporting SUN in 2020, were less likely to have died by 2021, compared with individuals with lower education/income, also reporting SUN in 2020. Still, coefficients are not statistically significant. We do not report OR for the remainder covariates as there are no differences worth mentioning, compared with results in Table 7.

Discussion

The COVID-19 pandemic generated unprecedented levels of SUN (Arnault et al. 2021). Our results show a pronounced decrease in SUN, due to cancellation/postponement and fear of infection, from 2020 to 2021. Multiple causes can account for this decrease, including the relaxation of some lockdown measures, on the one hand, that allowed an improved healthcare service response and, on the other, the positive evolution of the vaccination rates, which allowed individuals to progressively seek medical care without the fear of being infected by the coronavirus. Notwithstanding this decline in SUN rates, the figures obtained for 2021 are well above average values obtained from prior waves of SHARE (own calculations), 12.3% and 9.7%, in 2015 and 2017, respectively. But we are mostly interested in associations between SUN in 2020 and health outcomes observed in 2021.

The results show that reporting SUN in 2021 is more likely among individuals who reported SUN in 2020 as well, compared to individuals with no SUN in 2020, suggesting some persistence of SUN over time. In the pandemic context, a large proportion of unmet healthcare needs come from cancellations or postponement of planned healthcare. Thus, many individuals with SUN in 2020 went without previously scheduled care and therefore are expected to have medical appointments, or seek medical attention, again in 2021. For this reason, they are more exposed to SUN in 2021. Differently, those who did not report SUN in 2020 either did not seek healthcare/did not have any appointment or had their healthcare needs met. This might mean that they are healthier, not needing healthcare also in 2021, or that they are sicker individuals, and for this reason they were prioritised in the pandemic context, being less likely to see their appointments cancelled or demands denied both in 2020 and in 2021.

Regarding the association of SUN in 2020 with health outcomes in 2021, the statistical analysis suggests a positive association with poor/fair SAH and cancer, and a negative association with mortality. Controlling for possible confounders, the multivariate analysis shows that these results hold for mortality, but the association loses statistical significance regarding SAH. In the case of cancer, the positive association with SUN only appears in the model with SUN (Global) (model 4). The association between SUN and cancer is in accordance with the few studies on the positive association between SUN and worse health (Ko 2016; Ju et al. 2017; Gibson et al. 2019). Our results suggest that new diagnoses of cancer in 2021 are more likely among individuals who missed scheduled appointments than among individuals who either did not have/did not seek any appointment or did not forego planned healthcare, in 2020. Some screening modalities have the potential to detect and remove cancer precursors, such as those for colorectal and cervical cancers. In these situations, screening itself can reduce cancer incidence (Lauby-Secretan et al. 2018). Still, for most cancer cases, it is unlikely that the absence of cancellation/postponement of medical appointments and treatments in 2020 would have prevented the new cases of cancer in 2021. However, there might have been a delay in diagnosis, and this can have serious health consequences. Depending on cancer type and location, delaying cancer screening and preventive services by six weeks is problematic; delaying by six months may lead to dramatic increases in cancer death rates (Meyer et al. 2020; Sud et al. 2020). When it comes to SUN, there is always the discussion on whether unmet needs are true needs. Our results suggest that these individuals really needed healthcare.

Concerning the association between SUN and mortality, our results differ from previous evidence (Zhen et al. 2015; Lindström et al. 2020). This might be explained by the specificity of unmet healthcare needs during the pandemic. Many of these SUN were due to the cancellation or postponement of, and non-attendance to, planned appointments. Because healthcare systems were forced to prioritise patients, our results suggest that patients at greater risk of death were given priority and were less likely to experience SUN, either due to their own decision or as the result of the health system response to the COVID-19 crisis.

While in the case of mortality, the evidence obtained suggests that health systems prioritised life-threatening conditions, in the case of cancer, health systems seem to have failed to address patients' needs. It is not possible to know the full extent of the consequences of these SUN. It depends on the delays of diagnosis, but cancer-related mortality might increase in the future (Richards et al. 2020; Sud et al. 2020). Based on previous evidence, a stronger association between SUN and health outcomes was expected among individuals with higher levels of education and income. However, the interaction terms obtained in this study are not statistically significant. This result is reassuring from the perspective of health inequalities, which could widen if richer and more educated individuals had greater chances to resume cancer screening (and hence, greater chances of reporting a diagnosis of cancer in 2021) or if they had greater chances of being prioritised during the pandemic (showing therefore a stronger negative association between SUN and mortality).

Some limitations apply to our analysis namely using data from an observational study which can jeopardise the validity of our results as causal estimates of the impact of exposure to SUN on health outcomes. The follow-up period is one year which may not be sufficient to fully capture the association between SUN and health status. Still, there are no certainties on the optimal follow-up time. Zhen et al. (2015) conjecture that the mortality risks associated with unmet needs may be substantially higher if examined over a period longer than three years. On the other hand, Gibson et al. (2019) argue that an annual panel would allow for more flexibility to test a more immediate effect of SUN. Kim et al. (2019) say that the time lag between unmet needs and the manifestation of self-rated poor health may not be as long as a year. The exposure status (SUN) may not fully and properly measure unmet healthcare need. The only information provided by the dataset is whether the individual had an unmet health care need at the baseline, but nothing is known about the length of the exposure to SUN, and if the unattended medical treatments were recovered. Nonetheless, there is evidence that waiting times alone can cause harm to individuals' health (Moscelli et al. 2016). Our results are valid for individuals who never had cancer and started at baseline with an excellent or very good health. This might explain why, unlike in the previous studies, we did not find an association between SUN and SAH. As noted by Gibson et al. (2019), citing Heckman (1981), if deterioration of health at time *t* (within the period analysed) is affected by baseline health status, prior to the beginning of the follow-up period (that is, if health deteriorates slower, *ceteris paribus*, among those with better initial health), we might have obtained a biased estimate of the true effect of SUN on the deterioration of health, measured by SAH. Ko (2016), for example, did not find evidence of a significant association of unmet needs due to mild symptoms with health outcomes. Although the available data does not allow us to distinguish mild symptoms from the remainder, it is likely that SUN among individuals with excellent or very good SAH concerned not so severe situations, otherwise, the system would have prioritised them. In addition, the baseline population for the SAH analysis is restricted to 8465 individuals which represents a drop of about 77% of the sample. It is also possible that among older individuals the association between SUN and health is more visible for specific symptoms, such as fatigue, falling or dizziness. Bergeot and Jusot (2022) analysed these conditions, obtaining clearer results than ours regarding the association between unmet health care needs and deterioration of health. Also, in future research, other models (e.g. fixed effects) might be used to explore the association between SUN and SAH, mortality and cancer.

Despite the limitations, the study population is large, and our work not only contributes to an under researched topic, but also, to the best of our knowledge, it is also the first to analyse the association between SUN and cancer prevalence. It further contributes to a better understanding of the consequences of the pandemic. Several studies relied on SC1 to identify the predictors of SUN during the first wave of the pandemic, but our study goes a step forward investigating what health implications might follow from the unprecedented levels of SUN during the first months of the pandemic. During public health crises, like the COVID-19, it is important, firstly to ensure that individuals do not shy away from health services due to fear, avoiding unmet needs for this reason. And, secondly, health systems should not lose sight of patients affected by conditions other than the disease responsible for wide outbreaks. Perhaps, the lasting effect of what we learned now will depend on how far we are from the next worldwide pandemic.

Appendix

Variable	Source of data
Health outcome measures	
Cancer	All waves of SHARE: the baseline population, in 2020, consists of individuals who, in the regular waves of SHARE, never selected the option 'Doctor told you had: cancer', and, in SC1 wave, did not select the option "Cancer or malignant tumor, including leukemia or lymphoma" in the question "Since we last interviewed you, were you diagnosed with a major illness or health condition?". We used the SC2 wave to identify individuals with cancer in 2021
Mortality	xt module released jointly with SC2 data (sharewX_rel8-0-0_gv_allwaves_cv_r file)
SAH	For the baseline population, in 2020, and controls, data come SC1. For the outcome, in 2021, data come from SC2
SUN as measure of exposure	
SUN (all motives)	To identify exposure to SUN we used data from SC1; data from SC2 were used simply to compute some descriptive statistics
Control variables	
Age	SC1
Male	SC1
Education	Data come from the last regular wave of SHARE in which the individual was interviewed and had level of education measured

Variable	Source of data
Income	Information about household income comes from SC1, obtained from the question "How much was the overall monthly income, after taxes and contributions, that your entire household had in a typical month before Corona broke out?". To compute the equivalent income, information about the household size was extracted from the file CV_R file released along with the SC1 wave
Lives alone	SC1—module CV_R
Place of residence	Data come from the last regular wave of SHARE in which the individual was interviewed and had place of residence registered
n_Chronic	The information about chronic diseases before the Corona outbreak comes from regular waves of SHARE—gv_health module. This number adds up with newly diagnosed chronic diseases reported in SC1
Diabetes	All regular waves of SHARE and SC1, depending on when the disease was diagnosed

SC1 SHARE Corona Survey 2020, *SC2* SHARE Corona Survey 2021.

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ORIGINAL INVESTIGATION

Cared and uncared populations: understanding unmet care needs of older adults (65+) across different social care systems in Europe

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Abstract

Population care needs are dynamic. They change throughout individuals' life courses and are related to the population structure. These needs are particularly demanding during population ageing and may vary depending on how societies cope with them. In this study, we explored the unmet social care needs of individuals in twelve European countries with different social care systems. We used data from the seventh wave of the Survey of Health, Ageing and Retirement in Europe (SHARE) to conduct a cross-sectional study of individuals aged 65 and over with care needs ($n = 7136$). Unmet care needs were measured from an absolute approach. We fitted binomial regression models to explain the relative importance of individuals' characteristics, health status and different social care systems on unmet needs. The absolute measure shows that 53.02% of the analytical sample faced unmet care needs as they reported limitations and did not receive help. The prevalence of unmet care needs is higher for men than women and for younger than older individuals. Furthermore, we found that individuals living in Mediterranean social care systems have the highest prevalence of these unmet needs. This analysis contributes to the ongoing debate about the challenges posed by ageing populations and their relationship with care.

Keyword Social care systems · Ageing · Unmet care needs · Care provision · Europe

Background

Care is a basic need of human beings throughout their life. As anthropological and philosophical work has suggested, care constitutes individuals' personhood (Buch 2015) and acts in the foundations of society itself (Fisher and Tronto 1990). The most paradoxical aspect of care, however, is that it is usually recognized because of the lack of it. People usually feel they are not receiving enough care when they stop being cared for or when new care needs emerge. Furthermore, demographic dynamics fundamentally impact social care demand and supply (Spijker et al. 2022). For instance, care needs are not the same between populations in the earlier stages of the demographic transition, characterized by high fertility rates where children take up most of the care and the social services, in comparison with those in the fourth stage of the transition that are facing ageing processes and challenges regarding caring for older people (Bom and Stöckel 2021; Rechel et al. 2013).

European countries are forerunners in this ageing process that will affect many countries worldwide (Vaupel and Kistowski 2008). Therefore, Europe is a critical scenario for understanding population ageing effects on care provision, policies, and welfare systems. Previous literature has highlighted that care is affected by its gendered provision, as is mainly given by women (Schmid et al. 2012; Uccheddu et al. 2019; Young and Grundy 2008); the central role played by the family and informal care provision (Pickard et al. 2007; Tennstedt et al. 1993); and new changes in the design and use of social services (Cantor 1991; Davey 2017; Spijker and Zueras 2020).

Some authors have suggested that we are facing a care crisis driven by demographic dynamics leading to population ageing and changes in family trajectories, household units, and social and economic transformations (Pérez

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Orozco 2021). Discussions about care provision have also underlined how it is affected by policy changes (Pfau-Effinger 2005) and social perceptions about ageing and support that usually shape specific care systems to help people with disabilities and facing limitations in daily life. However, in many societies, some individuals are not receiving the support they need and are facing unmet care needs that can negatively affect their health, well-being, and life expectancy.

In this article, we aim to analyse the unmet care needs experienced by people aged 65 and over within twelve European countries. We examined the socio-demographic characteristics of middle-age and older adults with care needs and estimated the prevalence of unmet care needs in the following social care systems: the Mediterranean, characterized by family-based care provision; the Nordic, where care provision is strongly linked to welfare-state services; the Western, where care provision is articulated between informal and formal care provision, also including the participation of private providers; and, the Eastern, which used to be based on 'familialist' care provision but has undergone various transformations since the fall of the Berlin Wall.

Different typologies for understanding social care systems

Social care is conceptualized as the coexistence of informal and formal care activities that addresses three primary needs: socialization, activities of daily living and personal needs related to severe disability (Cantor 1991). The differences between social care systems are related mainly to the way informal and formal care is organized. For example, family-centred systems rely primarily on informal care, whereas welfare-state centred systems emphasize the availability of formal care through its provision by people who are not relatives.

Theoretically, the configuration of social care systems relates to values (Pfau-Effinger 2005), ancient family systems (Reher 1998), religion (Damiani et al. 2011), and the structural socioeconomic context (Ariaans et al. 2021) that have shaped care provision itself as well as public policies related to it. The starting point for exploring unmet care needs is the recognition that social care systems may fail to provide universal coverage, access, and funding for individuals' care needs. This idea also emphasizes that the relationship between formal and informal care provision is not always virtuous, that the availability of one of these types of care does not guarantee the availability of the other, and that access to both does not necessarily lead to all care needs being met; for example, there may be times of the day when the individuals has no one to help them, or certain tasks for which they do not get the help they need.

The literature on social care systems mainly focuses on childcare and infants' care needs; meanwhile, the one referred to the care for the older population is based on different typologies. These have been built according to theoretical or empirical perspectives. The theoretical approach focuses on the configuration of the welfare state within Europe, where care systems fall on the spectrum of family-centred care (Hrast et al. 2020) and social care-based services provided by the welfare state (Bergmark et al. 2000; Pfau-Effinger 2005). This theoretical framework refers especially to service provision and articulation between informal and formal care provision.

On the other hand, the empirical approach has constructed different typologies of social care systems using statistical methods such as clustering and principal components analyses. Previous evidence has focused on OECD, high-income and middle-income countries and has emphasized diverse aspects of care provision like service availability, public expenditure, care demand, performance, and, regulation (Ariaans et al. 2021; Damiani et al. 2011). Despite the importance of this approach, one of its main limitations is that the demographic dynamics in care provision remain barely explored. In this article, we focused on the theoretical typology to explore unmet care needs in countries where social care systems have been shaped by a long-term policy history.

Measuring unmet care needs

Underlying the measurement of unmet care needs is the discussion about social care services and how informal and formal care are articulated through policies, public institutions, households, and families (Broese van Groenou & de Boer 2016; Uccheddu et al. 2019). However, research on this topic has stressed the challenges of measuring unmet care needs among the ageing population (Allen et al. 2014; Bień et al. 2013; Dunatchik et al. 2019; Stein et al. 2020). These difficulties by and large occur because surveys do not usually include enough information about care provision and the quality of care received. Consequently, its analysis should be done through indirect estimations based on questions about experiencing functional limitations that affect the performance of daily life activities.

Evidence on the subject has identified different dimensions of these functional limitations and distinguishes between mobility, Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs) (Ćwirlej-Sozańska et al. 2019; Mlinac & Feng 2016; Wolinsky et al. 2011). The definition used here is based on previous work by Vlachantoni's (2011), where unmet care needs from an absolute approach refer to the type and amount of support received by someone who reports functional limitations (mobility, ADL and IADL) and is, consequently, assumed

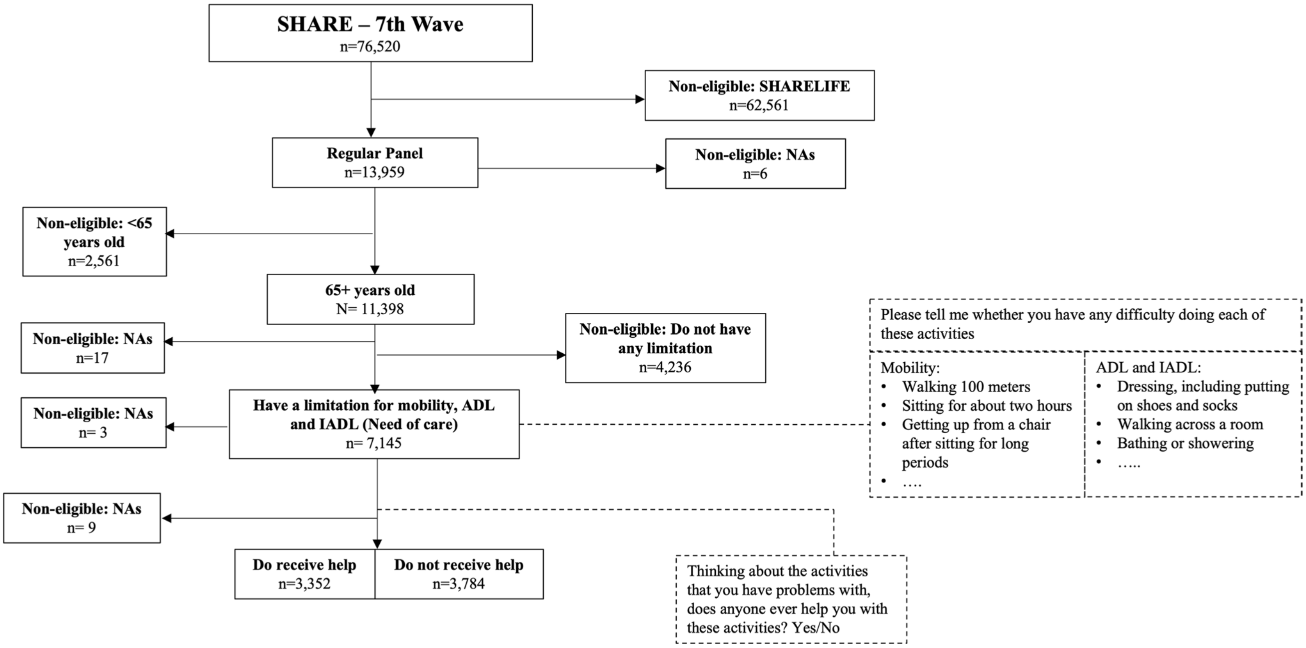

Fig. 1 Flow chart for the selection of the analytical sample. *Note* ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living. *Source* Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

to be in need of help but does not report receiving it. Previous evidence has shown the importance of demographic and socioeconomic circumstances on people's needs and unmet care needs and has emphasized that socioeconomic variables like housing tenure and education level may explain the experience of unmet needs (Maplethorpe et al. 2015; Vlachantoni 2019). It has also called attention to the relationship between unmet needs, health conditions (McGilton et al. 2018), and types of limitations faced (Mlinac & Feng 2016).

In this article, we explore two hypotheses about the unmet care needs of people over 65 based on previous literature. Firstly, due to women's greater longevity and likelihood of being widowed and living alone (Delbès et al. 2006), as well as the fact that those with worst health and financial circumstances have less access to care provision outside home (Dupraz et al. 2020), we hypothesized that women in the older age group, in poor health and with low educational attainment (Momtaz et al. 2012), would be those that are most likely to face unmet needs (Hypothesis A). Second, in terms of issues related to the functioning of social care systems, there are concerns about the availability of informal care provision and its limits in meeting the increasing demand for care (Pickard et al. 2007; Tennstedt et al. 1993), hence, we hypothesized that the propensity to have unmet care needs would be higher among middle-aged and older adults living in countries with family-centred social care systems (Mediterranean) than in countries with other types of state participation (Hypothesis B).

Data and methods

Data

This cross-sectional study uses data from the seventh wave of the Survey of Health, Ageing and Retirement in Europe (SHARE), collected in 2017 (Börsch-Supan 2022). The SHARE provides harmonized longitudinal data through eighth waves about individuals aged 50 and older, and their partners, from 28 participant countries (27 European countries plus Israel). The eighth wave of SHARE, with more recent data is currently available, but it was collected during the pandemic of COVID-19 when many changes in older adults' lives and care provision at the household level took place (Lebrasseur et al. 2021). In the seventh wave, the module about physical health included questions about functional limitations and care received by individuals (Börsch-Supan et al. 2013). However, the relevant questions for this study were not available in all countries.

We selected 12 countries based on the availability of the studied variables concerning facing limitations in daily life and receiving help or not for dealing with these limitations. The analytical sample was composed of individuals who reported having limitations in performing at least one activity related to mobility, ADL or IADL. Figure 1 includes the flowchart and questions to illustrate the selection process of the analytical sample. This sample was composed of 7,136 individuals with complete information for the questions about coping any of the previously mentioned limitations and care received.

Analytical strategy

The analysis of unmet care needs consisted of two steps. Firstly, we measured the percentage of people with absolute unmet care needs by type of limitation and analysed these measures by age, gender, and social care system. Secondly, we conducted a multivariate analysis regressing the binary dependent variable of absolute unmet need for social care (0 = received care; 1 = did not receive care) considering socio-demographic and health variables: gender, age group, educational level, marital status, housing tenure, living arrangements, self-rated health, chronic disease, and type of limitations. These variables are ex ante harmonized through the SHARE, which are also harmonized with similar surveys from other countries like the ELSA (England) and the HRS (US) (Börsch-Supan 2017), the variables are measured indirectly through individuals' responses and were selected based on available evidence on unmet care needs, in particular on Vlachantoni's previous study of England with data from the ELSA (2019). Finally, given the purpose of this study, the variable accounting for the European countries' clusters by social care systems was also included.

Regression models were built using a forward method and were aligned with the two hypotheses. Model one included the individuals' demographic and socioeconomic variables, and the second model added the macro variable identifying the social care system. Model three again considered individuals' socio-demographic characteristics and included information on the type of limitation, to better understand its relationship with unmet care needs. Model four added all the health variables, and model five adjusted for having children as an indicator of potential availability of care outside the household. Finally, model six included all the previous variables and, again, the social care system of the country of residence.

Variables

As mentioned above, the dependent variable was the absolute unmet need for social care, measured through the question related to help received by individuals reporting any mobility, ADL and IADL limitation. Participants were asked about these limitations through two questions referring to 25 activities, 10 for mobility and 15 combining ADL (6 limitations) and IADL (9 limitations). For mobility limitations, the question was: "Please look at card 36. Please tell me whether you have any difficulty doing each of the everyday activities on this card. Exclude any difficulties that you expect to last less than three months."[1] On the other hand, for measuring ADL and IADL, the survey asked: "Please tell me if you have any difficulty with these activities because of a physical, mental, emotional or memory problem. Again, exclude any difficulties you expect to last less than three months."[2] In addition, for those who report having problems with any of these types of activities, the survey includes the following question: "Thinking about the activities that you have problems with, does anyone ever help you with these activities?".

Independent variables were included as follows. Age was aggregated into three categories (65–74, 75–84 and 85+); the education level was harmonized through ISCED 1997 classification and grouped into low (until primary school), mid (secondary education), and high education (college and above); even though ISCED 2011 is also included in the SHARE, this variable presented higher proportions of missing values than the ISCED 1997. Housing tenure was also regrouped into three categories: (i) owner, (ii) tenant and (iii) other; this last category includes members of a cooperative, subtenant and rent-free.

Self-rated health was treated as binary, distinguishing between good health (excellent, very good or good) and poor health (fair or poor self-rated health). Besides, given the information available, we followed the approach used by Spijker and Zueras (2020) and combined the type of functional limitations to create a variable that captures the degree of severity depending on the type of limitations reported: (i) facing only mobility limitations (for those who reported any mobility limitation but no limitations in performing IADLs and ADLs), (ii) those who reported limitations in one ADL and/or any IADL, (iii) those who reported limitations in two or more ADLs. Even though the Global Activity Limitation Indicator (GALI) has been validated as a severity measure and is also included in the SHARE, it does not provide detailed information about the type of limitation faced by

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[1] Activities on card 36 included: i) Walking 100 m; ii) Sitting for about two hours; iii) Getting up from a chair after sitting for long periods; iv) Climbing several flights of stairs without resting; v) Climbing one flight of stairs without resting; vi) Stopping, kneeling, or crouching; vii) Reaching or extending your arms above shoulder level; viii) Pulling or pushing large objects like a living room chair; ix) Lifting or carrying weights over 10 pounds/5 kilos, like a heavy bag of groceries; and x) Picking up a small coin from a table.

[2] The activities asked for were: i) Dressing, including putting on shoes and socks; ii) Walking across a room; iii) Bathing or showering; iv) Eating, such as cutting up your food; v) Getting in or out of bed; vi) Using the toilet, including getting up or down; vii) Using a map to figure out how to get around in a strange place; viii) Preparing a hot meal; ix) Shopping for groceries; x) Making telephone calls; xi) Taking medications; xii) Doing work around the house or garden; xiii) Managing money, such as paying bills and keeping track of expenses; xiv) Leaving the house independently and accessing transportation services; and xv) Doing personal laundry. Activities from i to vi refer to ADL, while from vii to xv are related to IADL.

Table 1 Descriptive statistics of the analytical sample by social care system

	Mediterranean		Eastern		Western		Nordic		Total sample	
	n = 2662	%	*n* = 1160	%	*n* = 2364	%	*n* = 950	%	*n* = 7136	%
Age group										
65–69	543	20.4	289	24.9	511	21.6	170	17.9	1513	21.2
70–74	588	22.1	301	25.9	497	21.0	226	23.8	1612	22.6
75–79	569	21.4	225	19.4	465	19.7	195	20.5	1454	20.4
80–84	510	19.2	183	15.8	406	17.2	160	16.8	1259	17.6
85+	452	17.0	162	14.0	485	20.5	199	20.9	1298	18.2
Gender										
Female	1616	60.7	726	62.6	1460	61.8	615	64.7	4417	61.9
Type of limitation										
Only mobility	1456	54.7	627	54.1	1223	51.7	508	53.5	3814	53.4
One ADL and/or any IADL	852	32.0	356	30.7	873	36.9	327	34.4	2408	33.7
Two or more ADL	354	13.3	177	15.3	268	11.3	115	12.1	914	12.8

ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

Source: Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

individuals, moreover, the way in which it is included in the questionnaire does not allow to directly connect it with the measure of unmet care needs that we used.

Finally, countries were grouped into four theoretical regions according to their social care system following a welfare-state configurations typology (Pfau-Effinger 2005). The Mediterranean social care system includes Spain, Greece, and Italy; the Nordic considers Sweden and Denmark; the Western has Germany, France, Austria, Switzerland, and Belgium; and the Eastern is composed of the Czech Republic and Poland. Table 1 displays the composition of the analytical sample by age, sex, and type of limitations by the social care system.

Sensitivity analysis

We conducted an alternative analysis exploring different aggregations of marital status and living arrangements to understand how unmet care needs were related to the availability of potential informal care within households. Marital status was grouped in two different ways. First, we considered three categories: (i) married or with a registered partner, (ii) ever married, and (iii) never married; secondly, four categories distinguishing: (i) married or with a registered partner, (ii) divorced or separated, (iii) never married, and (iv) widowed. However, none of these variables showed significance and were removed to avoid multicollinearity with the living arrangements variable.

We extended sensitivity analysis by grouping living arrangements in two different ways. In the first place, the following three arrangements: Living arrangements distinguished people (i) living with their partner, either with or without other people, (ii) living alone, and (iii) living with other people but the partner. Secondly, as (i) living alone, (ii) living as a couple, with the partner only, (iii) living with one or more relatives and non-relatives. The results including this second way of coding living arrangements, by which we take into account the availability of care provided by the partner, showed a lower level of statistical significance than the first one included in the final models.

The severity variable aimed to explore how the number and type of limitations explained the experience of unmet care needs. Before including it, we fit the models with the specific limitations (ADL, IADL, and mobility) and also fitted three different models for individuals by each specific limitation but the results were very similar to those presented here and did not include the number of limitations, which is related to the amount of help needed, so we used the severity variable with the categories described earlier, which considered both the type and number of limitations. Finally, we also analysed results by including countries instead of social care systems, which showed the internal coherence of the Mediterranean social care system and the differences within the other groups, especially for the Nordic and Eastern countries.

Results

We present two types of results: First, the descriptive analysis of the analytical sample focusing on the prevalence of unmet care needs from an absolute approach and the demographic characteristics of those with any of these needs; second, binomial regression models, which illustrate how individuals' demographic and economic characteristics and health status explain the experience of unmet care needs as

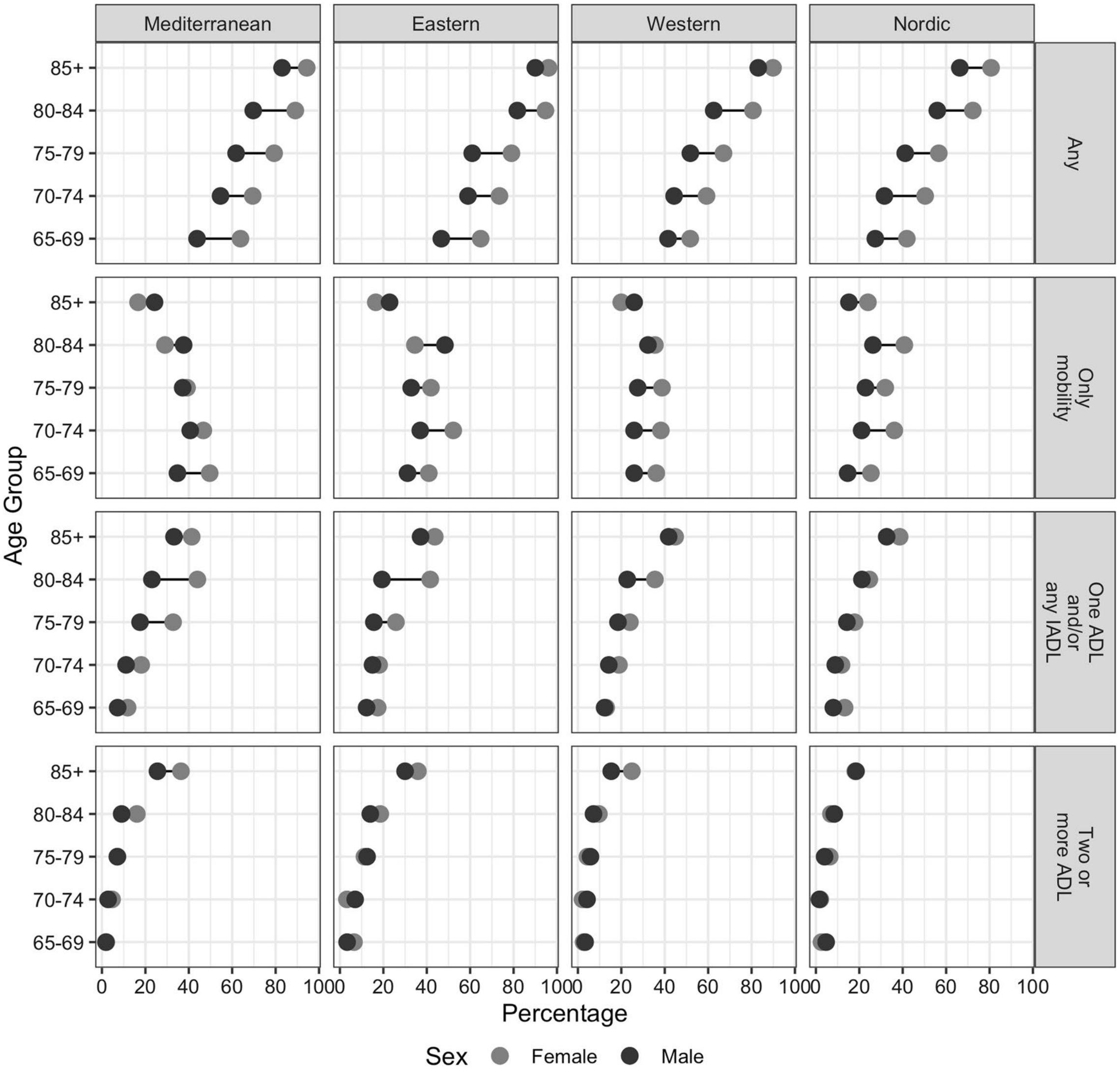

Fig. 2 Percentage of people 65 + with functional limitations by type of limitation, age, sex, and social care system. *Note* ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living; All: presents any type of limitation on these activities. *Source* Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

well as its relationship with specific social care systems in Europe.

Who needs care?

People with any limitation (mobility, ADLs and IADLs) were considered to be at risk of having unmet care needs. Figure 2 presents the prevalence of each type of limitation among women and men by age group and social care system. In the four social care systems analysed, women have more limitations of any type (69.67%; CI 68.54–70.80%) than men (53.74%; CI 52.37–55.11%); these percentages are also higher in the Eastern region (70.43%; CI 68.22–72.63%) for individuals with any type of limitations and for specific type of limitations.

As expected, the prevalence of care needs is higher and more severe in older age groups. The most common type of limitation below age 85 is to experience only mobility difficulties, while limitations for performing one ADL and/or any IADL are the most common for those aged 85 and over. Having only mobility limitations shows the highest prevalence across the sample (33.46%, CI 32.60–34.32%), exceeding 15% in all the age-sex groups. Also, smaller percentages of this population face the other two types of limitations, and differences between men and women regarding the prevalence of limitations related to ADLs and IADLs are minor in the younger age groups and in the oldest age group. However, the gender gap is larger in the Mediterranean social care system, and in the Nordic social care systems for people aged 85+.

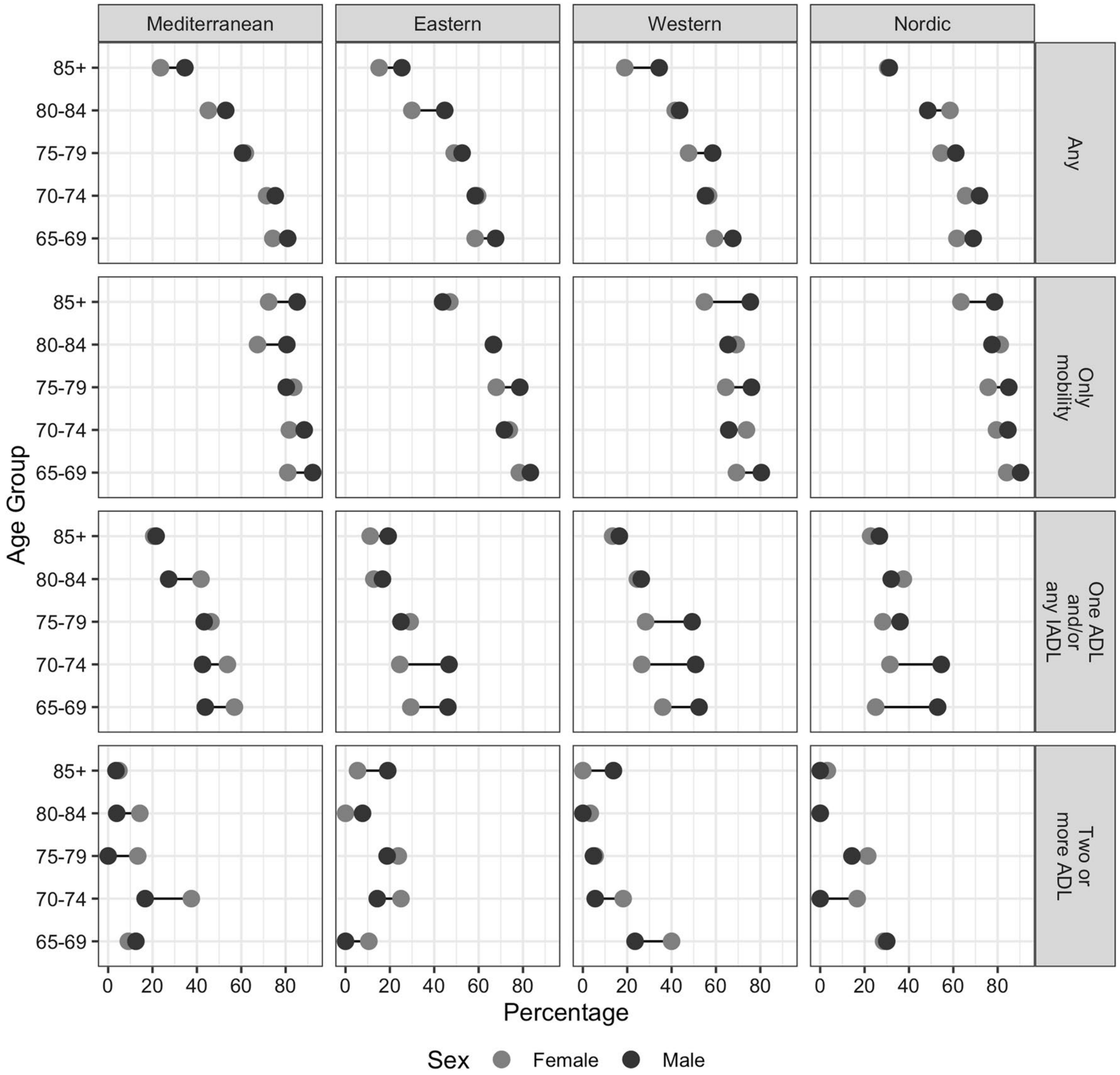

Fig. 3 Percentage of people 65+ facing unmet care needs from an absolute approach by type of limitation, age, sex, and social care system. *Note* ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living; All: presents any type of limitation on these activities. *Source* Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

Relating to the prevalence of unmet care needs, from the absolute approach, 53.03% (CI 51.87–54.18%) of the individuals in the analytical sample ($n = 7136$) dealt with these. Therefore, more than half of the population who reported at least one limitation did not receive any help. Figure 3 shows the results by social care system, age, sex, and type of limitation. The main trend is that the percentage of people with any limitation experiencing unmet care needs is lower in the older age groups, and, with some exceptions for the age-sex groups. In general, proportions are higher for men (56.75%; CI 54.90–58.61%) than women (50.73%; CI 49.26–52.21%), even though the latter experience more limitations than the other.

In general, individuals with any limitation from the Mediterranean group have higher percentages of unmet care needs (56.87%; CI 57.00–60.73%), which is also the trend by age and gender when compared with the other three groups. Moreover, Fig. 3 shows the relevance of mobility limitations in the experience of this circumstance because the higher percentages of unmet care needs are experienced by people with only mobility limitations. Additionally, percentages of individuals with unmet care needs that face two or more ADL are lower when compared with the other types of limitations (less than 40% for all the analysed combinations of age and sex groups).

Percentages of unmet care needs also varied across countries, Table 2 presents percentages of individuals with unmet care needs for those with any limitations and by type of limitation. Overall, the trend is that more than 30% of the population with any limitation is experiencing unmet

Table 2 Percentage of people 65 + with an unmet care need from an absolute approach by country and type of limitation

Social Care System	Country	Any		Only mobility		One ADL and/or any IADL		Two or more ADL	
		n	%	*n*	%	*n*	%	*n*	%
Mediterranean	Spain	340	49.49 [45.75–53.23]	220	80.00 [75.27–84.72]	110	42.64 [36.60–48.67]	10	6.49 [2.60–10.39]
	Greece	750	65.85 [63.09–68.60]	599	82.50 [79.74–85.27]	144	41.86 [36.65–47.07]	7	10.14 [3.02–17.27]
	Italy	477	57.06 [53.70–60.41]	379	83.30 [79.87–86.72]	82	32.80 [26.98–38.62]	16	12.21 [6.60–17.82]
Western	Germany	179	43.77 [38.96–48.57]	150	60.00 [53.93–66.07]	27	25.23 [17.00–33.46]	2	3.84 [− 1.38–9.07]
	France	316	57.04 [52.91–61.16]	227	81.36 [76.79–85.93]	83	38.25 [31.78–44.71]	6	10.34 [2.50–18.18]
	Belgium	347	42.16 [38.79–45.54]	251	67.29 [62.53–72.05]	89	25.36 [20.80–29.91]	7	7.07 [2.01–12.12]
	Austria	153	50.33 [44.70–55.95]	125	81.17 [74.99–87.34]	27	24.55 [16.50–32.58]	1	2.50 [− 2.34–7.34]
	Switzerland	135	49.27 [43.35–51.19]	102	61.08 [53.68–68.47]	29	32.95 [23.13–42.78]	4	21.05 [2.72–39.38]
Nordic	Sweden	309	62.05 [57.79–66.31]	243	82.09 [77.73–86.46]	60	40.00 [32.16–47.84]	6	11.54 [2.85–20.22]
	Denmark	212	46.90 [43.30–51.50]	163	76.89 [71.21–82.56]	44	24.66 [18.49–31.22]	5	7.93 [1.26–14.61]
Eastern	Poland	398	62.97 [59.21–66.73]	316	89.27 [86.04–92.49]	62	37.13 [29.80–44.45]	20	18.01 [10.87–25.17]
	Czech Republic	168	31.81 [27.85–35.79]	139	50.92 [44.99–56.85]	28	14.81 [9.75–19.88]	1	1.51 [− 1.43–4.46]

ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living. Confidence intervals, in squared brackets, were estimated based on the z value for 95% confidence (1.96) and standard errors from the analytical sample

Source Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

care needs. Greece has the highest percentage (68.60%; CI 63.10–68.60%), and the Czech Republic the lowest (31.82%; CI 27.85–35.80%). However, less than 25% of people with two or more ADL limitations make front of unmet care needs in all countries. For example, in Czech Republic and Austria, less than the 3% of people that has two or more ADL limitations have unmet needs (respectively 1.51%; CI − 1.43–4.46 and 2.26; CI − 2.33–7.33%), while in France, they are the 10.34% (CI 2.51–18.18%). At the same time, these percentages are higher for people facing one ADLs and/or one or more IADLs difficulties, ranging between 14.81% (CI 9.75–19.90%) in Czech Republic and 42.64% (CI 36.60–48.67%) in Spain.

The experience of unmet care needs: individuals vs social care systems

Table 3 summarizes the results of six regression models. Similar results were observed between the first two models, which refer mainly to demographic and economic characteristics (model 1) and social care systems (model 2). In models 3 to 6, we observed the importance of health status in explaining unmet care needs, in these models the variables of self-reported health and chronic disease where included and both showed statistical significance ($p < 0.001$) for these coefficients in the three versions of the models. According to the statistics used (Akaike and Bayesian indexes of goodness of fit, AIC and BIC), model 6 had the best fit. It included demographic, economic and health variables, having children (a potential source of care), and social care systems.

In all models, younger people (65–74) presented higher risks of dealing with unmet care needs than the 85+ group, but this difference showed a statistically significant reduction of the odds ratio after adjusting for health status from 8.908 in model 1 to 3.007 in model 6, this reduction is smaller but also noticeable in the age group from 75 to 84 from 4.971 in model 1 to 2.032 (see Table 4). Also, men were statistically significant ($p < 0.001$) at higher risk of experiencing that situation than women in all models. The odds of facing unmet care needs differed depending on living arrangements: living with other than the partner

Table 3 Binomial logistic regressions for estimating unmet care needs in different social care systems

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	0.418***	0.612***	1.298*	1.966***	2.434***	3.650***
	[0.344, 0.507]	[0.493, 0.758]	[1.038, 1.623]	[1.552, 2.492]	[1.782, 3.329]	[2.611, 5.112]
Age						
85+ (Ref.)	1	1	1	1	1	1
65–74	5.555***	5.461***	3.030***	3.127***	3.113***	3.009***
	[4.768, 6.485]	[4.681, 6.385]	[2.545, 3.611]	[2.620, 3.737]	[2.608, 3.720]	[2.517, 3.602]
75–84	2.984***	2.929***	2.029***	2.105***	2.100***	2.032***
	[2.575, 3.465]	[2.525, 3.403]	[1.714, 2.404]	[1.775, 2.500]	[1.771, 2.494]	[1.712, 2.415]
Gender						
Female (Ref.)	1	1	1	1	1	1
Male	1.239***	1.227***	1.366***	1.427***	1.413***	1.410***
	[1.115, 1.378]	[1.103, 1.365]	[1.212, 1.541]	[1.264, 1.612]	[1.251, 1.597]	[1.248, 1.595]
Living arrangements						
Partner in household (Ref.)	1	1	1	1	1	1
Living alone	1.048	1.062	1.322***	1.321***	1.277***	1.302***
	[0.933, 1.178]	[0.945, 1.195]	[1.157, 1.511]	[1.155, 1.513]	[1.112, 1.468]	[1.132, 1.497]
In other arrangements	0.607***	0.596***	0.784*	0.831	0.816+	0.801+
	[0.496, 0.741]	[0.486, 0.729]	[0.622, 0.987]	[0.658, 1.047]	[0.647, 1.030]	[0.633, 1.012]
Housing tenure						
Owner (Ref.)	1	1	1	1	1	1
Tenant	1.002	1.112	1.034	1.082	1.081	1.205*
	[0.863, 1.164]	[0.952, 1.298]	[0.874, 1.225]	[0.912, 1.284]	[0.911, 1.283]	[1.009, 1.440]
Other	0.890	0.985	0.894	0.945	0.953	1.030
	[0.756, 1.047]	[0.834, 1.164]	[0.744, 1.075]	[0.785, 1.138]	[0.792, 1.148]	[0.851, 1.247]
Level of Education						
High (Ref.)	1	1	1	1	1	1
Mid	0.713***	0.716***	0.756***	0.769**	0.772**	0.767**
	[0.622, 0.818]	[0.622, 0.823]	[0.648, 0.882]	[0.657, 0.899]	[0.660, 0.902]	[0.654, 0.900]
Low	0.806**	0.673***	1.064	1.116	1.124	0.931
	[0.700, 0.929]	[0.578, 0.782]	[0.906, 1.250]	[0.948, 1.315]	[0.954, 1.325]	[0.782, 1.108]
Social care system						
Mediterranean (Ref.)		1				1
Nordic		0.745***				0.784*
		[0.629, 0.883]				[0.643, 0.956]
Western		0.559***				0.527***
		[0.491, 0.636]				[0.453, 0.613]
Eastern		0.588***				0.632***
		[0.504, 0.685]				[0.528, 0.756]
Self-reported health						
Good health (Ref.)				1	1	1
Poor health				0.708***	0.707***	0.662***
				[0.626, 0.800]	[0.625, 0.800]	[0.584, 0.750]
Chronic disease						
No (Ref.)				1	1	1
Yes				0.569***	0.570***	0.598***
				[0.500, 0.647]	[0.501, 0.649]	[0.524, 0.682]
Type of limitation						
Only mobility (no ADL nor IADL)			1	1	1	1
One ADL and/or any IADL			0.165***	0.188***	0.187***	0.189***
			[0.146, 0.186]	[0.166, 0.212]	[0.166, 0.211]	[0.167, 0.214]

Table 3 (continued)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Two or more ADL			0.039*** [0.030, 0.049]	0.052*** [0.040, 0.066]	0.051*** [0.040, 0.065]	0.051*** [0.039, 0.065]
Children						
No (Ref.)					1	1
Yes					0.804* [0.653, 0.990]	0.807* [0.653, 0.995]
Num.Obs	7136	7136	7136	7136	7136	7136
AIC	9187.2	9101.8	7583.7	7436.8	7434.6	7364.0
BIC	9256.0	9191.2	7666.1	7533.1	7537.7	7487.7
F	−4.583.617	−4.537.907	−3.779.830	−3.704.423	−3.702.311	−3.663.999
RMSE	68.272	56.848	148.446	129.183	119.964	99.875

+$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Odds ratio are reported with its confidence intervals in squared brackets. ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

Source Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

reduced the risk of experiencing it (results were statistically significant with different p values for all the models but the fourth one).

The educational attainment showed similar results across models, suggesting that being low- and middle-educated was associated with lower risks of experiencing unmet care needs than higher-educated individuals. However, differences for individuals in the lower levels of education became non-significant after controlling for health variables (models 3 to 6). Regarding health variables, first, the type of limitation showed that those with ADLs and IADLs were less at risk of experiencing unmet care needs than those with mobility limitations alone ($p < 0.001$). In this line, individuals with self-reported chronic diseases and poor health were not that exposed to experience unmet care needs than those without chronic disease and good health ($p < 0.001$). In addition, having children is associated with a more consistent satisfaction of individuals' care needs when compared to those who do not have children ($p < 0.001$).

Finally, the models showed that the risk of suffering unmet care needs is lower for individuals in other social care systems than the Mediterranean. This risk was lower in the final model for the Western region (0.527, $p < 0.001$) and higher in the Nordic one (0.784, $p < 0.05$); however, smaller p values were observed in the Nordic group ($p < 0.001$ vs. $p < 0.05$). Refined analysis including countries instead of regions, revealed considerable heterogeneity within the analysed social care systems, particularly in the Eastern and Nordic social care systems. In the former, Czech Republic had lower than expected odds ratios, and in the later, Sweden odds ratios were not statistically significant different from Spain. In contrast, countries in the Mediterranean and Western regions had more homogeneous results (Table 5).

Discussion

This study aimed to understand the unmet care needs of people aged 65+ from different social care systems in twelve European countries. Results showed that the most vulnerable individuals (with poor health, chronic disease, older age group, and women) are at lower risk of experiencing unmet care needs, rejecting Hypothesis A. This is consistent with previous evidence from England, which suggested that men were at a higher risk of experiencing these (Vlachantoni 2019) and that older people with poor health were more likely to report receiving care (Maplethorpe et al. 2015). These results are probably due to social awareness of the care and social support needed by older people with health problems, indicating the importance of social imaginaries.

In contrast, we observed that people living in countries with Mediterranean social care systems are at a higher risk of having unmet care needs than in other systems, in line with Hypothesis B. These results are indicative of the diverse approaches within social care systems, as well as of social awareness about the urgent care needs required by older adults. Additionally, results show that family-centred systems may face more challenges in meeting individuals' needs due to its dependence on the availability of family members willing and able to provide care (Tennstedt et al. 1993), and these may be changing as women's engagement in the labour market increases. For example, a study in Spain showed that the willingness to care for the older family members was lower among women with a high level of education and doing paid work (Zueras et al. 2018). Previous studies have also emphasized that ageing due to demographic changes poses challenges on the availability of informal because of low fertility rates and increases in the percentage of dependent elders who are childless (Spijker and Zueras 2020).

Table 4 Comparison between model 1 (rescaled to the variance) and model 6

	Estimate	OR	Std	Error	*z* value	Pr(>|z|)
Age						
65–74						
Model 1	2.187	8.908	0.093	23.404	< 2.2e – 16	***
Model 6	1.101	3.007	0.091	12.049	< 2.2e – 16	***
Difference	1.085		0.062	17.385	< 2.2e – 16	***
75–84						
Model 1	1.404	4.071	0.088	157.977	< 2.2e – 16	***
Model 6	0.709	2.032	0.087	80.729	6,87E – 13	***
Difference	0.695		0.057	120.377	< 2.2e – 16	***
Gender						
Male						
Model 1	0.294	1.342	0.062	47.326	2,22E – 03	***
Model 6	0.343	1.409	0.062	54.882	4,06E – 05	***
Difference	– 0.049		0.034	– 14.43	0.149	
Living arrangements						
Living alone						
Model 1	0.108	1.114	0.068	15.784	0.114	
Model 6	0.263	1.301	0.071	37.012	0	***
Difference	– 0.155		0.042	– 36.778	0	***
In other arrangements						
Model 1	– 0.644	0.525	0.118	– 54.378	5,39E – 05	***
Model 6	– 0.221	0.802	0.119	– 18.539	0.063	
Difference	– 0.422		0.074	– 57.034	1,18E – 05	***
Housing Tenure						
Tenant						
Model 1	0.009	1.009	0.087	0.105	0.915	
Model 6	0.186	1.204	0.09	20.602	0.039	
Difference	– 0.177		0.053	– 33.129	0	*
Other						
Model 1	– 0.143	0.867	0.095	– 15.067	0.131897	
Model 6	0.029	1.029	0.097	0.3034	0.761593	
Difference	– 0.172		0.058	– 29.578	0.003099	**
Level of education						
Mid						
Model 1	– 0.431	0.650	0.08	– 53.516	8,72E – 05	***
Model 6	– 0.265	0.767	0.081	– 32.531	0.001	**
Difference	– 0.166		0.042	– 39.333	8,38E – 02	***
Low						
Model 1	– 0.243	0.784	0.083	– 29.196	0.003	**
Model 6	– 0.071	0.931	0.088	– 0.803	0.421	
Difference	– 0.171		0.052	– 32.761	0.001	**

Source Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

The main contribution of this study is its comparative approach to the analysis of this largely unexplored issue. Our findings show that unmet care needs change depending on the social care systems of the countries where older people live. Despite previous research has shown differences in social care systems between regions and countries (Ariaans et al. 2021; Dunatchik et al. 2019; Pfau-Effinger 2005), to our knowledge this is the first study comparing unmet care needs between different social care systems. Results spotlighted that the demographic characteristics like the age group and gender, were associated with unmet care needs, i.e., a higher risk was found for men than women and for younger than older age groups. In line with previous research, findings showed that the type of limitation explained the risk of facing unmet

Table 5 Odd ratios of model 6 using countries instead of grouping by social care systems

Social care system	Country	OR
Mediterranean	Spain (Ref.)	1
	Greece	0.729 [0.570–0.933]
	Italy	0.832 [0.644–1.073]
Western	Germany	0.262 [0.190–0.361]
	France	0.684 [0.514–0.909]
	Belgium	0.298 [0.227–0.389]
	Austria	0.494 [0.347–0.703]
	Switzerland	0.287 [0.200–0.411]
Nordic	Sweden	0.763 [0.560–1.039]
	Denmark	0.404 [0.296–0.552]
Eastern	Poland	1.353 [1.020–1.796]
	Czech Republic	0.149 [0.110–0.203]

Confidence intervals are provided in squared brackets

Source Survey of Health Ageing and Retirement in Europe, seventh wave (2017)

care needs, in our results individuals with only mobility limitations faced lower risk, meanwhile others have shown that the chance of suffer them is more strongly associated to ADL (Vlachantoni 2019). Living with other people in the household is associated with a lower risk, which may indicate that care is being provided by someone other than the couple, although previous research has shown that partners are still the main informal care providers (Kaschowitz and Brandt 2017; Uccheddu et al. 2019; Young and Grundy 2008).

In addition, people who live with someone other than a partner (compared with living alone or with a partner with or without another person) and who are neither owners nor tenants of the house in which they live are less likely to have unmet care needs. Previous evidence on the subject comes from England, where it was estimated that about 55% of older individuals with ADL, 24% of people with an IADL difficulty, and 80% of people with a mobility limitation have unmet care needs based on ELSA (Vlachantoni 2019). In contrast, this study found lower percentages of unmet care needs by each type of limitation, even for the population with only mobility difficulties, for whom the highest percentage was found in Greece. Nevertheless, these results are not fully comparable as the estimation comes from similar but not equivalent questions and filters in the analysed surveys (Ashokkumar et al. 2012).

However, further research about the relationship between these unmet needs and different social care systems is still needed; through the sensitivity check of the models, it was visible that there are differences within the groups of Nordic and Eastern countries. For instance, the results for Sweden and Poland may be explained by recent changes in care policies in these two countries. In the Swedish case, changes during the last three decades have been orientated towards enhancing voluntary choices and individuals' involvement in their own care; however, these measures are taking place in a context where the second demographic transition may affect the availability of care provision by children and partners (Edlund and Lövgren 2022; Moberg 2021). Meanwhile, Poland's history is characterized by an essential differentiation between hospice-palliative care, which emerged in the seventh decade of the last century, and home care (Krakowiak 2020), gaps between these two ways of care provision may reflect the lower quality of informal care provided in Poland when compared to the other countries (Dobrzyn-Matusiak et al. 2014).

In any case, this study has some limitations related to the sample and the measure that we used. The most relevant limitation is posed by the assumption behind measuring unmet care needs, which supposes that individuals facing any limitation, in fact, need help, even though some of them may be able to cope with these limitations without the support of a caregiver. Another limitation comes from the small sample size and lack of representativeness of the analysis by countries, which is why we used groups of countries based on theoretical typologies of social care systems, despite there are internal differences between the countries that are part of the Nordic and the Eastern social care systems. How to construct typologies of social care systems is still an ongoing debate. Previous evidence says that there may be more appropriate criteria than a regional approach (Ariaans et al. 2021; Damiani et al. 2011). Nevertheless, this study based its theoretical typology on previous work about welfare state configuration (Pfau-Effinger 2005).

Some relevant aspects come from using SHARE data to measure unmet care needs. While studies based on the ELSA usually ask if someone facing a limitation is receiving the help needed for performing a specific activity (e.g., bathing or eating), the SHARE asks this after all the questions about limitations for performing these activities are asked, which makes it impossible to know the specific activities for which individuals are facing these unmet needs. Likewise, we cannot truly know if the individual needs help to cope with the limitations that s/he is facing. This problem can only be solved by adding a new question in the survey that directly ask if the person needs care from other to perform these activities.[3] Still, the main value of this study lies in

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[3] Following the SHARE wording it can be formulated as: "Thinking about the activities that you have problems with, do you need help or support from someone else for performing these activities? Yes/No".

its comparative nature, which makes it possible to provide an empirical estimate of unmet care needs in 12 countries and to gain insights into the differences between social care systems at the regional level, which may be useful for policy makers interested in care demand and provision in ageing societies.

Conclusions

Care provision within ageing scenarios make front of challenges in assuring people's rights and well-being. This article suggests that individuals from older age groups and those in poorer health and worse functioning conditions face more negligible risks of experiencing unmet care needs. This scenario could indicate that social care systems meet the most pressuring needs: they are reactive but not preventive because they do not consider the future effects of unmet care needs on individuals' morbidity, well-being, and physical and mental health. Also, living arrangements respond to higher needs of care and are effective in supplying at least some of it; in spite of that, whether this is sufficient, or the most appropriate care, should also be a matter of investigation. Care is a basic need that changes through life courses and poses challenges to ageing populations, particularly in those societies based on family-centred care provision. More information and research are needed to examine current and future responses to the actual care demands to leave no one behind.

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Author contributions Both authors have participated in the conception, design, analysis and interpretation of the results of this study. MCJ performed the statistical analysis. All authors have read and approved the final manuscript.

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Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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CORRECTION

Correction: Subjective age and the association with intrinsic capacity, functional ability, and health among older adults in Norway

Ellen Melbye Langballe[1,2] · Vegard Skirbekk[1,2,3] · Bjørn Heine Strand[1,2,3]

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In the original publication of the article, the word "Urinary incontinence" should be replaced with "incontinence" throughout the article.
The original article has been corrected.

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ORIGINAL INVESTIGATION

Will your child take care of you in your old age? Unequal caregiving received by older parents from adult children in Sweden

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Abstract

Intergenerational family care provided to older parents by adult children is growing and differs based on gender and socioeconomic status. Few studies consider these elements in relation to both the parent and their adult child, and little is known about the number of care tasks received even though those providing intensive levels of care are at risk of experiencing adverse consequences in their lives. This study uses data from the nationally representative 2011 Swedish Panel Study of Living Conditions of the Oldest Old (SWEOLD) and includes child-specific information from parents aged 76 years and above. Analyses used ordinal logistic regression and are presented as average marginal effects and predictive margins. Results show that parents in need of care report that one-third of all adult children in the sample provide care to three out of five of them. The care is most often non-intensive, yet nearly one in ten of all children provide more intensive care of two or more tasks. When adjusting for dyad characteristics as well as geographic proximity, results show adult–child gender differences where parents receive more care from manual-working-class daughters than manual-working-class sons. Overall, manual-working-class daughters are most commonly reported as carers among adult children, and they are particularly overrepresented in providing intensive care. We conclude that gender and socioeconomic inequalities exist among care receivers' adult children, even in a strong welfare state such as Sweden. Knowledge about levels and patterns of intergenerational care have important implications for how to reduce unequal caregiving.

Keywords Intergenerational caregiving · Gender · Social class · Socioeconomic inequalities · Informal caregiving · Sweden

Introduction

Family care remains the most common source of care for older adults and exceeds formal care provisions from the welfare state. In Sweden, where formal care is comprehensive, family care is estimated to be three times as common (Wimo et al. 2020), with adult children providing around half of the family care for older adults (National Board of Health and Welfare 2012). Generally, family care has increased in recent decades (Wolff et al. 2017). This increase has been more evident in Sweden compared to other Nordic countries (Szebehely and Meagher 2018). In caregiving studies, it is important to separate spouses from adult children, as they reflect fundamental differences in both the experiences and consequences of caregiving (Qualls 2021). Caregiving can be a positive practice; however, children providing intensive care more often tend to have poorer health, lower labour market participation and fewer financial resources (Bastawrous et al. 2015; Szebehely et al. 2014).

Parental caregiving has been shown to differ by gender and socioeconomic position of both parents and their adult children (Wong et al. 2020). However, in Sweden, studies on socioeconomic differences in caregiving have mostly focused on parental social position and not that of the adult child. In addition, to our knowledge, few studies internationally and in Sweden consider both the gender and socioeconomic position of the adult child when assessing subgroup differences in parent–child caregiving intensity. Even less is known about these care patterns when controlling for

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parental characteristics and geographic proximity. Caregiving inequalities are particularly important, as informal caregiving may enhance health and financial inequalities. This study examines the distribution and intensity of caregiving received by older parents from each individual adult child, with a specific focus on the gender and social class differences of the children.

Intergenerational informal care

Informal care refers to unpaid care provided by family members, neighbours or friends of a person needing support due to disability, long-term illness, or old age. It can range from personal care, such as personal hygiene or showering, often considered intensive and demanding for the provider, to lower-intensity practical care such as support with household chores, shopping, or transport (Szydlik 2016). The range of care types received is important for the health and well-being of the recipient (Li and Song 2019).

It can be said that Sweden and the neighbouring Nordic countries relieve families of care obligations through relatively extensive public care services. Swedish law states that care provided by family members should be voluntary and that the state is to be the primary source of care when needed (Prop.2008/09:82 2008). This prioritisation is supported by both older adults and their family members (Szebehely and Trydegård 2007) as well as the Swedish population (Svallfors 2011). Nevertheless, studies show that adult children more often provide care, however, less intensive, in generous welfare state countries compared to countries where family obligations are greater and there is less public spending on care for older adults (Deindl and Brandt 2011; Verbakel 2018). When adult children are relieved from intensive care tasks, more children seem to provide less intensive care to their parents (Saraceno 2010). Despite the significance of the parent–child care relationship, it has received less attention in the caregiving literature in Sweden, than for example spousal care (National Board of Health and Welfare 2020; Ulmanen 2015).

Gender and socioeconomic inequalities

International findings consistently show that daughters are more likely to care for an older parent compared to sons (Wong et al. 2020), especially if the parent is a mother (Grigoryeva 2017; Silverstein et al. 2006; Szydlik 2016). Findings in Sweden are less clear and vary depending on the assessment of caregiving. Gender differences tend to be insignificant when considering whether care has been provided at all, or at least monthly (Szebehely et al. 2014; von Essen and Svedberg 2020). However, there are gender differences regarding the type of care and care intensity; daughters are more likely to provide intensive care, for example, personal care (Kridahl and Duvander 2021) together with other care tasks. Sons, on the other hand, tend to provide practical care (Jegermalm 2006). To accurately capture gender differences in caregiving, it is important to incorporate as wide a range of care tasks as possible, including those where sons are the most prevalent caregivers (Ulmanen 2016).

Universalism is a cornerstone in the Swedish welfare system, e.g. publicly funded care for older adults should be available to all as needed, regardless of an individual's financial or family resources (Sipilä 2019). However, care provided by the state has undergone a process of deinstitutionalisation and marketisation, having various implications for the lives of older adults and their families (Rostgaard et al. 2022). Older adults needing care appear to arrange their care provision depending on their socioeconomic status, especially if they do not qualify for formal services. Previous research in both Europe and Sweden has shown that those with lower socioeconomic resources receive more care from family members, than those with higher socioeconomic resources, who are more likely to enlist private-sector providers (van Groenou et al. 2006; Sarasa Urdiola and Billingsley 2008; Ulmanen 2015). In Sweden, such market solutions have also been fostered by the introduction of tax relief for many domestic services.

Caregiving to any family member seems to be more common when caregivers are from low socioeconomic groups, especially when the care is more intensive (Carmichael et al. 2010; Tough et al. 2019) and provided by a spouse (Glaser and Grundy 2002). Socioeconomic differences in parental caregiving show mixed results. In a comparative European study (Brandt 2011) all forms of caregiving were more common among adult children with higher education than lower, while the opposite was found in another comparative European study (Sarasa Urdiola and Billingsley 2008). However, the latter did not find any such differences among the Nordic countries. One explanation for the likelihood of higher educated children providing more care could be related to the association between education and health (Zimmerman and Woolf 2014). Good health is a prerequisite for providing intensive care, and higher education might correlate more in countries with weaker welfare states and educational systems. The non-differential socioeconomic patterns of the Nordic countries have been confirmed in both Norway (Gautun and Hagen 2010) and Sweden (Jegermalm and Grassman 2012; von Essen and Svedberg 2020). Even if this socioeconomic caregiving perspective has been less researched in the Nordic countries (Ulmanen 2022), there are indications of care intensity being an important factor for distinguishing socioeconomic differences among caregiving adult children.

Research addressing both gender and socioeconomic differences in family caregiving indicates that gender differences can be modified by education. In the UK, women with lower education were most likely to provide intensive care to a parent (Henz 2021) and in Japan, they were most likely to be the primary caregiver (Tokunaga and Hashimoto 2017). In Sweden, parents with a lower socioeconomic status were more likely to receive care from a daughter than a son (Ulmanen and Szebehely 2015). However, the associations in Sweden seem to vary across specified care relationships. For example, one study found that higher-educated women were slightly more likely to be caregivers to any family member than women with lower education (Ulmanen 2022), while the opposite was found when focusing on adult child characteristics in parental caregiving during the 1990s (Winqvist 1999). Daughters with lower educational levels were more likely to provide intensive care such as household-related tasks and personal care to an older parent, while sons with lower educational levels would provide less intensive care such as repairs and gardening. No gender differences were found among highly educated children, which was explained by a more equal distribution of care tasks provided. To our knowledge, this gender and socioeconomic interaction of adult children have not been investigated further among care-receiving older parents in Sweden and even less is known when taking care intensity, parental characteristics and geographic proximity into account.

Geographic proximity and other potential covariates

Living close to an adult child facilitates care receipt through more efficient use of time and reduced travel costs. This is particularly significant for regular and demanding care (Pillemer and Suitor 2013; Wong et al. 2020). Decisions to move closer to a child or a parent can be determined by a prospective need to provide care for both older and younger generations (Pettersson and Malmberg 2009). Mothers are more likely to live closer to an adult child than fathers, as are parents with lower levels of education (Choi et al. 2015; Lennartsson 2001). Chan and Ermisch's (2015) study of the UK found no gender difference between children in geographic proximity to parents, although more educated children tended to live further away.

Parental age is also an important factor in care needs. Functional limitations and health problems become more frequent and permanent with age, especially beyond the age of 80 (Fors et al. 2022; Nilsen et al. 2019). Time availability from the caregivers' perspective is also important, as adult children at work provide less care (Wong et al. 2020).

This study adds to previous research by assessing the prevalence, intensity and distribution of informal caregiving received by older parents from individual adult children, while taking parental and child characteristics as well as geographic proximity into consideration. The focus is on the gender and socioeconomic differences of adult children providing care to older parents in need. Inequalities in formal and informal care reception among older adults are well-established. However, it is also crucial to understand the overall distribution and possible subgroup differences in the caregiving of older parents by adult children (Qualls 2021; Tokunaga and Hashimoto 2017; Ulmanen and Szebehely 2015). Only then can we identify potentially vulnerable groups of adult children providing care and risking adverse health and financial outcomes and provide social policy measures against increasing inequalities in family caregiving.

Aim

This study aims to describe the distribution of informal care received by older parents from adult children with a specific focus on gender and social class differences among children. The study asks:

1. What portion of adult children are parents reporting as providing care to them and how are care tasks distributed among the children?
2. Does the distribution of care tasks differ by adult children's gender and social class as reported by older parents?
3. To what extent can these differences be explained by parental characteristics and geographic proximity?

Data and methods

Design and participants

Data were taken from the 2011 *Swedish Panel Study of Living Conditions of the Oldest Old* (SWEOLD), a randomly sampled national survey conducted continually since 1992 comprising 931 people in 2011. It is a nationally representative sample of people born between 1909 and 1934 aged 76 and above. The response rate was 86.2% and interviews were conducted face to face, with the option of taking place over the telephone. If a person was unable to participate due to issues such as dementia or frailty, an indirect interview was performed with a close relative or healthcare worker (Lennartsson et al. 2014). The sample included only those with adult children who needed care, indicated by being a care recipient. The following types of care being received formed the eligibility inclusion: help buying and/or preparing food, cleaning, help with personal hygiene, providing transport, etc. (see dependent variable), general household or personal care, and formal care. People living in care facilities and responding via self-completion questionnaires (as they did not receive any questions about who helped them) were

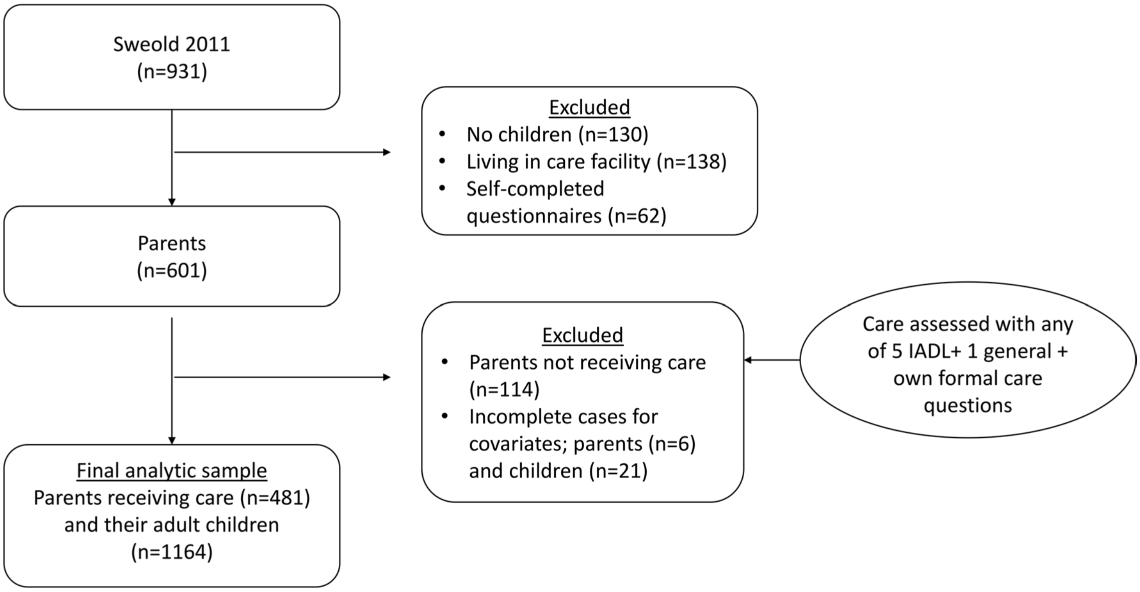

Fig. 1 Flow chart of the final analytic sample with parents ($n=481$) and their adult children ($n=1164$)

excluded. After omitting incomplete cases for covariates, the final analytical sample consisted of 481 older parents with child-specific data on 1164 adult children (see Fig. 1). Informed verbal consent was obtained prior to each interview. Ethical approval was provided by the Regional Ethical Review Board in Stockholm (2010/403–31/4) and Ethical Review Agency (2019-06324).

Dependent variable

The dependent variable concerns the number of care tasks received by parents from each adult child. Five survey questions were used and incorporated a range of care tasks, all defined as practical care, including the more intensive personal care task of bathing and/or showering.

The first four questions were: Do you usually buy food by yourself? Do you usually prepare food by yourself? Do you usually clean the house by yourself? and Do you bath/shower yourself? The response alternatives were: 'Yes, unaided', 'Yes, with help' and 'No, not at all'. The latter two responses were followed with the question: Who usually helps you with…?. Multiple answers were possible, such as cohabitant, daughter, son, and formal care services, and when the answer was a child, each specific child was linked by their name to create a child–parent dyad.

The last question, here referred to as 'transportation, etc.', was: Over the last 12 months, have you received any help from relatives or friends (not living with you) with any of the following: repairs or maintenance; gardening, personal finance, buying clothes or other items, being driven somewhere (response options: Yes, No). 'Yes' answers were followed with the question: Who usually helps you? Multiple answers were possible such as daughter, son, female/male relative, or another person. If the answer was a child, that specific child was linked by their name. Receiving help with transportation was the most common response and a requirement for inclusion in this care category. Other tasks within the category ranged from 34% (repairs and maintenance) to 50% (buying clothes or other items), with a mean of 2.76 tasks mentioned, and a standard deviation of 1.21. The tasks included in the transportation, etc., group are generally of lower intensity (Ulmanen 2016).

The final dependent variable was represented by four groups: no care received; one care task; two care tasks; three or more care tasks received from the adult child. Relatively few children were reported to provide more than three care tasks, so the last category represents three to five care tasks (see Table 2).

Independent variables

Gender and social class of the adult children were the main independent variables of interest. Social class was assessed using the official Swedish socioeconomic classification (SEI), which is based on and similar to several dimensions of the internationally established Erikson–Goldthorpe–Portocarero (EGP) classification (Erikson and Goldthorpe 1992). The occupation and position in the labour market of the respondent are the foundation for SEI (Andersson et al. 1981).

Given that adult child occupation information was provided by parents, the possibility to distinguish between a wider range of occupations was more restricted compared to the parent. Adult child social class was represented by four groups: manual workers; non-manual workers, self-employed and farmers, and unclassified.

Parental gender, social class, and geographic proximity formed other independent variables. Social class was measured using the same classification as for children. Since the occupation of both the respondent and the living or deceased spouse was known, a household class position was assigned to the parent, assuming that some positions dominate over others in terms of values, attitudes, and behavioural patterns (Erikson 1984). Parental household class was represented by four groups: manual workers, lower non-manual workers, intermediate and higher non-manual workers, and self-employed and farmers. Geographic proximity was represented by three categories: less than 20 km; 21 to 100 km; and over 100 km.

Control variables included the adult child's labour market activity represented by working; retired; other (where 'other' includes, e.g. the unemployed persons and students), parental age and if the parent was living alone.

Analytic approach

Descriptive statistics were presented for all study variables. Bivariate analyses were performed to determine differences between independent variables and care intensity using Chi^2 tests. Ordinal logistic regression models were used to study the association between gender and social class of adult children and receiving increasing numbers of care tasks. Estimates were presented as average marginal effects (AME) and 95% confidence intervals to enable comparisons across models (Mood 2010; Williams 2020). AME can be interpreted as the average difference in probability (0–1) of the outcome depending on the value of the independent variable. Analyses were stratified by social class of children, as social class may modify gender differences in caregiving. Finally, we use predictive margins (PM) to present the probability of receiving informal care across the different caregiving groups by gender and social class of children while holding all other variables constant, including an interaction term of gender and social class of children. PM facilitates the interpretations of the results compared to regression coefficients, especially when presenting group differences in the presence of interaction terms (Graubard and Korn 1999). Significant levels were set at $p < 0.05$. Since the regressions are based on our constructed adult child population, the unit of analysis is not independent (several children can share the same parent). Therefore, we perform our statistical tests with robust standard errors adjusted for clustering. Analysis was performed using weights to compensate for unequal probability to be included in the sample depending on gender and age (85+) in the parental sample. Data were analysed using Stata 17.0 for Windows.

Results

Table 1 presents the baseline characteristics of the parents and their adult children. Most parents received a combination of care from children and others, with 'others' including partners, relatives, friends, formal, or private care. A minority of parents, 15%, only received care from their children. Around half of the parents were 85 years or older and more than half lived alone. Eight out of ten children were employed, and their mean age was 54 years. More than half of the children lived less than 20 km from their parent.

Figure 2 shows how care types were distributed within three caregiving groups. Parents reported that nine out of ten children who provided a single care task were helping them with transportation, etc. For the two care task group, the distribution became more even; transportation, etc., still dominated (47%) followed by food shopping (34%) and cleaning (15%). Finally, in the three or more care task group, differences between transportation, etc. (33%), food shopping (30%), and cleaning (27%) diminished, whereas cooking (11%) and bathing/showering (10%) became more prominent. Hence, providing more care tasks means providing a more diverse and intensive type of caregiving compared to those providing fewer care tasks. The differences across the groups can therefore be interpreted as differences in care intensity.

Bivariate analyses

The first column in Table 2 shows that parents in need reported that around one-third of all adult children in the sample provided some kind of care to them. Thus, parents in need of care do not receive care from two-thirds of the children in the sample, but from other sources. Care was slightly more commonly received from daughters than sons, as was care received from manual workers compared to other social classes. The first row in Table 2 shows that one in four children was reported to provide one care task, whereas two (5%) and three or more tasks (3%) were less common. Sons were more often reported to provide one task, while daughters were almost twice as prevalent among two-task providers and five times as prevalent among three-or-more-task providers. Patterns of care distribution also varied across social classes. Manual workers were more often reported to provide one (29% vs. 23%) and two tasks (9% vs. 4%) than non-manual workers, while no difference was found in the most care-intensive group. Self-employed and farmers followed the general pattern of non-manual workers in terms of

Table 1 Baseline characteristics of the study sample

Parents	*n*	%
Care receipt		
From adult children only	74	15.38
From adult children and others	214	44.49
From others only	193	40.12
Gender		
Mothers	243	50.52
Fathers	238	49.48
Household class		
Manual workers	116	24.12
Lower non-manual workers	73	15.18
Intermediate/higher non-manual workers	147	30.56
Self-employed/farmers	145	30.15
Age groups		
76–79	98	20.37
80–84	133	27.65
85+	250	51.98
Living alone	260	54.05
	Mean (SD)	Range
Number of adult children	3.1 (1.27)	1–10
Adult children		
Gender		
Daughters	588	50.49
Sons	576	49.51
Own class		
Manual workers	309	26.57
Non-manual workers	528	45.33
Self-employed/farmers	184	15.81
Unclassified	143	12.28
Labour market activity		
Working	968	83.18
Retired	106	9.12
Other	90	7.70
Distance between adult child and parent		
Less than 20 km	607	52.14
21–100 km	221	18.97
More than 100 km	336	28.89
	Mean (SD)	Range
Adult child age in years	53.96 (7.54)	18–78

Parents in need of care ($n = 481$) and their adult children ($n = 1164$)

[a]Parental characteristics not weighted

being less represented in all caregiving groups compared to manual workers. However, non-manual workers were least commonly reported as performing one task than all other social classes.

Older adults more commonly received intensive caregiving from children who had retired. Nevertheless, seven per cent of all reported children (4.6% + 2.6%), provided two or more care tasks on a regular basis while still working. Children living close to a parent were also reported to provide a higher number of care tasks; however, more than one in ten of those living the furthest away still provided one or more care tasks.

In terms of the parental characteristics across caregiving groups, our data show that mothers reported more care tasks

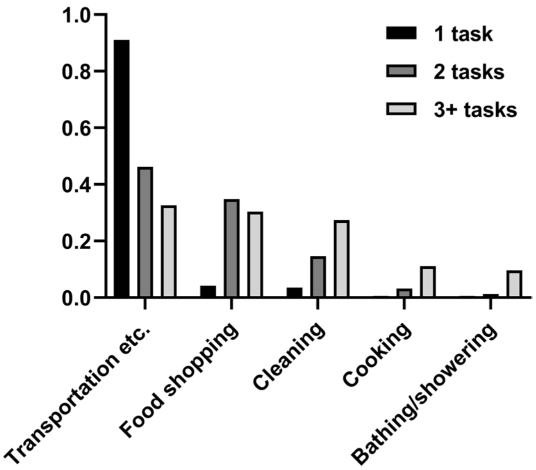

Fig. 2 Average distribution of care types such as transportation, etc., food shopping, and cleaning, received by older parents by three caregiving groups, defined as the number of tasks provided by adult children. Per cent. (*n* = 436)

received by their adult children than fathers. Parents in the intermediate or higher non-manual household class reported that their adult children provided the least care compared to all other social classes. Parents who had been self-employed or farmers reported receiving the most intensive care from their adult children. Intensive caregiving was most common for parents aged 85 and older. Parents who lived alone reported a higher share of caregiving by children in all caregiving groups.

Multivariate analyses

Table 3 presents the average difference in the probability of informal caregiving across each caregiving group regarding adult children's gender and social class. When controlling for children's labour market activity, Model 1 shows no gender differences. Non-manual workers and self-employed and farmers were statistically significantly less likely to be reported as providing increasing care tasks than manual workers. The self-employed and farmers were 12.1 percentage points less likely than manual workers, while the equivalent for non-manual workers was 9.9 percentage points. Excluding child labour market activity made no important changes to these estimates (not shown). Adjusting for both child and parental characteristics and geographic proximity (model 2), the significant social class patterns weakened. Instead, gender differences strengthened, where daughters were 5.7 percentage points more likely than sons to be reported as providing any kind of care. Sensitivity analysis (not shown) revealed gender differences when including geographic proximity as a final covariate to the model even though parents tended to live further away from their daughters than sons. The social class differences in the first model were largely explained by geographic proximity since parents were living closer to children with manual occupations.

We also analysed whether the association between adult children's gender and care intensity was modified by their social class. Table 4 shows the full model (Table 3, Model 2) stratified by child social class. The results show that daughters in manual occupations were reported to perform significantly more care tasks than sons. There was a 16.2 percentage point lower probability that a daughter in the manual social class group would provide no care, and 3.1 percentage point higher probability of performing three or more tasks than sons. There were no significant gender differences among other social classes.

Figure 3 shows the predictive margins (PM) from the ordinal logistic regression presented in Table 3 (Model 2), including a two-way interaction term between adult children's gender and social class. The PM can be interpreted as the reported probability of belonging to each caregiving group for daughters and sons, respectively, depending on their social class, while holding other variables in the model constant. Results show that manual-working daughters were 44.5% likely to provide care, whereas manual-working sons were 30.6% likely. The relative difference of 8 percentage points between manual-working daughters and sons remained significant among those reported to perform one care task. Patterns across the more intensive care groups suggest an increase in this relative difference. Results showed no gender differences among the other social classes in any of the caregiving groups. Further analysis showed that adding formal care receipt of the parent as a covariate in this final model did not significantly change the estimates (not shown), which is a finding in itself. Overall, regardless of care intensity, daughters of manual occupations were more often reported to be caregivers than other adult children.

Discussion

This study aims to describe the distribution of informal care received by older parents from adult children with a specific focus on these children's gender and social class differences. Our study shows that 15% of parents receiving care had this provided only by their child. We also found that parents reported that 34% of the children in our sample provided care on a regular basis and that the care was generally of a non-intensive practical nature. Five per cent of children were reported as performing two tasks, usually a combination of transportation, etc., and one other practical care task, most commonly food shopping, or cleaning. Three per cent of all children were reported to provide three or more care tasks, thus being the most care-intensive group.

Table 2 Baseline characteristics of the adult child study sample by informal caregiving group as reported by older parents ($n = 1164$)

Caregiving group	No care $n = 763$, (65.53%)	1 care task $n = 300$, (25.76%)	2 care tasks $n = 63$, (5.44%)	3+ care tasks $n = 38$, (3.27%)	*p* value
Adult children					
Gender					< 0.001
Sons	384 (66.65)	163 (28.30)	22 (3.78)	7 (1.27)	
Daughters	379 (64.42)	137 (23.28)	42 (7.07)	31 (5.23)	
Own class					0.034
Manual workers	173 (58.08)	86 (28.87)	27 (9.12)	12 (3.93)	
Non-manual workers	371 (67.91)	127 (23.27)	24 (4.35)	24 (4.48)	
Self-employed/farmer	127 (69.75)	48 (26.14)	7 (3.96)	0 (0.15)	
Unclassified	93 (67.41)	38 (27.76)	5 (3.42)	2 (1.41)	
Labour market activity					< 0.001
Working	603 (66.22)	242 (26.56)	42 (4.59)	24 (2.63)	
Retired	92 (53.73)	40 (23.37)	21 (12.23)	18 (10.68)	
Other	59 (71.98)	16 (20.01)	5 (6.54)	1 (1.47)	
Distance to parent					< 0.001
Less than 20 km	308 (51.20)	214 (35.49)	50 (8.26)	30 (5.05)	
21–100 km	164 (72.17)	51 (22.50)	10 (4.37)	2 (0.96)	
More than 100 km	292 (87.02)	35 (10.35)	4 (1.05)	5 (1.59)	
Parents					
Gender					< 0.001
Fathers	415 (72.56)	135 (23.59)	18 (3.10)	4 (0.75)	
Mothers	356 (60.18)	162 (27.41)	43 (7.22)	31 (5.19)	
Household class					< 0.001
Manual workers	174 (63.16)	80 (28.68)	14 (5.24)	8 (2.73)	
Lower non-manual workers	88 (57.30)	53 (34.28)	9 (5.62)	4 (2.80)	
Intermediate/higher non-manual workers	252 (75.83)	69 (20.86)	7 (2.21)	4 (1.10)	
Self-employed/farmers	246 (61.10)	99 (24.59)	34 (8.47)	24 (5.85)	
Age groups					< 0.001
76–79	182 (73.98)	53 (21.54)	6 (2.44)	5 (2.03)	
80–84	214 (64.65)	95 (28.70)	14 (4.23)	8 (2.42)	
85+	350 (59.63)	152 (25.98)	54 (9.19)	31 (5.21)	
Living alone					< 0.001
Yes	358 (56.68)	188 (29.78)	56 (8.91)	29 (4.63)	
No	399 (75.07)	114 (21.44)	9 (1.69)	10 (1.80)	

Row percentage. Statistical significance between groups (Chi^2): $*p < 0.05$

This confirms findings that indicate how it is the type of care received by older adults that reflects the relationship between welfare state design and caregiving patterns in a country—not only the proportion of adult children providing care (Saraceno 2010). Our study shows that the most common kind of care received by older parents from children was non-intensive, mirroring care needs that are seldom covered by formal care services, thus falling naturally on close family members such as adult children. The findings are therefore in line with the complementarity theory discussed by Litwak (1985), which claims that informal care complements formal care. The findings also agree with the notion of 'crowding in and out' (Szydlik 2016), where an extensive welfare state relieves (crowds out) children from intensive caregiving while increasing (crowds in) the need for non-intensive caregiving. However, this concept does not seem to fit all adult children. Ten per cent were reported to provide two or more care tasks, thereby performing a larger variety of task such as domestic and personal care tasks, which are also offered by formal care services.

This study shows that the receipt of caregiving and its intensity differ by adult children's gender and socioeconomic status. There were also differences linked to parental characteristics and geographic proximity between

Table 3 Average marginal effects (AME) and 95% confidence intervals of the number of care tasks by adult children's gender and social class as reported by older parents ($n = 1164$)

No. of care tasks	Model 1				Model 2			
	0	1	2	3+	0	1	2	3+
Gender								
Sons	Reference category				Reference category			
Daughters	−0.044 (−0.103, 0.014)	0.028 (−0.009, 0.065)	0.010 (−0.004, 0.023)	0.006 (−0.003, 0.015)	**−0.057** **(−0.111, −0.003)**	**0.034** **(0.003, 0.065)**	0.014 (−0.000, 0.028)	0.009 (−0.000, 0.019)
Social class								
Manual workers	Reference category				Reference category			
Non-manual workers	**0.099** **(0.022, 0.176)**	**−0.062** **(−0.110, −0.014)**	**−0.022** **(−0.042, −0.003)**	**−0.015** **(−0.028, −0.003)**	0.018 (−0.049, 0.085)	−0.010 (−0.049, 0.029)	−0.004 (−0.021, 0.012)	−0.003 (−0.015, 0.008)
Self-employed/farmers	**0.121** **(0.029, 0.214)**	**−0.077** **(−0.136, −0.017)**	**−0.027** **(−0.049, −0.003)**	**−0.018** **(−0.033, −0.003)**	0.077 (−0.001, 0.155)	−0.047 (−0.096, 0.001)	−0.018 (−0.036, 0.001)	−0.012 (−0.025, 0.001)

Model 1 adjusted for child labour market activity. Model 2 adjusted for child labour market activity and parental characteristics: gender, household social class, age, living alone as well as geographic proximity between parent and child. Statistically significant values in bold ($p < 0.05$). Unclassified social class not shown

Table 4 Average marginal effects (AME) and 95% confidence intervals of the number of care tasks by adult children's gender and stratified by their social class, as reported by older parents ($n = 1164$)

	0	1	2	3+
Manual workers				
Sons	Reference category			
Daughters	**−0.162** **(−0.262, −0.062)**	**0.071** **(0.031, 0.112)**	**0.059** **(0.014, 0.105)**	**0.031** **(0.002, 0.061)**
Non-manual workers				
Sons	Reference category			
Daughters	0.023 (−0.053, 0.098)	−0.013 (−0.057, 0.031)	−0.004 (−0.018, 0.010)	−0.005 (−0.023, 0.012)
Self-employed/farmers				
Sons	Reference category			
Daughters	0.034 (−0.094, 0.162)	−0.026 (−0.124, 0.072)	−0.007 (−0.037, 0.022)	−0.000 (−0.002, 0.001)

Adjusted for child labour market activity and parental characteristics, such as gender, household social class, age, living alone as well as geographic proximity between parent and child. Statistically significant values in bold ($p < 0.05$). Unclassified social class not shown

children and parents. Compared to sons, daughters were reported to provide more intensive care by combining practical and sometime personal hygiene tasks with transportation, etc. Daughters were also reported to provide most care even when they lived further away than sons. That differences in social class weakened in the full model is partially explained by the diversity in distance between parents and children depending on social class belonging. While this study considers several aspects lacking in previous research, the findings about gender differences are in line with international research (Wong et al. 2020). In the Swedish context, results provide a more nuanced picture of gender differences in intergenerational old age care. This study highlights the importance of assessing care intensity and type of care provided (Szebehely et al. 2014; von Essen and Svedberg 2020) in combination with accounting for the dyad characteristics, specifically geographic proximity (Jegermalm 2006; Kridahl and Duvander 2021) for better understanding potential gender differences. The non-differential social class patterns mirror previous research that has not found differences in educational background in caregiving by adult children in Sweden (Sarasa Urdiola and Billingsley 2008; von Essen and Svedberg 2020). However, our results revealed an interaction between the child's gender and social class, suggesting that when studying child socioeconomic differences in

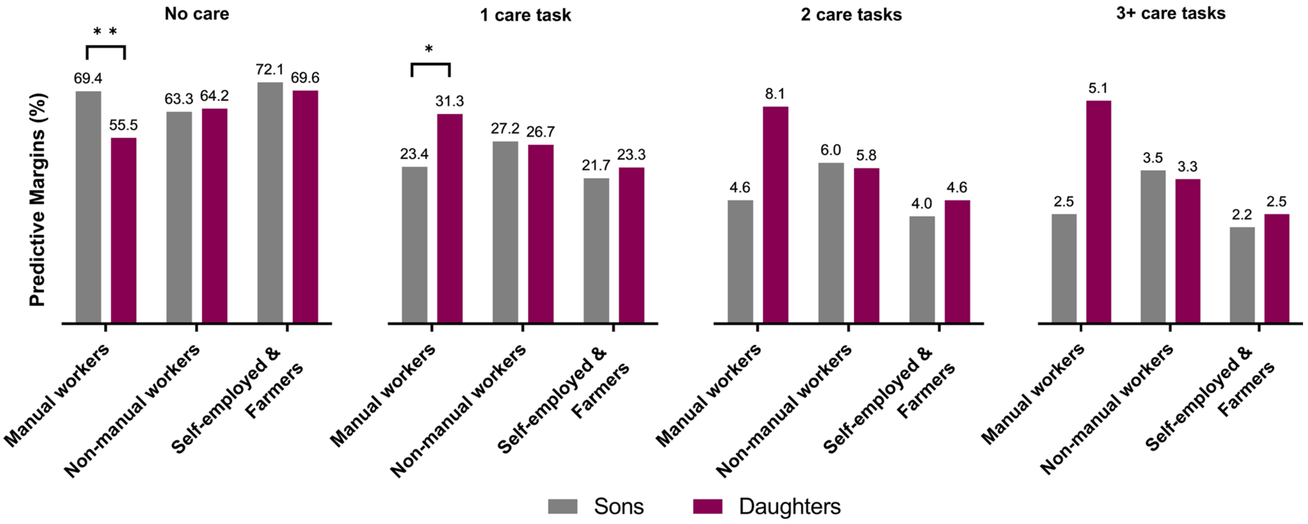

Fig. 3 Predictive margins (PM) of belonging to different caregiving groups, as reported by older parents, by adult child gender and social class. The results have been adjusted for adult child and parental characteristics, geographic proximity including an interaction term of child gender and social class ($n = 1164$). Statistical significance between groups: $*p < 0.05$; $**p < 0.01$

intergenerational old age care one should account for the gender of the care providing adult child.

Our analyses returned two particularly important results. Firstly, daughters in the manual social class group were more often reported to be care providers than sons in the manual social class group, regardless of parental gender, household social class, and geographic proximity, whereas no gender differences could be seen among the other adult child social classes. Secondly, as the care intensity increased, so did the relative difference between daughters in the manual social class and all other children. Even if the difference was not significant across all caregiving groups, this still suggests that disparities reported among daughters are greater than between sons and daughters when accounting for social class. Our results confirm international findings (Cohen et al. 2019; Henz 2021) and complement the finding by Ulmanen and Szebehely (2015) in a Swedish context, who showed higher and increasing caregiving by daughters of parents with lower socioeconomic status. We found that the social class of the adult child is in itself an important factor for understanding gender differences in caregiving, regardless of parental social class. By considering care intensity and adding several parent–child characteristics, our finding also refines those of Winqvist (1999). We show that gender and socioeconomic differences among adult children exist even when controlling for geographic proximity where sons tend to live closer than daughters.

Reported gender differences among manual-working-class children could be explained through more traditional gender roles (West and Zimmerman 1987) compared to other social classes even in a relatively gender-equal country such as Sweden (EIGE 2021). One explanation could be that families of lower social classes have been shown to be more family-oriented than other social classes (Silverstein and Bengtson 1997). Another explanation suggests that women in manual occupations either work part-time or retire earlier than others with more time to spend on informal caregiving (Dentinger and Clarkberg 2002). However, we cannot exclude that daughters with manual occupations may decrease their working hours due to their parents' care needs.

Informal caregiving can be a positive experience; however, negative consequences in terms of worse health, reduction, or termination of paid work and lower financial resources are common, especially among informal caregivers providing intensive care (Bastawrous et al. 2015; Johansson et al. 2022; Lilly et al. 2007). Furthermore, women are at higher risk of experiencing these negative consequences than men, even when accounting for gender differences in caregiving (Szebehely et al. 2014).

Our results support and exemplify research by Saraceno (2010), who investigated social inequalities in caregiving and care receiving from a bi-generational perspective. She argued that the structural features of public care support in any given country have a greater impact on family caregivers than care recipients from both a gender and social class perspective. When the overall coverage reduces, and the eligibility thresholds are relatively strict, older adults must have quite severe health problems to qualify for formal care. Consequently, the adult children of parents with less-severe health problems but who still need care will be affected (Rostgaard et al. 2022). However, this study shows that even when accounting for formal care received by parents, care received from children still vary depending on their gender and social class combined. It is also important to consider that daughters in manual occupations already face financial and social disadvantages, leaving them with fewer resources. In addition, these women are more likely to work in care-based occupations (Kjellsson 2021). Hence, social inequalities risk maintaining or even increasing inequalities in care receipt by older parents from adult children. Future research should monitor recent developments in unequal intergenerational care transfers in old age and try to understand how an adult child's gender and social class influences any care decisions received and provided.

Strengths and limitations

This study focuses on care reported and received by older parents in need from each individual adult child and therefore comes with both strengths and limitations. Assessing intergenerational transfers of resources may include risks of reporting bias from either generation and can vary depending on, e.g. type of support and differences in measurements. In a study from the USA by Lin and Wu (2017), adult child reports of time transfers provided to parents were found to be more reliable than that of parents when measured as a binary question and including children over 18 years and parents under 80 years. In another study from the USA, Kim et al. (2011), however, did not find any significant difference when measuring frequency of practical support while including children between the ages 40–60 and their parents 96 years and below. Bearing this in mind we consider the strengths of this study to include: (1) covering of the care received from parents in relation to all individual adult children which is a rare feature in previous studies (Lin 2017); (2) the inclusion of the oldest-old, which is a group with high care consumption, often underrepresented in informal care research; and (3) the ability to measure care intensity. To our knowledge, no other Swedish data provide the opportunity to consider these aspects when assessing informal care received by older parents from adult children.

The operationalisation of care intensity is an additional strength, measured by number of care tasks while considering type of care. By assessing care intensity in this way, we offer an alternative for when there is a lack of information about frequencies in caregiving. The list of care tasks included was not comprehensive; however, they covered a broad scope. This enabled us to assess both non-intensive and intensive caregiving, thereby capturing a more accurate picture of subgroup differences in caregiving (Szebehely 2005). The occupational grouping of adult children is a limitation. The non-manual social class category can include anything from less-qualified office staff to managing directors or professors. Results might have been more nuanced with more detailed social class categories. Given the sometime restricted knowledge parents had concerning their children's occupation, this was, however, not possible leading to a potential underestimation of the results.

Policy implications

This study challenges the idea that care of older adults in Sweden should be available for all when needed regardless of an individual's resources. The results demonstrate that deficiencies in this egalitarian system have consequences for both older parents receiving care and their adult children. This is worrying, especially as the proportion of older adults in need of care will double over the coming decade in Sweden (National Board of Health and Welfare 2020), while family care has been increasing over time (von Essen and Svedberg 2020). Another issue relates to the sustainability of the welfare system; the informal caregiving obligations of women must be recognised, if they are to continue working in the welfare sector where both their taxes and labour contributions are needed to support the system. Policies should therefore consider care intensity and a *combination* of gender and socioeconomic status, while identifying ways of counteracting inequalities in intergenerational caregiving.

Conclusions

Even in a strong welfare state and an equality-conscious country such as Sweden, older parents report a significant proportion of adult children providing them with informal care. Although reported to be generally less intensive, this care is unequally distributed among children. Daughters with manual occupations were reported to be the most common carers and are overrepresented in providing intensive care. These women are thereby at risk of experiencing adverse consequences in their lives. Hence, knowledge about levels and patterns of intergenerational care transfers in families of older adults has important implications on how to reduce care inequalities.

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Declarations

Competing interests The authors declare no competing interests.

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ORIGINAL INVESTIGATION

Gendered life courses and cognitive functioning in later life: the role of context-specific gender norms and lifetime employment

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Abstract
With increasing life expectancy, dementia poses an epidemiological challenge. As a cure has not been developed, the investigation into preventive factors becomes pivotal. Previous research emphasizes the cognitively stimulating and socio-emotional benefits of lifetime employment, but research on heterogeneous patterns across social groups and societal contexts remains sparse. Sociological approaches have a promising potential to provide insights into health inequalities and can contribute to the study of this major societal challenge. We investigate the influence of previous employment biographies on cognitive functioning for men and women aged 50 to 75 in 19 European countries, using longitudinal and retrospective information from the Survey of Health, Ageing and Retirement in Europe. We link individual information on employment biographies and cognitive functioning to contextual measures of gender norms, using aggregated agreement rates to both men's and women's role in employment and family. We find that previous employment affects cognitive functioning men and women differently. Part-time employment is beneficial for women's cognitive functioning, but not for men's. Traditional gender norms are associated with lower levels of cognitive functioning for both genders and moderate the linkage between previous employment and cognitive functioning. In contexts with more traditional gender norms, men's part-time employment is associated with lower and women's part-time employment with higher cognitive functioning. We conclude that employment and non-employment participation can, depending on characteristics of individuals and contexts, benefit or hinder the life-course accumulation of cognitive reserve, and those with norm-deviating behaviour are disadvantaged.

Keywords Cognitive ageing · Gender · Life course · Lifetime employment · Gender norms · Europe

Introduction

Cognitive ageing, particularly memory impairment, is the hallmark symptom of dementia (Albert 2011), a range of conditions typically arising in old age which co-occur with gradual decline of physical health (Livingston et al. 2020). Due to increasing numbers of people affected by dementia and the consequences for health and social care systems, dementia prevention has become a public health policy goal. Studies confirm the importance of lifetime employment for later-life cognitive functioning. Employment experiences over the life course, particularly *occupation and employment intensity* explain variation in older-age cognitive performance beyond education (Ford and Leist 2021; Finkel et al. 2009; Greenberg and Burgard 2021). Similarly, the contribution of childhood socioeconomic disadvantage on cognitive performance at older ages is mediated through both educational attainment and occupation (Aartsen et al. 2019; Ford et al. 2022).

Particularly occupational complexity, i.e. complex job tasks and skills, has been shown to be a valid proxy for cognitive stimulation and to influence cognitive trajectories (Andel et al. 2015; Finkel et al. 2009; Kröger, et al. 2008). Occupations also act through psychosocial work characteristics, such control over one's tasks, on cognitive functioning (Nexø et al. 2016; Then et al. 2014). Cognitive stimulation has been put forward as a major determinant of cognitive reserve (Stern 2002), and *work-related cognitive stimulation* constitutes the major pathway through which lifetime employment influences cognitive functioning (Lövdén et al. 2020).

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With regard to *employment intensity,* studies have concentrated on part-time vs. full-time employment. Part-time employment comes with better opportunities for work-care reconciliation and reduces stress. Moreover, from the literature on health and well-being benefits of part-time employment, one can assume that individuals also benefit cognitively from occupying *multiple roles* (Rozario et al. 2004). With regard to the role of lifetime part-time employment for cognitive functioning in later life, the evidence is less clear. Some studies find that, for mothers, part-time employment seems to be more beneficial than full-time employment; however, full-time employed mothers have higher cognitive functioning than non-employed mothers (Ice et al. 2020). Other studies (for instance, Roxo et al. 2021a) do not support such part-time benefits.

Additionally, homemaking and unpaid family caregiving can be cognitively enhancing. It has been argued that cognitive benefits from unpaid family caregiving—particularly parenthood—come from learning new tasks. Fewer studies have investigated the linkage between other types of non-employment (such as unemployment, illness) and cognitive functioning. It can be assumed that different situations leading to non-employment (e.g. parenthood, illness, unemployment) may also influence cognitive functioning at later ages (Leist et al. 2013). To sum up, various life course models provide different opportunities for cognitive reserve accumulation and cognitive stimulation via full-time employment, part-time employment, family caregiving and other unpaid activities.

Research indicates that biological and behavioural reasons for dementia are partly gender-specific (Artero et al. 2008; Ferretti et al. 2018). Some studies emphasize biological differences in brain ageing, e.g. due to stress (Snyder et al. 2016), or link biological differences in brain aging to possible roles of oestrogen and other sex hormones (Zarate et al. 2017). Yet, the role of these hormones is not an established finding, but an open research question that needs further attention (Snyder et al. 2016). With regard to behavioural factors, men and women show different health-promoting or risky behaviours, such as smoking, drinking, nutrition and exercise (Schünemann et al. 2017); however, associations between dementia-relevant risk factors and dementia are largely similar between the genders (Sindi et al. 2021; Geraets and Leist 2023). A promising way is to investigate life courses, as men and women differ considerably with regard to their participation in paid employment and unpaid activities, as well as family roles (Madero-Cabib and Fasang 2015; McMunn et al. 2015).

While a growing number of studies investigate how participation in employment relates differently to men's and women's cognitive functioning, fewer studies examine how these linkages depend on the macrosocial context (Engelhardt et al. 2009; Ice et al. 2020). Sociologists argue that consequences of biographies for later-life health are context-sensitive (Mayer 2018; Struffolino et al. 2016), as social contexts shape opportunities for the accumulation of health risks and protective resources (Ferraro and Shippee, 2009). More specifically, macrosocial contexts, with their gender cultures and welfare regimes, create opportunities for (gendered) accumulation of cognitive reserve both early in life (e.g. via education) and later in life (e.g. via gendered caregiving expectations and women's labour market participation) (Weber et al. 2014; Wu et al. 2016). Comparative research shows that women's employment biographies vary substantially across Europe (Van Winkle 2018). Studies evaluating context-level opportunities for accumulating cognitive resources refer to women's access to education (Leist et al. 2021) and gender ideologies as drivers of gender gaps in cognitive functioning (Bonsang et al. 2017).

To sum up, while there is growing evidence of the importance of work intensity and family roles as micro-level mechanism to explain later-life cognitive functioning, and ample evidence on the role of gender cultures and gendered welfare regimes as macro-level influence on later-life health, few studies have addressed these two factors jointly, establishing micro–macro linkages needed to understand life course outcomes in their contexts (Mayer 2018). To study how different forms of previous (non-)employment affect later-life cognitive functioning according to gender cultures in macrosocial contexts is thus a highly promising way to understand this major challenge for ageing societies. We add to this emerging literature by investigating heterogeneity in the linkage between previous employment and cognitive functioning between men and women, and between societal contexts.

Protective resources and risks factors for cognitive functioning in older age

Cognitive decline is a normal feature of aging (Salthouse 2010). As people age, their cognitive abilities start to decrease. "Cognitive reserve" refers to the set of cognitive skills and resources that are formed early in childhood and youth and accumulate across the life course (Stern 2002). Nevertheless, we observe substantial heterogeneity in cognitive functioning among the older population, both in terms of starting levels and speed of the decline trajectory. Cognitive functioning at older ages has been widely studied. Findings point to biological, behavioural, psychological, relational, social and macrosocial preventive and risk factors for cognitive decline. Biological factors include genetic risk and cardiovascular health, but also heightened levels of stress hormones, which has been shown to affect brain structures negatively (McEwen 2000). Behavioural factors comprise health behaviour, including smoking, nutrition, and exercise, and leisure activities which are cognitively stimulating, e.g. doing quizzes, puzzles or reading (Ihle et al. 2018). Psychological factors that may lead to faster cognitive decline include impaired mental health, most prominently depression, which has been shown to be a relevant risk factor for dementia (Livingston et al. 2020). Moreover, stress, which is often of psychological origin (Pearlin et al. 1981), also constitutes a risk factor for cognitive decline (Agbenyikey et al. 2015). Relational factors include social networks, regular contacts, volunteering and family relations, such as being partnered (Bertogg and Leist 2021) or looking after grandchildren (Arpino and Bordone 2014). Social factors include social class and living conditions, whereas macrosocial factors refer to the welfare context with its public health services and the cultural context with its normative ideals and prescriptions. These factors are not isolated but intersect across the life course. For instance, cardiovascular risk is the consequence of health behaviour, and changes in the family structure may trigger stress with cognitive consequences (Vidarsdottir et al. 2014).

The role of employment and non-employment activities for cognitive functioning

To sum up, cognitive reserve is developed mainly earlier in life, while risk factors and resources *accumulate* over the entire life course. Employment is an important resource for cognitive functioning in later life. Its benefit emerges via two mechanisms. First, participation in the labour market provides opportunities for *cognitive stimulation*. This particularly applies to high-skill jobs, which are often characterized by higher degrees of occupational complexity and agency. Occupational complexity includes demanding work tasks and is linked to higher levels of cognitive functioning and lower risk of dementia (Andel et al. 2015; Finkel et al. 2009; Kröger, et al. 2008). Agency, i.e. a higher level of control over one's workflows and tasks (Nexø et al. 2016; Then et al. 2014), is also associated with higher cognitive performance (Ford et al. 2021).

Second, studies document the *socio-emotional* benefits of being employed. Employed persons are exposed to regular social interactions and have larger a larger network of "weak" ties at their workplace (Berkman 2014; Granovetter 1983). Moreover, employment benefits well-being by providing a sense of purpose and community (Hinterlong et al. 2007; Rozario et al. 2004), which—in combination with family tasks—increase well-being.

Even though there is considerable institutional variation in Europe, shaping opportunities for labour market participation and the need for family-based care (Pfau-Effinger 2005; Saraceno and Keck 2010), men's and women's employment biographies differ substantially from each other within most countries, both in terms of quantity (i.e. duration and intensity) and quality (i.e. occupational complexity and agency) of lifetime exposure to employment (Madero-Cabib and Fasang 2015; McMunn et al. 2015). In the 19 countries studied in this article, men have spent on average over 90% of their life between 20 and 50 years in full-time employment, whereas full-time employment of women comprised only 66% of that time span. Moreover, among women, being a homemaker (10% of the time) or working part time (15% of the time) was much more common than among men (homemaking: 0.12%; part-time 2% of the time between ages 20 and 50).

Evidence suggests that the duration of exposure to (full-time) employment matters for later-life cognitive functioning (Greenberg and Burgard 2021), and that men and women may have similar returns (Ford and Leist 2021). The main mechanism brought forward in the literature refers to *cognitive stimulation* (Lövdén et al. 2020). Hence, it is plausible to assume that the more years someone has spent in full-time employment, the better their cognitive functioning in later life (H1). The benefits of full-time employment in terms of well-being and health are expected to extend to part-time employment as well. This is in line with role expansion theory (Thoits 1983; Nordenmark 2004), which argues that having *multiple roles* is beneficial, because multiple types of activities generate different resources (such as income, social network ties, satisfaction and a sense of purpose) that complement each other. However, having too many roles simultaneously or experiencing work-family reconciliation conflict may create *role overload* and generate stress which might negatively affect cognitive functioning (Sabbath et al. 2015; Chandola et al. 2006). Yet, the benefits from work-related *cognitive stimulation and multiple roles* should outweigh the potentially stressful effects of having to combine work and family. Being a (part-time) worker next to caregiving tasks or motherhood has been shown to be beneficial for well-being and health (Hinterlong et al. 2007; Rozario et al. 2004; Webber and Williams 2008). We thus assume that, previous part-time employment, similar to previous full-time employment, has beneficial effects on cognitive functioning later in life (H1).

Non-employment activities can be distinguished according to their cognitively enhancing potentials. Cognitive benefits may also emerge from non-employment activities which foster cognitive stimulation via *learning new skills*, or which foster complexity in everyday life. This includes being a homemaker and family caregiver. Particularly childbearing requires parents to acquire new skills and competencies during each phase of development of the child (Richards and Hatch 2011). Periods off work due to maternity have been shown to go along with lower cognitive decline in women as compared to periods off work without maternity, suggesting that a balance between work and family commitments can be beneficial for women (Leist et al. 2013). Even in the older birth cohorts studied in this article, most women have participated in the labour market before and after maternity. Hence, periods off work dedicated to homemaking are another way of combining employment careers and family roles across the life course. Similar to part-time workers, homemakers, too, may accumulate several social roles across phases with different paid and unpaid activities. Longer periods of time spent in homemaking may thus also be beneficial for cognitive functioning.

On the other hand, having been away from the labour market may hamper the chances of re-entry into the labour market, particularly into a position with higher complexity, autonomy and cognitive stimulation. An alternative argumentation postulates that longer spells spent in homemaking (if not combined with part-time employment) are associated with lower levels of cognitive functioning. To the best of our knowledge, these assumptions have not been tested yet. The finding that women who were exclusively homemakers exhibit stronger cognitive decline as compared to women who work full-time or combine work and care via part-time employment supports the latter idea (Leist et al. 2013). Overall, the second line of argumentation seems thus more plausible, motivating our second hypothesis assuming that longer time spent in homemaking should be associated with lower levels of cognitive functioning (H2).

Non-productive time away from work seems thus to pose the greatest risk of cognitive functioning (H3). As one prominent example for non-productive non-employment, unemployment has been shown to be negatively associated with cognitive functioning, although here selection effects could play a role (Leist et al. 2013; Abrassart 2013). Retirement is another type of labour market non-participation. Evaluating the link between retirement and cognitive functioning is complex since selection into retirement needs to be accounted for. Accordingly, results are mixed (Bonsang et al.*,* 2017; Celidoni et al. 2017). Besides unemployment and retirement, there are still other types of non-employment, which include the inability to work due to ill health or disability, or being institutionalized, but also being in education, or travelling. Hence, there are a number of very heterogeneous non-productive inactivities, which may have differential effects on cognitive functioning (Leist et al. 2013). Few studies have investigated the distinct reasons for non-employment and their influence on cognitive reserve and cognitive functioning at later ages in detail. Because most of these activities occur quite rarely, a separate analysis of each of them is challenging and out of the focus of this study. We thus combine these different states into one single category, differentiating them only from unemployment.

We hence distinguish between five previous activities: full-time employment, part-time employment, homemaking, unemployment and other activities, for which we can formulate hypotheses. To sum up, we expect the following:

H1 The longer the time an individual has spent in full-time and part-time employment between the ages of 20 and 50 years, the higher their levels of later-life cognitive functioning.

H2 The longer the time an individual has spent in homemaking between the ages of 20 and 50 year the lower their levels of later-life cognitive functioning.

H3 The longer the time an individual has spent in unemployment and other non-productive activities between the ages of 20 and 50 years, the lower their levels of cognitive functioning.

The general expectation is that paid employment, homemaking and the combination of both (e.g. in the case of part-time work) can all be cognitively enhancing the longer an individual has spent in these states. When compared relative to each other, the benefits of these three states may vary. Since it is yet not clear from the literature whether part-time employment carries the same cognitive benefits as full-time employment, or whether combining family tasks and work via part-time employment carries similar cognitive potentials as being a homemaker, we need to analyse these various aspects of previous (non-)employment biographies separately, hence also the separate hypotheses.

Moreover, these associations could be gender-specific, although the literature yields mixed findings on gender-specific employment-cognition relationships. Based on gender-role socialization, men and women exhibit different behaviours and fill in different social roles (West and Zimmerman 1987), and this also affects employment and family life courses (Moen 2001). The gender roles men and women are socialized with are shaped prevailing gender norms in the societal context. As has been shown for Europe, these norms vary not only between countries, but also within countries, across cohorts (Shorrocks, 2018). Moreover, women exhibit more egalitarian gender role attitudes than men in all countries studied. Men and women thus not only differ in their exposure to work-related cognitive stimulation and multiple role benefits; the benefits from these different activities may also be different for men and women. Particularly, having *multiple roles* may be more beneficial for women than for men. In most Western countries, even women in older birth cohorts have some formal education and training, preparing them for participating in the labour market. Yet, their cultural socialization has prepared them for being family caregiver, enabling them to adapt to both environments.

Men, in contrast, were less prepared to take on family care tasks in the context of their socialization and are still less likely to take on housework or retire early, even if they earn less than their wives (Hank and Jürges 2007; Bertogg et al. 2021). Some studies found that men are penalized on the labour market for being a family caregiver or for working part time (Coltrane et al. 2013; Fernandez-Lozano et al. 2020), which may offset some of the benefits stemming from multiple roles. Overall, one can thus assume that women, with their double socialization, may have larger benefits from reconciling employment and family via part-time employment. Not least, departing from less favourable economic positions than men, women's cognitive gains via employment participation may be more pronounced than men's. In order to shed light on gender-specific cognitive benefits of part-time employment, we analyse men and women separately and assume the following:

H4 The beneficial effects of earlier part-time employment and homemaking are stronger for women than for men.

Context-sensitive patterns of later-life health

Macrosocial characteristics have been shown to influence both levels and changes in cognitive functioning, as well as gender differences therein. Evidence stems from various research designs, which systematically examine how the context influences the accumulation of cognitive reserve, or shapes individuals' exposure to protective and risk factors. Natural experiments regarding the length of compulsory schooling (Glymour et al. 2008; Schneeweis et al. 2014), and multilevel modelling testing the role of inequality of educational opportunity for men and women (Leist et al. 2021), have confirmed that the accumulation of cognitive reserve through early-life education depends on the opportunities provided by the context. Regarding the role of unemployment as a risk factor, studies have found that economic downturns—particularly during young adulthood, the phase in which cognitive reserve is accrued—influence cognitive functioning negatively (Leist et al. 2014).

A less explored source of macrosocial contextual influence lies in opportunities for work-related cognitive resource accumulation via cognitive stimulation. First studies have shown that strong welfare states reduce gender and class gaps in physical health in later life (Sieber et al. 2020; Uccheddu et al. 2019). Moreover, participation in various paid and unpaid activities was associated differently with cognitive development across eleven European countries (Engelhardt et al. 2009). These studies indicate that health gaps arising from (women's) weaker economic positions are moderated by welfare institutions. It is often argued that cultural norms drive women's and men's different decision regarding labour market participation and multiple social roles (Pfau-Effinger 2005). Yet, with regard to cognitive functioning, no study has so far tested the role of gender norms for levels of cognitive functioning, or its moderating role of the cognitive benefits stemming from different employment-related experiences.

Social norms and consequences of employment biographies

Traditional gender norms restrict women's access to educational opportunities, which are crucial for building cognitive reserve (Roxo et al. 2021b; Weber et al. 2014). They also promote "standard models" of breadwinning and caring. Such standard models serve as frames of orientation for men's and women's family and labour market decisions and shape their employment biographies. Via these two mechanisms, gender norms may directly influence the accumulation of cognitive resources. Gender norms also work indirectly, by moderating the effects of life courses employment biographies on cognitive outcomes.

Social norms impose sanctions and "punish" individuals who deviate from standard models. Negative social sanctions often comprise social exclusion, stigmatization and reduced well-being. Compliance with norms, on the other hand, is "rewarded", promoting gain in social status, integration and well-being (Elster 2009). As social integration and mental health are important resources for cognitive functioning, cognitive enhancement should depend on *how well one's own life course fits with prevailing normative ideals*. Punishment for deviation may offset some of the benefits associated with work-related cognitive stimulation or occupying multiple roles, as negative social sanctions block social interactions needed for these benefits to emerge (Elster 2009). Conversely, reward may reinforce the benefits associated with employment or multiple roles. Such benefits are likely reinforced when individuals occupy high social status, interact frequently and high levels of well-being. Several studies show that the well-being and labour market consequences of caregiving differ according to the normative context (Verbakel 2014; Bertogg 2022). We assume that:

H5 ("punishment") In contexts with stronger gender norms, individuals whose employment biography deviates from normative ideals (i.e. full-time working women, part-time working or homemaking men) exhibit lower levels of cognitive functioning than in contexts with weaker gender norms.

H6 ("reward") In contexts with stronger gender norms, individuals whose employment biography conforms with the normative ideal (full-time employed men, part-time employed or homemaking women) exhibit higher levels of cognitive functioning than individuals whose employment biography does not conform with the normative ideal.

Data and method

Sample

This study draws on the Survey of Health, Ageing and Retirement in Europe (SHARE). We use waves 1–2 and 4–7 (collected between 2004 and 2019), as well as retrospective SHARELIFE interviews, which were collected first in wave 3 (2008, purely retrospective interview), or wave 7 (2017, mixed wave: retrospective and reduced panel for those respondents who did not take part in wave 3, and "normal" panel wave for those who did). Since not all countries ever sampled feature two full panel waves, we use data collected in 19 European countries (Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland).

SHARE waves 1 through 7 collected information from more than 119,000 participants living in a private home, who were observed in more than 300,000 person-year observations. We limit our analytical sample to those aged 50–75 years of age in order to avoid survivor bias and attrition selective on cognitive abilities in high old age. The selected age range includes 78% of the original sample. We exclude all respondents who have been diagnosed with dementia or brain cancer (see Ngandu et al. 2015), since we are interested in cognitive decline as an early hallmark for dementia and not progressed forms thereof (Albert 2011), or score high on depression scale (2 + SD above the mean), as depression impairs recall abilities. These three steps reduce our analytical sample to 96,466 persons. After excluding respondents who only took part in one panel wave (and hence, cannot be analysed longitudinally), we observe 74,519 participants in our sample 214,447 times (the eligible sample).

As our analyses rely on information regarding previous employment biographies, which were captured retrospectively in SHARELIFE interviews, we had to exclude all respondents for whom no SHARELIFE interview was available. In total, 72,173 only (about sixty per cent of the ever sampled respondents) took part in SHARELIFE and provided full information on previous employment. Among our analytical sample, 57,558 respondents (or 77% of the eligible sample for this study) answered the retrospective questionnaire, resulting in 180,509 valid person-year observations. Finally, we exclude all person-year observations with missing values on the dependent or explanatory variables (listwise deletion). This leaves us with 114,357 person-year observations nested in 43,860 respondents.

To sum up: from the overall SHARE sample, 62% are eligible due to age, health and panel participation. From the eligible sample (n = 74,519 persons), we retain 59% for analysis. A major part of lost cases (23%) can be attributed to unavailability of retrospective interviews, and around 19% being attributed to missing data on either the dependent variable (5%) or the explanatory variables (14%).

Cognitive tests

A composite sum score from three cognitive tests serves as outcome variable. It measures three important dimensions of cognitive functioning, namely short-term and long-term memory, as well as executive functioning. These cognitive tests have been used for composite scores of cognitive functioning in different variations (Ford et al. 2021; Leist et al. 2021). Short-term and long-term memory consists of a ten-word learning list, which was captured with an immediate, respectively, delayed recall test. These scales range from 0 (no word remembered) to 10 (all ten words remembered). The third measure consists of a verbal fluency test, in which respondents were asked to name as many animals as they could in one minute (the observed values ranging between 0 and 100 animals). On average, respondents remembered 5.7 words at the immediate recall and 4.4 at the second, delayed recall, and named a total of 21 animals (SE 7.6). After standardizing the verbal fluency test to range from 0 to 10, by dividing the realized value by ten, the three scales were added up with a weight of 25% for each of the memory tests and 50% for the verbal fluency test. The final composite score ranges from 0 to 20. The average value on this composite score of cognitive functioning is 7.2 with a standard deviation of 2.1 (women's mean: 7.4, men's mean: 6.9). For our analyses, this score is z-transformed (yielding a mean of zero and a standard deviation of one); one unit corresponds to ten animals named or one word remembered.

Previous employment biographies

In the SHARELIFE spell data, respondents provided information on their employment status for each year of life since completing education, or the age of fifteen, up to the interview. We recoded the original eighteen employment categories into five dichotomous variables, which—for each person and year of life—indicate whether the person has been in full-time employment (at least 31 working hours per week), part-time employment (max. 30 working hours per week), has been a homemaker, unemployed or "other". "Other" combines all remaining non-employment spells, (such as disabled, travelling, volunteering, military service, being institutionalized or being education), which only occurred with low frequencies. The five dichotomous variables are mutually exclusive: individuals coded as being "full-time" employed at age 27 receive the value "0" on the other four variables. For each respondent, we aggregated these dichotomous variables over the age span from 20 to 50. This leaves us with five continuous variables ranging from 0 to 100, indicating the percentage of years between ages 20 and 50 spent in the respective state (see Figure A.1 in the supplementary files). Two retrospective control variables were computed the same way, namely: the percentage of time one lived with a partner (married or cohabiting) and the average number of children that one lived with during those 31 years.

Gender norms

The measures for gender norms are derived from three rounds of the European Social Survey (ESS): round 2 (2004), round 4 (2010) and round 8 (2016). We aggregated the (weighted) percentage of *agreement* to the following two statements indicating two different aspect of gender norms: "Men should have more right to job than women when jobs are scarce" and "Women should be prepared to cut down on paid work for sake of family". Higher agreement rates indicate a preference for a stricter gendered division of labour in the population. While this approach to measuring gender norms is quite novel in the analysis of later-life health, it has been used to explain retirement timing (Bertogg et al. 2021), well-being in the general population (Hagqvist 2016) and among informal caregivers (Verbakel 2014) and has been shown to contribute to explain gender gaps in cognitive functioning globally (Bonsang et al. 2017). Since gender role attitudes vary within countries—across time and birth cohorts (Inglehart 2002; Ebner et al. 2020)—we calculated the agreement rates separately for men and women from different birth cohorts in each country. Agreement ranges between 1 and 82 per cent (men have right to a job), respectively, 9 and 88 per cent (women should cut down) and vary considerably across birth cohorts countries (see Table A.2 and Figure A.5 in the supplementary files for the dispersion of values).

Gender norms, however, may also be associated with the economic well-being of a country (such as GDP per capita) or structural gender inequalities (such as women's access to education and employment, life expectancy and political representation of women). In order to rule out that our findings are driven by the proposed normative mechanism of punishment and reward and not structural opportunities, we estimated robustness models adjusting for these variables. Women's labour market participation or opportunities for full-time vs. part-time work may also depend on family policy characteristics. Hence, we additionally estimate models adjusting for country fixed effects.

Covariates

To capture individual trajectories in cognitive functioning, the most important covariate in our models is the passing of time since the first measure (baseline). We created a time variable which takes on the value "0" at first observation and denotes the number of years since first observation for each subsequent observation. In order to allow for non-linear cognitive trajectories, we include a square term.

Further, we adjust for a number of important individual-level socio-demographic characteristics which influence both health risks and previous employment patterns. These variables include age at baseline as well as the square term thereof, in order to adjust for lower levels of cognitive functioning among those who entered the panel at later ages. We include information on birth cohort, which we use to match the norm variables to, with five categories: born before 1930, born 1930–1939, born 1940–1949, born 1950–1959 and born after 1959. Given that we control for cohort, age at baseline and time have to exclude period effects. Social stratification variables which affect both cognitive levels and employment trajectories are an individual's highest educational level (ISCED 1 or 2, ISCED 3 or 4, ISCED 5 or 6, or not available). Another—subjective, but country-comparable—indicator for socio-economic status is the self-reported ability of the household to "make ends meet". Finally, we control for whether one was born in the country (1 = yes).

As important correlates of impaired cognitive functioning and dementia, we control for physical health limitations (an index of mobility and functional health limitations) and depression, measured with the EURO-D scale. We control for whether one has received help or care due to health issues in the past 12 months.

Further control variables include information on respondents' current life course situations and family roles at the time of the interview: we add current employment status (full-time, part-time, retired, inactive), civil status (married, repartnered, single, divorced, widowed) and the number of children and grandchildren (biological and non-biological, co-residing with the respondent or not), measured with two continuous variables. Representing family roles, we control for whether one has provided help or care to someone in the past 12 months.

Finally, we include five variables for cognitively stimulating job characteristics and behavioural factors which can mitigate cognitive decline. Occupational complexity is measured with two dichotomous variables: a high degree of autonomy and control at work, and the need to learn new things. These characteristics were asked for the current job among respondents still working and otherwise asked for the last job for those retired or not working. We further include the sector of concurrent or last employment by collapsing the 1-digit ISCO-88 of respondents' concurrent or last occupation into four categories (agriculture, manufacturing, low-skill service and high-skill service). Cognitively stimulating activities are captured using two dummy variables: at least weekly participation in volunteering, associations, or clubs ("social activities"), and at least weekly doing puzzles or quizzes, or taking part in educational courses ("educational activities").

Analytical strategy

Observing respondents several times allows us to exploit the longitudinal variance both within and between individuals. We estimate Linear Random Effects Growth Curve models, with person-year-observations nested in persons. These models adjust for individual trends by including the time-variable with a random slope at the higher level. All models are estimated using Stata Version SE 16.1 using the *mixed* command. In the first step, we investigate the association between previous employment biographies and cognitive functioning using stepwise model building. In the second step, we enter separately the country-, cohort-, and time-specific gender norms variables. Finally, we investigate whether gender norms moderate the linkage between previous (non-)employment and cognitive functioning, by including interaction terms between these variables. All models are estimated separately for men and women.

Results

Employment biographies and cognitive functioning

Figure 1 displays the association between durations of previous (non-)employment and cognitive functioning (Table 1 for coefficients). As the durations in all five states sum up to 100 per cent, we have to omit one of the variables, selecting full-time employment, as it is the most common state, which men (> 90%) and women (66%) have been in. When adjusting only for the time trend, age at baseline and birth cohort, we find that both men and women benefit from longer aggregate durations in part-time employment and in the "other" category (including higher education and training), supporting H1. Both genders have lower cognitive scores the more time they spent in unemployment or homemaking, supporting H2.

When including all other covariates, however, most of these results are no longer statistically significant at $p < 0.05$ for men, however, and effect sizes decrease for women. This indicates that the current situation, such as being employed, partnered, having children, mediates the effects of previous (non-)employment. When including country fixed effects to adjust for context-specific education and employment opportunities, women's previous unemployment experiences are no longer statistically significant at $p < 0.05$.Thus, when adjusting for potential confounders and mediators, H1 and H2 only hold for women.

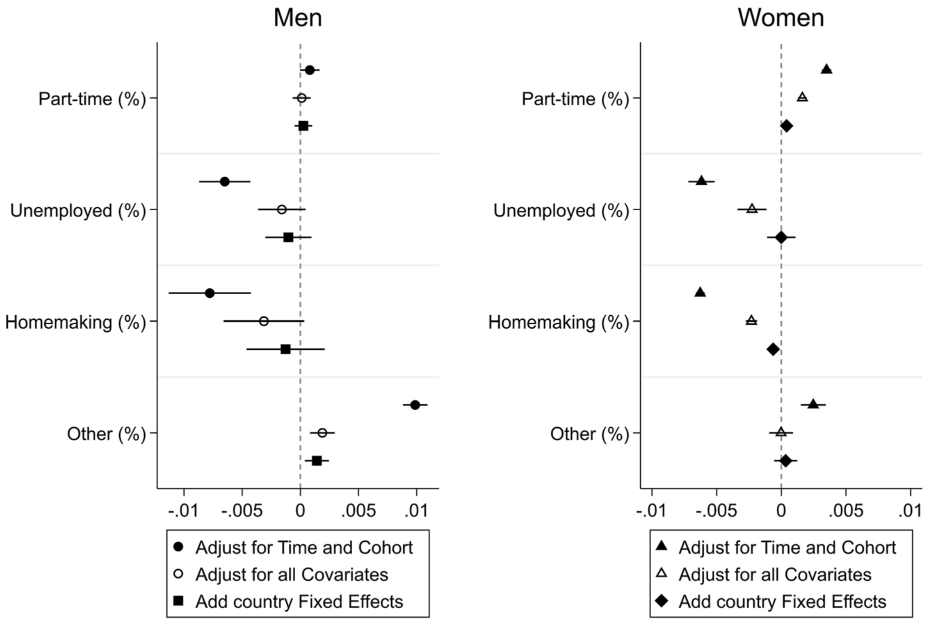

Fig. 1 Effects of Duration of Previous (Non-)Employment on Cognitive Functioning Legend: SHARE, waves 1–2, 4–7, respondents aged 50–75 years without diagnosis of brain cancer or Alzheimer's, observed at least twice, with valid information on the retrospective survey (wave 3 or 7). Multilevel Growth Curve models, stepwise model building. Model estimates in Table A.4 in the supplementary files. X-axis: Effect on z-standardized composite score (memory + verbal fluency, range (original metric): 0–20, 1SD = 6 scale points)

Table 1 Associations of Previous Employment Characteristics and Sociodemographic Covariates with Cognitive Score

	Women		Men	
	Full model	+Country FE	Full model	+Country FE
Part-time (%)	0.002^{***}	0.000^{*}	0.000	0.000
Unemployed (%)	-0.002^{***}	-0.000	-0.002	-0.001
Homemaking (%)	-0.002^{***}	-0.001^{**}	-0.003	-0.001
Other (%)	-0.000	0.000	0.002^{***}	0.001^{**}
Lives with partner (%)	0.083^{***}	0.070^{**}	0.164^{***}	0.116^{***}
Lives with children (%)	-0.031^{***}	-0.033^{***}	-0.036^{***}	-0.030^{***}
Time	0.032^{***}	0.028^{***}	0.034^{***}	0.031^{***}
Time, squared	-0.003^{***}	-0.003^{***}	-0.004^{***}	-0.004^{***}
Birth cohort: before 1930 (ref.)				
1930–1939	0.013	-0.003	0.093	0.042
1940–1949	0.133	0.129	0.233^{**}	0.158^{*}
1959–1959	0.268^{**}	0.291^{**}	0.406^{***}	0.327^{***}
1960 or younger	0.397^{***}	0.422^{***}	0.590^{***}	0.495^{***}
Age at baseline	0.087^{***}	0.088^{***}	0.088^{***}	0.089^{***}
Age at baseline, squared	-0.001^{***}	-0.001^{***}	-0.001^{***}	-0.001^{***}
Number of functional limitations	-0.024^{***}	-0.023^{***}	-0.026^{***}	-0.027^{***}
ISCED 1 or 2 (ref.)				
3 or 4	0.377^{***}	0.319^{***}	0.322^{***}	0.245^{***}
5 or 6	0.649^{***}	0.605^{***}	0.569^{***}	0.501^{***}
Education: n.a	-0.289^{***}	-0.173^{***}	-0.284^{***}	-0.200^{***}
EURO-D depression scale	-0.024^{***}	-0.024^{***}	-0.029^{***}	-0.030^{***}
Vigorous weekly workout	0.042^{***}	0.038^{***}	0.049^{***}	0.039^{***}
Moderate weekly workout	0.084^{***}	0.076^{***}	0.073^{***}	0.064^{***}
Current employment: Full time (ref.)				
Part-time	-0.009	-0.012	-0.013	-0.007
Retired	-0.060^{***}	-0.039^{***}	-0.072^{***}	-0.049^{***}
Inactive	-0.090^{***}	-0.062^{***}	-0.061^{***}	-0.047^{***}
Sector: Agriculture (ref.)				
Manufacturing	0.100^{***}	0.036	0.081^{***}	0.063^{***}
Service, low-skill	0.119^{***}	0.063^{**}	0.097^{***}	0.096^{***}
Service, high-skill	0.175^{***}	0.109^{***}	0.177^{***}	0.172^{***}
Social activities at least weekly	0.121^{***}	0.098^{***}	0.108^{***}	0.084^{***}
Educational activities at least weekly	0.092^{***}	0.089^{***}	0.061^{***}	0.060^{***}
Married or cohabiting (ref.)				
Repartnered	0.025	-0.030	0.033	-0.018
Single	0.008	-0.004	-0.123^{***}	-0.161^{***}
Divorced	0.036^{**}	-0.003	-0.003	-0.041^{**}
Widowed	-0.029^{*}	-0.031^{*}	-0.049^{*}	-0.063^{**}
Number of children	0.016^{***}	0.018^{***}	0.006	0.010^{*}
Number of grandchildren	0.010^{***}	0.003	0.006^{**}	-0.002
Given help or care to others	0.048^{***}	0.041^{***}	0.049^{***}	0.037^{***}
Received help or care from others	0.024^{**}	0.006	0.010	-0.004
Household makes ends meet: easily (ref.)				
With some/great difficulty	-0.078^{***}	-0.043^{***}	-0.105^{***}	-0.068^{***}
Information n.a	-0.051^{***}	-0.040^{***}	-0.064^{***}	-0.054^{***}
Born in country	0.134^{***}	0.209^{***}	0.129^{***}	0.190^{***}
Country fixed effects	No	Yes	No	Yes
n (person-years)	59,425	59,425	55,922	55,922

Source: SHARE, waves 1–2, 4–7, SHARELIFE. Respondents aged 50–75 years without diagnosis of brain cancer or Alzheimer's, observed at least twice, with valid retrospective interview. Multilevel Growth Curve models

Macrosocial differences in cognitive functioning

The next step turns to macrosocial differences. We assumed that gender norms both directly and indirectly affect cognitive potentials. As Fig. 2 indicates, individuals living in contexts with more traditional gender norms show lower levels of cognitive functioning. This association is highly significant and remains significant when adjusting for covariates and employment biographies (see Table A.4).

Finally, we investigate how gender norms moderate the association between employment biographies and cognitive functioning (Table 2). We assumed that the cognitive benefits of being exposed to work-related cognitive stimulation and multiple roles only apply to those men and women whose employment biographies conform to normative prescriptions (reward), whereas cognitive levels should be lower among those who deviate from the normative ideal (punishment). As expected (H4, punishment), we find that men's longer time in part-time employment is associated with lower cognitive functioning in contexts with higher overall agreement to the norm that "men should have more right to a job than women". Confirming our expectations (H5, reward), we find that women's longer time in part time is associated with higher levels of cognitive functioning in contexts with higher overall agreement to the norm that "women should cut down on their jobs for the sake of the family". Longer spells of unemployment or homemaking among women are negatively associated with cognitive functioning, and this effect is stronger the more traditional the gender norms. This is counter to what we had expected from H5. The highly significant "main effect" of gender norms reflects a general negative correlation for those who with previous full-time employment. For women, this could be expected (H4, punishment). For men, this finding is surprising; men do not seem to benefit from a protective effect of full-time employment when gender norms are strong.

In order to interpret these findings in a more intuitive way, Fig. 3 shows predicted probabilities for four ideal–typical groups with various (non-)employment states. Groups were interacted with an index of both norm measures (see Figure A.1 and Table A.3 in the supplementary files). For all four typical groups, we find lower levels of cognitive functioning the more traditional the gender norm (downward pointing slopes). The degree to which stronger norms are associated with lower cognitive functioning depends on individuals' biographies. Men have a slight benefit from having worked part time—but only in contexts where gender norms are egalitarian. In gender traditional contexts, they "lose" this advantage. Women whose biography comprised substantial part-time employment are not significantly different from women who predominantly worked full-time in contexts with egalitarian gender norms, but part-time becomes advantageous in contexts with more traditional gender norms.

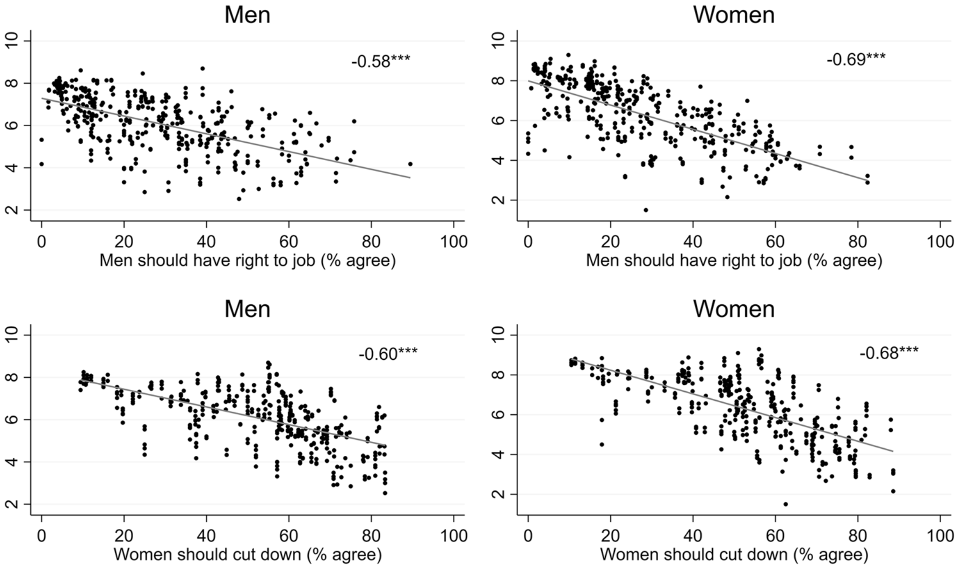

Fig. 2 Bivariate Correlations of Cognitive Scores with Gender Norms Across Countries, Survey Years and Birth Cohorts Legend: Bivariate correlations, scatterplots with regression line. Y-axis: Average cognitive functioning scores by country, cohort and survey year (micro-level data: SHARE waves 1–2, 4–7, respondents aged 50–75 years without diagnosis of brain cancer or Alzheimer's, observed at least twice, with valid information on the retrospective survey (wave 3 or 7)). X-axis: Gender norm indicators (data source: ESS rounds, 4, 5 and 8). Weighted aggregated agreement to two statements (1 = (fully) agree). over countries, birth cohorts and survey years, by gender. n = 816 gender-cohort-country-years. Correlation coefficients: Pearson's r (two-tailed)

Table 2 Interaction Terms between Gender Norms and Previous Employment – Associations with Cognitive Functioning

Gender norm indicator	Men		Women	
	Right to job	Cut down	Right to job	Cut down
Men should have right to job (% agree)	− 0.007***		− 0.011***	
Women should cut down (% agree)		− 0.091***		− 0.104***
% Part-time	− 0.000	− 0.000	0.001**	0.001***
Part-time * Men should have right to job	-0.000**		0.000	
Part-time * Women should cut down		− 0.001		0.001***
% Unemployed	− 0.002	− 0.002	-0.002***	− 0.002***
Unemployed * Men should have right to job	0.000		-0.000	
Unemployed * Women should cut down		0.000		− 0.001
% Homemaking	− 0.002	− 0.002	− 0.002***	− 0.001*
Homemaking * Men should have right to job	0.000		− 0.000	
Homemaking * Women should cut down		− 0.004		− 0.001***
Control variables	Yes	Yes	Yes	Yes
Random Slope (time)	Yes	Yes	Yes	Yes
n (person-years)	55,922	55,922	59,425	59,425
ICC (person)	0.477	0.479	0.468	0.474

Legend: SHARE waves 1–2, 4–7, respondents aged 50–75 years without diagnosis of brain cancer or Alzheimer's, observed at least twice, with valid information on the retrospective survey (wave 3 or 7). Multilevel Growth Curve models, including all control variables. ICC = intra-class correlation. "Right to Job": "If jobs are scarce, men should have more right to a job than women" (% agree, centred). "Cut Down": "Women should prepare to cut down for the sake of the family" (% agree, centred). For robustness checks, see Table A.4

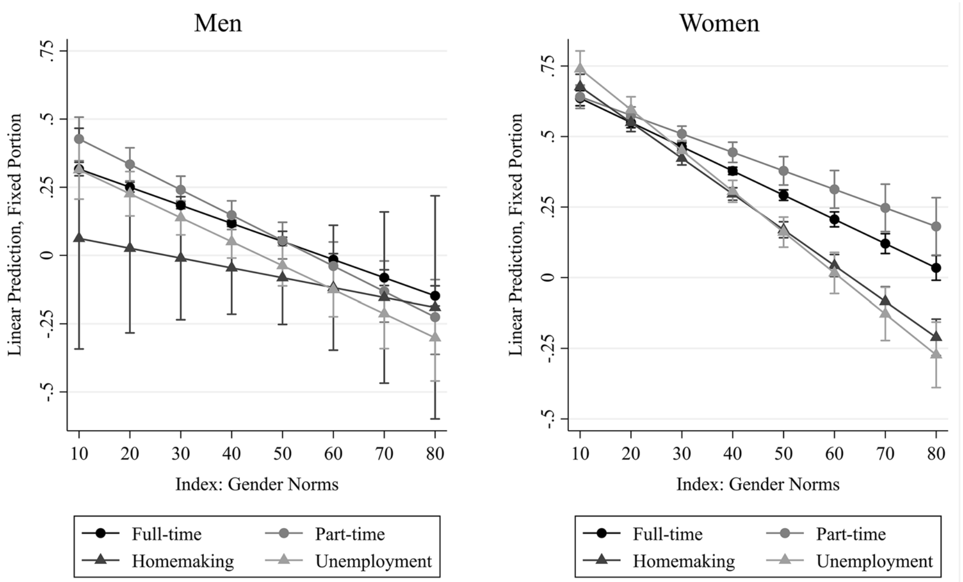

Fig. 3 Association of Typical Trajectories with Cognitive Functioning Across Gender Norms Legend: SHARE waves 1–2, 4–7, respondents aged 50–75 years without diagnosis of brain cancer or Alzheimer's, observed at least twice, with valid information on the retrospective survey (wave 3 or 7). Multilevel Growth Curve models with an interaction term between a gender norm index and typical trajectories. Gender Norm index: Both gender norms summed to an index ranging from 10–90 per cent agreement to either or both norms (Cronbach's Alpha = 0.83). Typical trajectories = Gender-sensitive categorical variable (4 groups) indicating typical patterns of previous (non-)employment between ages 20 and 50: Full-time (Men min. 90% full-time employment, women min. 66% full-time employment), Part-time (Men > 0% part-time employment, women min. 10% part-time employment), Homemaking (Men > 0% homemaking, women min. 10% homemaking), Unemployment (Men min. 10% unemployment, women > 0% unemployment)

In order to assess the robustness of our results, we included additional time-varying country-level variables regarding the economic situation (GDP per capita) and structural gender inequality (measured with the female employment rate among the 50- to 65-year-olds, and the Gender Inequality Index (GII)), and country fixed effects (separate models for each variable). GDP per capita and structural gender inequalities only partly mediate associations between gender and cognitive functioning for individuals with different labour market biographies. Thus, the cognitive benefits from egalitarian values work via another pathway than women's educational and labour market or economic development. Such differences may be rooted in countries' labour market policies, including social protection of part-time work (Nicolaisen et al. 2019). When controlling for country fixed effects, all interaction terms between previous employment and gender norms become insignificant. This suggests that heterogeneous patterns between individuals with different employment biographies may be explained by country-level factors.

Discussion and conclusion

This article extends on previous research on the importance of life-course factors for later-life cognitive functioning by focusing on the role of previous employment biographies. It takes a gender- and context-sensitive approach to evaluate the potentials of cumulative exposure to five different forms of (non-)employment between the ages of 20 and 50 for later-life cognitive functioning. In doing so, this study contributes to both the literature on cognitive aging and sociological research on life-course influences on health. Another contribution lies in the theoretical linkage between sociological theory and an epidemiological perspective on ageing. More specifically, we argue that both employment and family caregiving may come with cognitive benefits, and work via two mechanisms: work-related cognitive stimulation and multiple-role benefits.

Our results support these suggested mechanisms. We find that longer spells of both full-time and part-time employment are beneficial for cognitive functioning, supporting the idea of work-related cognitive stimulation. For women, we find that part-time employment—as a means of reconciling family tasks and professional careers—comes with higher cognitive benefits, supporting the idea of multiple role enhancement and confirming previous findings documenting a positive effect of part-time employment on physical health and well-being (e.g. Rozario et al. 2004; Webber and Williams, 2007). Longer spells of homemaking are less beneficial for cognitive functioning, as are longer spells of unemployment.

Moreover, our findings document considerable contextual heterogeneity in how previous employment biographies affect later-life cognitive functioning. Extending on previous studies on women's educational and employment opportunities, we focus on gender norms, measured as gender-, country-, cohort- and time-specific agreement to traditional male breadwinner and female caregiver roles. We find lower cognitive functioning among individuals in contexts where gender norms are more traditional. It can be assumed that a strict gendered division of labour blocks opportunities for experiencing multiple roles and hinders the accumulation of cognitive reserve for both genders. Furthermore, the association between previous part-time employment biographies and cognitive functioning is moderated by these norms. We find evidence for both *punishment* of deviation from traditional male breadwinner patterns, indicated by lower levels of cognitive functioning among men with previous part-time employment in gender traditional contexts, and *reward for compliance*, indicated by higher levels of cognitive functioning among women with longer spells of part-time employment in gender traditional contexts. These findings support our theoretical assumptions that negative social sanctions, such as exclusion and stigmatization, offset some of the cognitive benefits from part-time employment, while positive social sanctions, such as social integration and higher social status, reinforce these benefits.

Our findings have implications for policymaking. Enabling people to work and fostering reconciliation of paid employment and unpaid family care has been at the heart of social and family policy for decades. Yet, the long-term health consequences of lifetime work-and-care reconciliation are understudied. Our study documents the "long arm" of work- and family roles, as cognitive benefits or losses from previous employment accumulate up to advanced ages. Second, cognitive benefits seem gendered, with women being more susceptible to previous employment, while for men, the effects of previous employment biographies are largely absorbed by their current situation. This implies that for men, targeted interventions to improve cognitive functioning may ex post buffer the negative effects of earlier non-employment, for instance by addressing the current life situation and living conditions. For women, it should be more promising to promote the accumulation of cognitive benefits early in their careers. Women's educational opportunities for building cognitive reserve have greatly improved in most Western countries in the last five decades (Weber et al. 2014), and many pension systems today aim at keeping women in the labour market for as much time as possible (Ebbinghaus and Hofäcker 2013). Policy designs promoting the reconciliation of family and career which are equally attractive for men and women, and social investment strategies to bring non-workers back into the labour market independent of their gender and family situation, have the potential to decrease cognitive risks and balance inequalities in cognitive decline.

This study comes with some limitations. First, while our measures of gender norms have a high external validity, linking individuals with the norms agree to among persons from the same birth cohort and country, we have no individual information on whether respondents embrace these norms. Even though theory argues that norms may influence individuals' outcomes regardless of whether they embrace them (Elster 2009), individuals' own attitudes could be a critical moderator; one we cannot test in this study. Second, the two explanations (punishment, reward) are documented in the sociological literature, but we lack information to determine which mechanisms are exactly at work (e.g. reduced well-being, social exclusion). Thus, our analysis remains one of ecological, macrosocial factors, rather than individual attitudes. Third, due to data availability, we have to rely on a recent measure of gender role attitudes and are not able to measure the attitudes held at the time when the men and women in our study were socialized or took work- and family-related decisions. Fourth, certain previous employment spells remain rare (e.g. volunteering), limiting the power to detect their cognitively enhancing or limiting potentials. Finally, it remains speculative to compare the societal and cultural significance of particular types of work and non-work across heterogeneous contexts. For instance, the degree to which part-time is a proxy for precarious employment with little social protection depends on the specific welfare context (Nicolaisen et al. 2019). Part-time employment is particularly prevalent and protected in some continental European welfare states with rather traditional gender norms, and relatively inclusive and stable economies, such as Austria, Switzerland, Germany and the Netherlands. Our robustness analyses confirm this interpretation.

To sum, norms on the gendered division of labour extend their influence beyond working age. Both men and women bear negative cognitive consequences if they live in contexts with traditional gender norms, and these are further exacerbated if their life courses deviate from these norms. Only women may to some extent benefit from traditional gender norms, namely when adopting a part-time employment model. Our study contributes to the emerging strand of literature which employs sociological concepts to study social influences on one of the major epidemiological challenges in ageing societies. With our research design linking a life-course perspective with macrosocial influence in the form of social norms, we are able to explain heterogeneity between and within contexts. The systematic analyses of gendered life courses and gender differences in the health consequences of gender norms point to important interactions between norms and life-course factors in maintaining cognitive health up to advanced ages.

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CORRECTION

Correction: Social relations and exclusion among people facing death

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Correction to: European Journal of Ageing (2023) 20:1 https://doi.org/10.1007/s10433-023-00749-y

Following publication of the original article [1], the authors would like to change the corresponding author from Mia Niemi to Marjaana Seppänen.

The original article has been corrected.

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ORIGINAL INVESTIGATION

Subjective age and the association with intrinsic capacity, functional ability, and health among older adults in Norway

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Abstract

This study investigates the relationships between subjective age, intrinsic capacity, functional ability and health among Norwegians aged 60 years and older. The Norwegian Survey of Health and Ageing (NORSE) is a population-based, cross-sectional study of home-dwelling individuals aged 60–96 years in the former county of Oppland. Age- and sex-adjusted regression models were used to investigate the gap between subjective and chronological age and this gap's association with self-reported and objectively measured intrinsic capacity (covering all six sub domains defined by WHO), health, and functional ability among 817 NORSE participants. The results show most participants felt younger than their chronological age (86.5%), while relatively few felt the same as their chronological age (8.3%) or older (5.2%). The mean subjective age was 13.8 years lower than mean chronological age. Participants with incontinence, poor vision, or poor hearing felt 3.1 [95% confidence interval (CI) (0.6, 5.5)], 2.9 [95% CI (0.2, 5.6)], and 2.9 [95% CI (0.3, 5.5)] years older, respectively, than participants without those conditions, whereas none of the following factors—anxiety, depression, chronic disease, Short Physical Performance Battery score, grip strength, cognition, or frailty—significantly had an impact on the gap. In line with prior research, this study finds that feeling considerably younger than one's chronological age is common at older ages. However, those with poor hearing, poor vision, and incontinence felt less young compared to those not having these conditions. These relationships may exert undesirable effects on vitality and autonomy, which are considered key factors of intrinsic capacity and healthy ageing.

Keywords Subjective age · Intrinsic capacity · Hearing · Vision · Incontinence

Introduction

How old you feel defines your subjective age and has important relevance for social, health, and economic factors. One's subjective age relates to social relationships and comparison groups influencing self-perceptions of age (Settersten and Hagestad 2015). It is contextual and can depend on which groups on compares oneself to (Sayag and Kavé 2022). A literature review concluded that the most frequent themes considered when assessing older adults' self-perceived age were attitudes towards one's own ageing, own well-being, stereotypes of ageing, ageing identities, the ageing body, and one's future self-view (Hausknecht et al. 2020).

Chronologically older individuals tend to show a wider gap between their chronological and subjective ages, but that there is large individual variation (Shinan-Altman and Werner 2019). It is well-established that it is common for older adults to feel considerably younger than their chronological age (Pinquart and Wahl 2021) particularly if they have an active role in society (Rubin and Berntsen 2006; Gendron et al. 2018; Kwak et al. 2018; Stephan et al. 2018a, b). Being socially active, in good health and having more economic resources are associated with a younger subjective age relative to one's chronological age (Skirbekk et al. 2019; Hajek and König 2020; Ye and Post 2020). A younger subjective age relates to a host of outcomes concerning activity and social participation, such as Internet use among people 65 years old or older

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(Seifert and Wahl 2018). This indicates that subjective age and feeling young can be important for healthy ageing.

Subjective age

Health can have important implications for how old one feels and correlate with well-being (Kotter-Grühn et al. 2016). This important relationship can be reciprocal (Larkin 2013). Good health may promote a feeling of young subjective age, whereas the sense of feeling younger than one's chronological age may induce a positive health behaviour (Aftab et al. 2022), and lead to increased work participation and more income and savings (Ye and Post 2020). A younger subjective age relative to one's chronological age relates to better somatic and mental health, improved cognitive functioning, reduced hospitalization risks, and lower mortality (Stephan et al. 2018a, b; van Solinge and Henkens 2018; Hajek and König 2020; Schroyen et al. 2020; Ye and Post 2020). One study of 875 older women and men found that health as well as satisfaction with health accounted for one third of the variance in subjective age (Hubley and Russell 2009). Another study found that a younger subjective age was associated with a slower decline in functional health in a three-year follow-up study using the German Ageing Survey (Wettstein et al. 2021a, b). One Norwegian study found that wanting to be younger negatively related to life satisfaction and physical functioning over time, although variation in subjective age did not predict subsequent well-being or physical functioning (Veenstra et al. 2021). Moreover, depression is associated with both older subjective age and negative attitudes towards own ageing (Schönstein et al. 2021), whereas younger subjective age is associated with better subjective well-being and cognitive performance (Debreczeni and Bailey 2021).

Poor childhood health additionally relates to an older subjective age in adulthood and older age (Smith and Larkina 2021). Experiencing ageing-associated conditions such as grey hair, restricted mobility, and onset of chronic illness relatively early in life can lead to a feeling of being older, while conditions that are more temporary may not affect subjective age the same way (e.g. depression, viral infection, bodily aches, and exhaustion) (Leone and Hessel 2016; Agrigoroaei 2018; Stephan et al. 2018a, b; Sayag and Kavé 2022).

Particularly among older adults, a younger subjective age may help mitigate declining functional health (Wettstein et al. 2021a, b). Individuals who feel younger by a certain amount, but not more, have been found to have the highest levels of life satisfaction. This "optimal discrepancy" between subjective and chronological age widens across the adult age span—having an increasingly lower subjective age relative to chronological age relates to higher well-being as one grows older (Blöchl et al. 2021).

Intrinsic capacity

The World Health Organization (WHO) has defined *healthy ageing* as an "ongoing process of developing and maintaining the functional ability that enables well-being in older age" (Beard et al. 2016). Functional ability is defined as determined by the interaction of a person's intrinsic capacity (IC) and the environment. Whereas IC encompasses all physical and mental capacities, the environment in that context includes access to support that may facilitate functional ability and offer opportunities to exert control over that environment (Michel et al. 2021). Based on this conceptualization, the United Nations recently launched the Decade of Healthy Ageing (2021–2030) with the goals of monitoring and optimizing older people's functional ability for the benefit of both individuals and society (Michel et al. 2021). Meanwhile, other efforts have been made to construct common measures for healthy ageing to better compare results across cohorts and over time (Sanchez-Niubo et al. 2021). Although several scales measuring specific aspects of health and ageing have been developed, a comprehensive instrument for assessing IC and functional ability is still under debate (Bautmans et al. 2022). Nevertheless, Sanchez-Niubo et al. (2021) have used item-response theory to analyse relevant datasets from 16 international cohorts with the aim of developing a scale to assess healthy ageing that can be used globally, the Healthy Ageing Index (HAI) (Sanchez-Niubo et al. 2021). WHO has described six key domains of IC: vitality, visual capacity, hearing capacity, cognitive capacity, psychological capacity, and locomotor capacity (World Health Organization 2019). In this study, subjective age, objective and self-reported indicators covering health, functional ability and all six domains of IC suggested by WHO (World Health Organization 2019) are used to examine the relationship between subjective age and healthy ageing in a sample of individuals in Norway 60 years old or older.

Materials and methods

Participants

This research used data from the population-based Norwegian Survey of Health and Ageing (NORSE) (Strand et al. 2021), a study of health and living conditions conducted with a representative sample of the population 60 years old or above in the former Oppland County in Norway. The Norwegian Tax Administration gave permission to draw a random sample from the National Population Register. Three age strata were used: 60–69, 70–79 and 80+ years, with equal numbers drawn from each age group, achieving oversampling of the older age groups. Eligible participants were mailed by regular post a four-page leaflet and invitation letter with description of the study aims, testing procedures, and how data would be handled after the data collection. The leaflet contained ethical clearances and consent procedure, as well as how participants later could withdraw their consent at any time. Those willing to participate either sent a mobile text message or sign up using a pre-paid letter (Strand et al. 2021). Data were collected during 2017–2019. Out of 5981 invitations, a total of 957 participated. Descriptives of the sample were published in 2021 (Strand et al 2021). The 817 respondents with a valid response on the outcome variable assessing subjective age are included in the current analysis (14% response rate). Final-year nursing students at the Norwegian University of Science and Technology in Gjøvik, who were specially trained for the data collection, collected the data through standardized face to-face interviews, either at home or in local healthcare clinics or offices. Full population data from Oppland County for 2017 by age, sex, and level of education provided by Statistics Norway were used to create population weights to control for selection bias (Valliant and Dever 2018). This strategy provided us with information on the total population, including all nonrespondents, from administrative registries.

Subjective age

Participants were asked if disregarding their actual age, how old did they feel. The absolute discrepancy, in years, between subjective and chronological age was calculated as subjective age minus chronological age. For example, a value of – 10 would indicate that the respondent was feeling 10 years younger than her chronological age.

Indicators of IC

All six domains of IC were included in our study (1. Vitality, 2. Visual capacity, 3. Hearing capacity, 4. Cognitive capacity, 5. Psychological capacity, and 6. Locomotor capacity) (World Health Organization 2019). Because the aim was to investigate differences between groups, the study variables were dichotomized using established cut-off points.

Vitality

Vitality was assessed by hand grip strength (kg; Jamar hydraulic dynamometer; two attempts for each hand, including maximum score), self-reported chronic musculoskeletal pain (yes/no), degree of exhaustion (low/high), and incontinence (yes/no). Following the EWGSOP criteria (Cruz-Jentoft et al. 2010), grip strength scores were dichotomized as low (<27 kg for men and <16 kg for women) or high (≥ 27 kg for men and ≥ 16 kg for women).

Visual capacity

Visual capacity was based on self-reported vision assessed by the interview question “Is your eyesight [using glasses or contact lenses as usual]” 1. Excellent, 2. Good, 3. Fair, 4. Poor, or 5. I am blind (poor (3, 4 and 5/good (1 and 2)).

Hearing capacity

Hearing capacity was based on self-reported hearing assessed by the interview question “Is your hearing [using a hearing aid as usual]” 1. Excellent, 2. Very good, 3. Good, 4. Fair, 5. Poor (poor (4 and 5/good (1, 2 and 3)).

Cognitive capacity

Cognitive capacity was assessed with the Montreal Cognitive Assessment (MoCa) and grouped as normal (24–30), mild cognitive impairment (19–23), or dementia (0–18) (Carson, Leach, Murphy, 2018).

Psychological capacity

Psychological capacity was measured by assessments of depression, anxiety, and quality of sleep, using the EURO-D depression scale—no depressive symptoms (score 0–4), depressive symptoms (score 5–12) (Prince et al. 1999)—the generalized anxiety scale, GAD-7 (anxiety GAD ≥ 8, no anxiety GAD <8) (Löwe, Decker et al. 2008), and self-reported sleep problems (yes/no), respectively.

Locomotor capacity

Locomotor capacity was assessed with the Short Physical Performance Battery (SPPB), in three groups rated as low performance (0–6), reduced performance (7–9), or normal performance (10–12) (Bergh, Lyshol et al. 2006).

Indicators of health

Health-related variables included self-reported general health (0 = very poor/poor/slightly poor; 1 = good/very good) and chronic disease (yes/no).

Indicators of functional ability, and frailty

Two variables on functional ability were included: frailty, using Fried’s criteria (Fried et al. 2001), and the widely used global activity limitation indicator (GALI) (Van Oyen, Van der Heyden et al. 2006, Berger, Van Oyen et al. 2015). The GALI was based on the question “For the past 6 months or more, have you been limited in activities people usually do because of a health problem?” and participants were grouped as 1 = Yes, strongly limited, 2 = Yes, limited, 3 = No, not limited. Fried's frailty criteria were based on all five original items: 1. Measured grip strength, 2. Measured gait speed (metre/second; based on the faster of two timed 4-m walks), 3. Self-reported weight loss, 4. Self-reported physical activity, and 5. Self-reported exhaustion.

Statistical analysis

Mean and standard deviation of the outcome variable defined as the difference between subjective and chronological age was calculated for the total sample, and by categories such as sex, age groups, as well as for intrinsic capacity and health and function categories. We regressed the outcome variable against the intrinsic capacity, health and function variables, one by one, adjusted by sex and age. Furthermore, to account for nonresponses, the regression was weighted using inverse probability weighting and calibration. The inverse probability weights were constructed using Statistics Norway´s population for Oppland in 2017 by sex and age in five-year age groups (60–64, 65–69,70–74, 75–79, 80–84, 85+), and we assessed the size of each stratum in our study population. For example, in Oppland in 2017, there were 6032 women aged 60–64 years, while we had 100 of this group in our sample, which corresponds to 1.6%. Hence, each of these 100 women represented 6032/100 = 60.3 women. Thus, the weight 60.3 was assigned to all women aged 60–64 years. A similar procedure was applied for the other age and sex strata. In Stata, we used the *svyset* command, and inverse probability weighting (IPW) was used as the probability weight (pweight). Second, for calibration we used post-stratified weights to account for nonresponse bias due to education. We had access to the overall distribution of people in Oppland in 2017 by sex, in three age groups (60–69, 70–79, 80+) and at three educational levels (compulsory (< 10 years), secondary (10–12 years), and tertiary (13+ years)) from Statistics Norway. These data were merged with our data by matching strata and used as post-stratified weights. The reliability of the scales was investigated using Cronbach's alpha.

Results

In our sample, 86.5% felt younger than their chronological age, 5.2% felt older, and 8.3% felt exactly their chronological age (Fig. 1). These percentages were similar for men and women. Overall, the subjective age was found to be 13.8 years lower than chronological age (Table 1). This discrepancy between subjective and chronological age was slightly larger for men (14.3 years) than for women (13.2 years). It was also higher for the oldest chronological age group 80+ (15.2 years) compared to the youngest group aged 60–69 (13.5 years). However, the sex and age differences did not reach statistical significance in the weighted regression analyses and could have been due to chance (Table 1). Due to the similar discrepancy between subjective and chronological age between the sexes, men and women were collapsed in the analyses. With some exceptions, in age- and sex-adjusted analyses, there were few significant findings, but the tendency was in the expected direction, namely that poor health and poor function were associated with a smaller discrepancy between subjective and chronological age (Table 1). Among the IC indicators, those reporting having incontinence (vitality domain) the discrepancy between chronological and subjective age

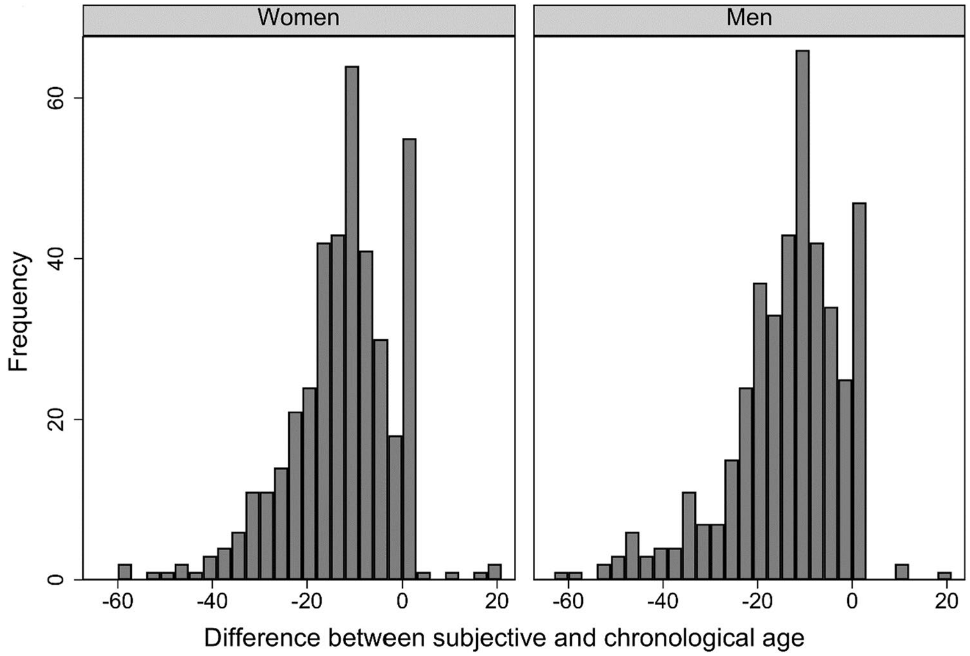

Fig. 1 Frequency histogram, difference in years between subjective and chronological age, by sex. $N = 817$

Table 1 Descriptive statistics of the sample ($n = 817$) and results of the regression analysis investigating the association between the subjective and chronological age gap and intrinsic capacity, health and function

	N	Mean difference (in years) between subjective and chronological age	SD	Mean weighted* difference in years between subjective and chronological age, adjusted by age and sex, using one of the categories a reference	p-value	95% CI low	95% CI high
Total	817	−13.77	11.64				
Men	418	−14.29	11.96	−0.8	0.363	−2.6	1.0
Women	399	−13.22	11.28	Ref	–	–	–
Age							
60–69	353	−13.48	10.91	Ref	–	–	–
70–79	329	−13.47	11.43	0.3	0.726	−1.5	2.2
80+	135	−15.24	13.78	−2.3	0.128	−5.2	0.7
Intrinsic capacity							
Vitality							
Grip strength							
High	716	−13.81	11.15	Ref	–	–	–
Low	100	−13.00	14.10	1.3	0.445	−2.1	4.7
Musculoskeletal Pain							
No	286	−13.33	10.80	Ref	–	–	–
Yes	529	−14.02	12.10	−1.0	0.299	−2.9	0.9
Energetic							
No	557	−13.83	10.99	Ref	–	–	–
Yes	255	−13.70	13.01	0.8	0.449	−1.3	2.8
Incontinent							
No	683	−14.14	11.84	Ref	–	–	–
Yes	132	−11.88	10.45	3.1**	0.015	0.6	5.5
Sensory function							
Vision							
Normal	711	−14.07	11.49	Ref	–	–	–
Poor	103	−11.56	12.53	2.9**	0.037	0.2	5.6
Hearing							
Normal	656	−13.89	11.62	Ref	–	–	–
Poor	110	−12.53	11.76	2.9**	0.030	0.3	5.5
Cognitive capacity							
(MoCa scores) Normal (24–30)	604	−13.73	11.61	Ref	–	–	–
MCI (19–23)	171	−13.35	11.43	1.8	0.100	−0.3	3.9
Dementia (0–18)	37	−17.41	13.10	−1.8	0.445	−6.5	2.9
Psychological capacity							
Depression (EURO-D)**							
No (0–4)	530	−13.71	10.73	Ref	–	–	–
Yes (5–12)	287	−13.87	13.18	0.7	0.510	−1.3	2.6
Anxiety (GAD)**							
Normal (GAD < 8)	771	−13.69	11.63	Ref	–	–	–
Anxiety (GAD ≥ 8)	46	−14.98	11.89	0.1	0.956	−4.0	4.3
Sleep problems							
No	563	−13.69	11.44	Ref	–	–	–
Yes	253	−13.94	12.12	−0.4	0.720	−2.5	1.7
Locomotor capacity							
SPPB score (0–12)							
Low (0–6)	53	−15.17	16.77	Ref	–	–	–
Medium (7–9)	236	−13.08	11.88	1.2	0.651	−4.0	6.3
High (10–12)	528	−13.93	10.90	0.3	0.906	−4.8	5.5
Health							
Self-reported health							
Poor	181	−12.40	13.95	Ref	–	–	–
Good	635	−14.16	10.89	−2.2	0.076	−4.6	0.2

Table 1 (continued)

	N	Mean difference (in years) between subjective and chronological age	SD	Mean weighted* difference in years between subjective and chronological age, adjusted by age and sex, using one of the categories a reference	p-value	95% CI low	95% CI high
Chronic disease							
No	484	−13.69	10.90	Ref	–	–	–
Yes	333	−13.87	12.65	−0.5	0.604	−2.4	1.4
Function							
GALI							
No limitations	386	−14.32	10.98	Ref	–	–	–
Some limitations	344	−13.25	11.41	1.2	0.196	−0.6	3.1
Substantial limitations	87	−13.37	14.99	1.9	0.334	−2.0	5.8
Frailty (Fried´s phenotype)							
Normal	400	−13.78	10.71	Ref	–	–	–
Prefrail	260	−14.00	11.42	−0.4	0.698	−2.1	1.4
Frail	106	−14.10	13.89	3.6	0.121	−0.9	8.1

Bonferroni p-value to account for multiple testing (15 tests): 0.003

*The regression was weighted to adjust for nonresponse due to age, sex and education; ** Significant results $p < 0.05$

was 3.1 years narrower than those reporting no incontinence [95% confidence interval (CI) (0.6, 5.5)] adjusted by age and sex (Table 1). Correspondingly, for those with poor vision this difference was 2.9 years narrower compared to those not reporting poor vision [95% CI (0.2, 5.6)], and for those reporting poor hearing, this difference was 2.9 years narrower compared to those not reporting poor hearing [95% CI (0.3, 5.5)]. Some of the categories for vision, hearing and self-rated health had few responses. In addition to the analyses using dichotomized variables, we did finer analyses including the original scale, which also showed significant results and in the expected direction. There was no significant difference in the discrepancy between subjective and chronological age for cognitive capacity, psychological capacity, or locomotor capacity. For the health indicators, however, the discrepancy was 2.2 years narrower for those reporting poor health compared to those in good health ($p = 0.076$). No such discrepancies were found across the functional capacity or frailty indicators. Using metrical scales for grip strength, MoCa, EURO-D, GAD, SPPB, and frailty provided similar non-significant associations with the subjective age scores as in the analyses using dichotomized/categorical variables; in an age and sex adjusted, weighted analysis as in Table 1, using metrical scales the p-values were: grip strength 0.67, MoCa 0.56, EURO-D 0.66, GAD 0.43, SPPB 0.78, and frailty 0.22. Regarding the internal consistency, the Cronbach alpha were GAD = 0.78, EURO-D = 0.55, MoCa = 0.66, SPPB = 0.59, and frailty = 0.42. The overall internal consistency of the frailty scale was low. However, the frailty index is a multidimensional test including different components representing different constructs within two broader umbrella-constructs. The Cronbach's alpha reliability coefficients of the frailty components ranged from 0.33 to 0.44, and average inter-item correlation ranged from 0.12 to 0.16. In an additional analysis, 26 subjective age scores were truncated ±3 standard deviations apart from the mean. Results (not shown) were similar with and without this truncation and did not affect conclusions. Considering that we performed multiple testing (14 variables), the Bonferroni corrected p-value was $0.05/15 = 0.003$. Using this conservative p-value as guidance for statistical significance, rather than the usual 0.05, none of the findings reached statistical significance.

Discussion

Among home dwellers in Norway 60 years old or older in our sample, subjective age was consistently lower than chronological age, on average, by nearly 14 years. That finding aligns with past results (Stephan et al. 2013; Ye and Post 2020; Sayag and Kavé 2022; Veenstra et al. 2021). In prior research (Westerhof and Barrett 2005), those who felt younger than their chronological age were also found to generally have higher subjective well-being and positive emotions. The psychological pathways involved in subjective age can be complex and entail several reciprocal relationships, including with individual functional ability, health, and culture (Subramanian et al. 2009; Volz-Sidiropoulou and Gauggel 2012). Moreover, people may be able to sense changes in their physical health that have not yet been captured by objective health measures (Idler and Benyamini 1997) or they have been affected by negative views on ageing, which may potentially affect their subjective age and health behaviour (Wurm et al. 2017). This study found a substantially higher subjective age for participants who reported incontinence, poor vision, and poor hearing than for ones without those conditions, but other factors, including anxiety, depression, chronic disease, physical functional ability, cognition, and frailty, did not impact that discrepancy.

Incontinence

To the best of our knowledge, this is the first study to investigate the association between incontinence and the discrepancy between subjective and chronological age, and it showed that participants with incontinence had a smaller discrepancy than those without the condition. Urinary continence is a common condition for both men and women (2004), its prevalence increases with age, and more than 40% of women 70 years old or older are affected (Milsom and Gyhagen 2019). Studies from the Swedish Twin Registry have presented evidence that genetic and nonshared environmental factors contribute equally to 40% of the variation in liability (Wennberg et al. 2011), and certain behaviours—childbirth, for example—can also affect the prevalence of incontinence (Waetjen et al. 2007). Incontinence is associated with loss of vitality (Sanchez-Niubo et al. 2021), embarrassment, and isolation (e.g. (Esparza et al. 2018)), as well as a lower quality of life (Pizzol et al. 2021). Beyond that, many men and women with the condition bear a significant mental health burden (Coyne et al. 2012). Considering past results, our novel finding suggests that incontinence needs to be addressed and acknowledged as a multifactorial public health concern.

Vision loss, hearing loss and subjective age

Our study detected significantly smaller discrepancy between subjective and chronological age for those with poor vision and poor hearing than for the ones who did not report those sensory impairments. Although vision loss and hearing loss are common for older adults, few studies have investigated the association between the sensory functions of vision and hearing and subjective age. A recent study including 7085 individuals between 50 and 93 years of age from the Health and Retirement study found that subjective age was prospectively related to hearing function (Stephan, Sutin et al. 2022), but the studies that have been conducted have shown diverse findings. The German Ageing Survey, comprising 6378 individuals 40–89 years old observed over a nine-year period, showed that vision problems were associated with a higher subjective age (Wettstein et al. 2021a, b). However, no such result emerged in a relatively small study of 75 individuals, including a group of adults 93 years or older, but that study did find that hearing impairment was associated with higher subjective age (Schroyen et al. 2020).

Grip strength, frailty, and depression

Grip strength, frailty, and depression were not significantly related with subjective age. This is in contrast to results from other studies (Debreczeni and Bailey 2021; Stephan et al. 2021). We can only speculate why the present results differ from those of these studies. It could also be that this setting is different, and that being depressed, less physically strong or frail does not relate to how old people see themselves, the present study population in the county of Oppland, Norway. It may be that many in this region are less likely to see physical or somatic change associated with age as relevant for how old they perceive themselves.

Limitations

Among our study's limitations, the sample came from only one region in Norway and may not be generalizable to other regions or countries. The study was also limited to an exclusive set of variables related to healthy ageing to investigate the association with subjective age, the evidence was cross-sectional, and the inclusion of confounding factors was not exhaustive. The sample was representative regarding sex and age but skewed towards a higher level of education, and likely prone to healthy selection bias. To account for this, our analyses were weighted by level of education to minimize selection biases. However, if the sample differed in factors other than those included, or the lower educated participants differ from the lower educated non-participants in functional ability and subjective age, the results may be biased, nonetheless. Limitations to this study includes the unknown causal directionality of the associations due to the cross-sectional study design, and that some of the measures only assess the presence of conditions and no other aspects such as the severity (for instance musculoskeletal pain). Our study's overall response rate was low (14%), which also may have caused selection bias and a reduction in statistical power. Further, we used registry-based weights (for the whole population) to increase representativity. Last, our study is of limited size ($N=817$), and for a range of sub-analyses and for properly addressing multiple testing, the groups were small (<50). No effects remained significant after applying the conservative Bonferroni correction, so the analyses should be repeated in other, preferably larger, samples.

Conclusion

In this study of adults aged 60+, feeling younger than ones' chronological age is common. However, the discrepancy between subjective and chronological age was smaller for those who reported having incontinence, poor vision, or poor hearing than in participants without these conditions. Hence, higher subjective age may have undesirable relationships to vitality, autonomy, and perceived intrinsic capacity, which are considered imperative for healthy ageing.

Appendix I: Correlation table of the included variables

	SEX	AGE	GRIP	PAIN	ENERGY	INCONT	VISION	HEARING	MOCA	EURO-D	GAD	SLEEP	SPPB	SRH	DIS	GALI	FRAIL
SEX	1																
AGE	−0.0088	1															
GRIP	−0.0489	0.2562*	1														
PAIN	−0.1173*	−0.0198	0.0852*	1													
ENERGY	−0.1199*	0.1070*	0.1496*	0.1462*	1												
INCONT	−0.1671*	0.1861*	0.0795*	0.1229*	0.1644*	1											
VISION	−0.0922*	0.052	0.0916*	0.0742*	0.1051*	0.0875*	1										
HEARING	0.0397	0.1247*	0.0268	0.0581	0.1154*	0.0688	0.1149*	1									
MOCA	0.0707*	0.3181*	0.2088*	0.0697*	0.1632*	0.1230*	0.0579	0.1333*	1								
EURO-D	−0.0957*	−0.0111	0.0810*	0.0631	0.4141*	0.0387	0.1283*	0.0730*	0.0366	1							
GAD	−0.1113*	0.0366	0.0219	0.1120*	0.2000*	0.1219*	−0.0139	0.0699	0.1496*	0.1744*	1						
SLEEP	−0.2413*	0.0692*	0.0471	0.1855*	0.2594*	0.2010*	0.0767*	0.0958*	0.0910*	0.063	0.1793*	1					
SPPB	0.0497	−0.2926*	−0.2174*	−0.0838*	−0.2284*	−0.2409*	−0.1115*	−0.0814*	−0.2944*	−0.0940*	−0.0663	−0.1422*	1				
SRH	0.0146	−0.0532	−0.1755*	−0.2091*	−0.3646*	−0.2072*	−0.1381*	−0.069	−0.1558*	−0.2039*	−0.1117*	−0.1832*	0.3298*	1			
DIS	−0.0463	0.0395	0.1040*	0.2587*	0.2703*	0.1883*	0.0747*	0.0405	0.1111*	0.1452*	0.0990*	0.2109*	−0.2355*	−0.4463*	1		
GALI	−0.0946*	0.1666*	0.2057*	0.2763*	0.3384*	0.2500*	0.1103*	0.1024*	0.2358*	0.1908*	0.1250*	0.1731*	−0.3681*	−0.5024*	0.5506*	1	
FRAIL	−0.1230*	0.2760*	0.3811*	0.1788*	0.6583*	0.2469*	0.1698*	0.1093*	0.2744*	0.2886*	0.1689*	0.2160*	−0.5116*	−0.4041*	0.2988*	0.3908*	1

*$p < 0.05$. Variables are identical to those presented in Table 1, in the same order

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Author contributions EML and VS drafted the paper and BHS performed the statistical analysis. All authors participated in the planning and designing the study and critically revised the manuscript for important intellectual content. All authors have read and approved the manuscript.

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Data availability The NORSE project group can be contacted to get access to NORSE data. More information is found at the NORSE web site at the Norwegian Institute of Public Health: https://www.fhi.no/studier/norse-studien/norse/

Declarations

Competing interests The authors declare no competing interests.

Conflict of interest The authors do not have any conflict of interest or declarations of funding.

Ethical approval NORSE was assessed by the Norwegian Regional Ethics Committee for medical research (REC), which in a decision of 25.06.2015 (2015/970/REK south-east) concluded that the treatment involves the establishment of a health register and that the project therefore falls outside the scope of the Health Research Act. An application was therefore made for a license pursuant to section 7 of the Health Register Act, cf. Section 33 of the Personal Data Act. This license was granted 18.10.2016, and NORSE was then officially defined as a health registry, and the study, including all experimental protocols, was approved by the Norwegian data inspectorate (Reference number 16/00929–2/GRA). All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all NORSE participants at inclusion but not for this specific study. This study is assessed and approved by The Norwegian Centre for Research Data (reference number 501185).

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ORIGINAL INVESTIGATION

Internet usage among the oldest-old: does functional health moderate the relationship between internet usage and autonomy?

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Abstract

In recent years, research on internet usage in old age and its associations with well-being outcomes has increased. However, the oldest-old age group (80 years and older) is frequently underrepresented, and autonomy and functional health are rarely considered in these studies. By applying moderation analyses with a representative dataset of the oldest-old in Germany ($N = 1863$), our study has analyzed the hypothesis that the autonomy of older individuals, in particular of those with limited functional health, can be enhanced by internet usage. The moderation analyses indicate that the positive association between internet usage and autonomy is greater for older individuals with lower functional health. This association remained significant after controlling for social support, housing situation, education, gender, and age. Explanations for these results are discussed, and imply that further research is needed to understand the relationships between internet usage, functional health, and autonomy.

Keywords Information and communication technology (ICT) · Active aging · Compensation · Subjective well-being

Introduction

Maintaining autonomy is a key issue in active aging that is of crucial interest for both individuals and policymakers. In gerontology, “autonomy is the perceived ability to control, cope with and make personal decisions about how one lives on a day-to-day basis, according to one’s own rules and preferences” (WHO 2017). Maintaining autonomy improves outcomes like well-being and life satisfaction (cf. Hüning et al. 2018; Niemiec and Ryan 2009). The usage of information and communications technologies (ICT) in old age can help individuals maintain their autonomy, and, in turn, their quality of life (cf. Cotton et al. 2014; Szabo et al.2019). ICT usage (and technology use in general) by older individuals has considerable development potential in the domains of physiological and psychological health, everyday activities and leisure, mobility, social involvement, and security (Schmidt and Wahl 2019). Web-based ICT usage offers older individuals new forms of social participation and interaction, and enhances their access to information, services, and entertainment (Antonucci et al. 2017; Caruso 2018).

Many studies have investigated the relationship between internet usage and well-being outcomes, and have found positive effects (cf. Cotten et al. 2014; Szabo et al. 2019). However, compared with other indicators of well-being, the autonomy of older individuals has been rarely investigated. Moreover, in the studies that have considered autonomy, it was analyzed as one of several well-being indicators, and not as a separate factor (e.g. Szabo et al. 2019). A few studies have found a relationship between internet usage and higher levels of autonomy among older individuals (e.g. Hartanto et al. 2020; Schlomann et al. 2020). Other studies have shown that older individuals who use the internet see it as a resource for maintaining autonomy in old age, and for dealing with aging-related and general challenges, such as banking or understanding English (Nimrod 2020; Seifert and Schelling 2018). However, earlier studies found no

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evidence for an effect of internet usage on older individuals' autonomy (e.g. Slegers et al. 2008).

Research on internet usage in old age has mainly focused on its well-being outcomes, without taking older individuals' health into account (cf. Forsman et al. 2018), even though there is a high prevalence of functional health limitations in older age groups (Marengoni et al. 2011; Wolff et al. 2017). Maintaining autonomy with restricted health is challenging (Baltes and Silverberg 1994; Schüz et al. 2011). In particular, having low levels of functional health restricts the scope of individual's daily activities. To maintain an autonomous life, individuals have to cope with the challenges of limited health (Baltes and Silverberg 1994; Schüz et al. 2011). For example, individuals who are restricted in walking may be unable to do grocery shopping without help. The internet is a potential resource for helping such individuals cope with this constraint. One option is to order the groceries for delivery via the internet. Older individuals may have a stronger sense of autonomy if they are able to take action and make their own grocery choices. This is just one example of a range of opportunities for exercising autonomy via the internet.

A review of the current state of research on maintaining autonomy despite limited health shows that studies on this topic are often intervention studies that examine special health applications (eHealth; WHO 2017). The evidence for effects reported in eHealth studies is training or support effects, rather than effects of the internet usage itself (Dickinson and Gregor 2006). A study that took functional limitations into account without a focus on eHealth found that older individuals in residential care facilities who use the internet reported higher levels of autonomy and life satisfaction than those who do not use the internet (Seifert et al. 2017). The authors concluded that the internet is a resource, especially for older individuals, for coping with the challenges of vulnerability. These findings are in line with the results of Fang et al. (2018), who investigated internet usage by older individuals and their psychological well-being. According to the authors, the evidence for a positive effect of internet usage only applies to individuals aged 75 years or older, and especially to frail individuals. It has been suggested that internet usage can help to compensate for the functional limitations of the very old (Wangler and Jansky 2020).

In sum, the current state of research shows that the relationship between internet usage and autonomy in old age has hardly been investigated in detail, especially for older individuals with health limitations and the often underrepresented group of the oldest-old. The few studies that have investigated the well-being outcomes of internet usage by the oldest-old lacked representativeness and statistical tests, or left unclear whether the ICT usage was web-based (e.g. Sims et al. 2017). It is reasonable to assume that internet usage becomes more important to individuals in old age, as it helps them to compensate for the decline in the capabilities that they require to perform everyday activities, and to interact with the (social) environment in accordance with their own needs (cf. Wahl et al. 2010). Against this background, we aim to analyze the relationship between internet usage, autonomy, and functional health in the oldest-old age group. Our research question is whether internet usage by the oldest-old is related to their perceived autonomy, and whether this relationship is moderated by their functional health.

Human Development Theory assumes that human development is incomplete, and that developmental gains and losses vary within an individual's life span (Baltes 1997). First, it is assumed that with increasing age, the number of dysfunctional gene expressions increases. As a result of these dysfunctional gene expressions, the prevalence of diseases such as dementia increases with old age. Additionally, the need for psychological, social, material, and knowledge-based resources grows. To maintain high levels of functioning in old age, individuals need these resources to compensate for their developmental losses (e.g., health-related losses). Lastly, the theory assumes that there is a reduction in the efficiency of the aforementioned resources across an individual's life span (e.g., a reduction in the effectiveness of cognitive learning). To summarize, Human Development Theory asserts that with increasing age, individuals will experience more developmental losses than gains.

Accordingly, the internet as a (environmental) resource can contribute to an individual's ability to cope with age-related functional limitations while maintaining his or her autonomy. Baltes (1997) observed that in addition to the mechanisms of optimization and selection, compensation is often used to regulate functional losses in old age. The related strategy for aging successfully is to select a limited number of activities, and to optimize them to compensate for age-related losses. For example, older individuals could select the internet for online banking or online shopping in order to save time and energy (optimization), as well as to compensate for their restricted mobility (cf. Nimrod 2020).

The theoretical assumptions of Human Development Theory allow us to hypothesize that the assumed positive association between internet usage and autonomy is moderated by functional health. The internet can be categorized as an environmental resource, while limited functional health can be considered a state of reduced personal resources. Human Development Theory assumes that when individuals' personal resources, such as their (functional) health, are declining, they have a greater need for environmental resources to cope with the challenges they face in maintaining their autonomy. Thus, the internet is an external resource that can help individuals to maintain their autonomy via selection, optimization, and compensation processes. Furthermore, because the profound challenges individuals with functional health limitations face mean that they are more dependent on the support of the environment to maintain their autonomy, the utility of the internet should be higher for individuals with functional limitations than for individuals without these limitations. The association between internet usage and autonomy should become stronger with lower levels of functional health. Accordingly, our hypotheses are as follows: H1: Internet usage by the oldest-old is positively associated with their autonomy. H2: The association between internet usage and autonomy becomes greater with lower functional health.

Method and research design

Data and study sample

Data from a representative survey of adults aged 80 years and older (born before August 1, 1937) in North Rhine–Westphalia, a federal state of Germany, were employed. The survey on "NRW80+" (Wagner et al. 2018) was conducted from August 2017 to February 2018 (see Zank et al. 2020). The study was funded by the Ministry of Culture and Science of the German State of North Rhine–Westphalia. The computer-assisted face-to-face interviews were conducted in the homes of the target persons, and covered a variety of topics, ranging from family, health, living conditions, social relations, individual values, and well-being to daily activities and lifestyle. The dataset includes 1878 individuals who were living in private homes, as well as individuals who were living in institutional care settings. The multistage sampling was conducted in two steps. First, a sample of 93 communes was drawn from all communes in North Rhine–Westphalia. Second, a random sample of 48137 addresses was provided by the population registration offices, of which 8040 have been contacted. Apart from the age and the principal residence, there were no additional exclusion criteria. A total of 1702 interviews were conducted with the target individuals, and 176 interviews were conducted with a proxy informant to include individuals who were not able to answer the questions because of health impairments.

Measures

Dependent variable

Perceived autonomy was measured with a single item based on the autonomy scale by Schwarzer (2008). The corresponding question was: "Do you lead your life according to your own ideas?" The response scale was a four-point Likert scale, ranging from "does not apply at all" to "fully applies." As the planned duration of the interviews was 90 min, autonomy was included as a single item instead of as multiple items, based on the economic method in survey research. Because the items within the scale by Schwarzer (2008) show high internal consistence ($\alpha = 0.90$), the single item should sufficiently represent the multiple-item scale.

Independent variables

Internet usage was measured by asking whether the participant had used the internet in the last 12 months. The possible answers were "yes" or "no." The variable internet usage was dummy coded.

For measuring functional health, the "activities of daily living" (ADL) scale was included (McDowell 2006).[1] The scale measures seven items of activities of daily living: eating, dressing, body care, walking, bathing, and toilet use. Participants were asked whether they can perform the respective activity "only with help," "with little help," or "without help." A mean score was built from the seven items ranging from zero to two, with higher values indicating higher functional health.

Control variables

Research has shown that social support can promote autonomy (e.g. Warner et al. 2011). Furthermore, studies have found that social support can positively affect the usage of ICT, including of the internet (Hänninen et al. 2021). Thus, received social support was included in the analysis. Participants were asked how often in the past 12 months they had received social support from other persons in the form of "being comforted or cheered up" and "getting help with tasks and errands (excluding paid help)." The possible answers ranged from "never" to "always" on a five-point scale. Based on the two items, a mean score ranging from zero to two was computed.

Individuals' living environment may also influence their internet usage in old age (e.g., Seifert et al. 2017). Moreover, individual's living environment can affect their autonomy. Compared to living in a long-term care institution, living in a private household tends to offer people greater autonomy, as it provides them with more scope for taking action and making self-determined decisions (Hajek et al. 2021; Schüz et al. 2013). Thus, the living environment was included in the analysis by using the housing situation measure, which indicated whether the participant was living in a long-term

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[1] The health measure multimorbidity was also available in the dataset. However, we have decided to use functional health instead of multimorbidity, because the number of diagnosed diseases is often not in line with the perceived complaints and disabilities (Kuhlmey and Tesch-Römer 2013). Due to advancing medical technology, more diseases can be diagnosed, but they do not necessarily affect the functionality of an individual.

care institution or in a private home. The variable was dummy coded.

Individuals's demographic characteristics, such as their age, gender, and education, may also influence their functional health and internet usage. Age seems to negatively influence internet usage; men use the internet more often than women; and higher education seems to influence internet usage positively (cf. Hunsaker and Hargittai 2018; König et al. 2018). In addition, functional limitations seem to be more prevalent in women than in men; age positively influences the occurrence of functional limitations; and higher education seems to buffer the occurrence of functional limitations due to higher awareness of health behaviors (Marengoni et al. 2011; Wolff et al. 2017). Therefore, age, gender, and education were considered in the current analysis. Age was measured continuously in years. Gender was measured with a categorical variable ("male"[ref.] or "female"), and the level of education was measured based on the International Standard Classification of Education (ISCED) ("low"[ref.], "middle," or "high"). For the moderation analysis, the education variable was recoded into three dummy variables.

Statistical analyses

SPSS version 27 (IBM Statistics) and the PROCESS macro version 3.5.3 were used for the statistical analyses. Missing values were excluded listwise. All analyses included 1772 cases with valid values for all variables.[2] First, descriptive analyses were applied. Subsequently, the moderation model was initially conducted without covariates. In a second step, the control variables were included in the moderation model. To analyze whether the association between internet usage and autonomy becomes greater with lower functional health, model 1 of the PROCESS macro was used[3] with bootstrapping 10000 times and 95% confidence intervals. In terms of traceability, the seed was set to 10821. Based on the Breusch–Pagan test, heteroscedasticity could not be rejected (model without covariates: $\chi^2(1) = 242.85$, $p < 0.001$; model with covariates: $\chi^2(1) = 167.91$, $p < 0.001$). Thus, heteroscedasticity consistent standard errors were used in the moderation models. To probe the interaction effect, the mean value, the value of one standard deviation below the mean, and the value of one standard deviation above the mean were used. Additionally, to test whether significance transition points exist within the observed range of the moderator functional health, the Johnson–Neyman method was used.

Results

Descriptive statistics

The mean age in the sample was 86.97 years (SD = 4.50). The participants' ages ranged from 80 to 103 years. In terms of gender, 50.73% of the sample were female and 49.27% were male. In terms of education, 26.69% had low education, 52.09% medium education, and 21.22% high education. While 10.21% of the participants were living in a long-term care institution, the majority (89.79%) were living in a private home. The mean value of autonomy (ranging from one to four) was relatively high, at 3.43 (SD = 0.85). Only 20.15% of the participants reported using the internet, while 79.85% indicated that they were not using the internet. The mean value of functional health was 1.63 (SD = 0.53) (ranging from zero to two). The mean value of social support was 0.57 (SD = 0.25) (ranging from zero to two).

Table 1 shows the statistically significant different mean values and distributions in percent when comparing internet users and non-users based on individual and environment-related characteristics. These bivariate analyses indicated that compared to non-users, internet users had statistically significant higher levels of autonomy and functional health, were receiving less social support, were more likely to be living in a private home, had higher education, and were more likely to be male and to be younger.

Moreover, the bivariate correlations showed a statistically significant positive correlation between internet usage and autonomy ($r = 0.22$, $p < 0.001$), and between functional health and autonomy ($r = 0.57$, $p < 0.001$) (Table 4). The positive correlation between functional health and internet usage ($r = 0.23$, $p < 0.001$) indicated that the internet was more likely to be used as a resource by individuals with higher levels of functional health. Referring to the control variables, housing was relatively highly correlated with autonomy ($r = -0.45$, $p < 0.001$) and functional health ($r = -0.43$, $p < 0.001$). Likewise, education was relatively highly correlated with internet usage ($r = 0.36$, $p < 0.001$). However, to test the hypothesis that the association between internet usage and autonomy became greater with functional limitations, further multivariate investigations were conducted.

Moderation models

The aim of the applied moderation models was to examine the extent to which the differences in autonomy levels between internet users and non-internet users were a function of their functional health. Table 2 displays the two moderation models. While the first model did not

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[2] Besides single missing values in the included variables, education has a total of 80 missing values (cf. Table 3).

[3] PROCESS provides several moderation and mediation models. Model 1 calculates a simple moderation model.

Table 1 Internet usage by sample characteristics

Internet usage by sample characteristics		Internet usage	No internet usage	t/χ^2
Total	%	20.15	79.85	–
Autonomy	M(SD)	3.80 (.49)	3.34 (.89)	− 9.33 (1770), $p < .001$
Functional health	M(SD)	1.88 (.30)	1.57 (.56)	− 10.09 (1770), $p < .001$
Social support	M(SD)	.53 (.28)	.58 (.24)	3.30 (1770), $p < .001$
Age	M(SD)	85.12 (3.83)	87.44 (4.54)	8.89 (1770), $p < .001$
Education	Low (%)	4.23	95.77	241.21 (2), $p < .001$
	Medium (%)	17.55	82.45	
	High (%)	46.54	53.46	
Gender	Male (%)	30.24	69.76	108.98 (1), $p < .001$
	Female (%)	10.34	89.66	
Housing	Private home (%)	22.19	77.81	40.32 (1), $p < .001$
	Long-term care institution (%)	2.21	97.79	

$N = 1772$. 2-tailed significance with 95% confidence intervals. χ^2-tests were applied for the categorical variables gender, education, and housing. *T* tests were applied for autonomy, functional health, social support, and age. *M* mean, *SD* standard deviation

include the covariates, the second model included the covariates. The final model explained 38.06% of the variance in autonomy. The interaction of internet usage and functional health, as well as all of the other conditional associations, was statistically significant. This means that the positive association between internet usage and autonomy was stronger at lower levels of functional health, and was weaker at higher levels of functional health. The interaction coefficient estimated the difference in autonomy levels between internet users and non-users as the value of functional health increased by the value of one. Accordingly, with an increase in the value of one on the functional health scale, the difference in the association between internet usage and non-internet usage decreased by 0.33 scale points of autonomy.

This decreasing association was probed with the conditional association of internet usage at certain values of functional health. Therefore, the mean value of functional health and the values one standard deviation below and above the mean value of functional health were used. The model predicted that under the condition that someone had the mean level of functional health, internet usage increased his or her autonomy by 0.23 scale points compared to non-internet usage. If the value of functional health was one standard deviation below the mean, this association was greater ($b_{m-\mathrm{SD}} = 0.41$, $p < 0.01$), and if the value of functional health was one standard deviation above the mean, the association was smaller ($b_{m+\mathrm{SD}} = 0.11$, $p < 0.01$). These estimated conditional associations indicated that the association between internet usage and autonomy became greater with lower levels of functional health.

It is important to note that the coefficients of internet usage und functional health did not represent main effects, but were instead conditional effects. Thus, the coefficient of internet usage indicated that under the condition that individuals had low levels of functional health (the value of functional health was zero), those who were internet users were predicted to have a 0.77 higher value than non-internet users on the autonomy scale. The coefficient of functional health indicated that for non-internet users (the value of internet usage was zero), autonomy was predicted to increase by 0.72 scale points if functional health increased by the value of one.

Based on the Johnson–Neyman method, the observed range of the moderator (values from zero to two on the functional health scale) did not entail significance transition points. Thus, the moderation was statistically significant for all observed values of functional health. In sum, the described moderation models provided evidence of a stronger association between internet usage and autonomy when functional health was low. None of the control variables were significantly associated with autonomy, except the housing situation ($b = -0.68$, $p < 0.001$). Individuals who were living in a long-term care institution had a significantly lower level of autonomy than individuals who were living in a private home.

Figure 1 illustrates the conditional associations of the final moderation model. The graphs reflect the conditional associations between functional health and autonomy. The graph with triangles represents the association of functional health with autonomy under the condition that an individual was using the internet, and the graph with circles represents the association of functional health with autonomy under the condition that an individual was not using the internet. The triangles and circles represent the mean value, one standard deviation below and above the mean value of functional health. The positive association between internet usage and autonomy is reflected by the gap between the two graphs.

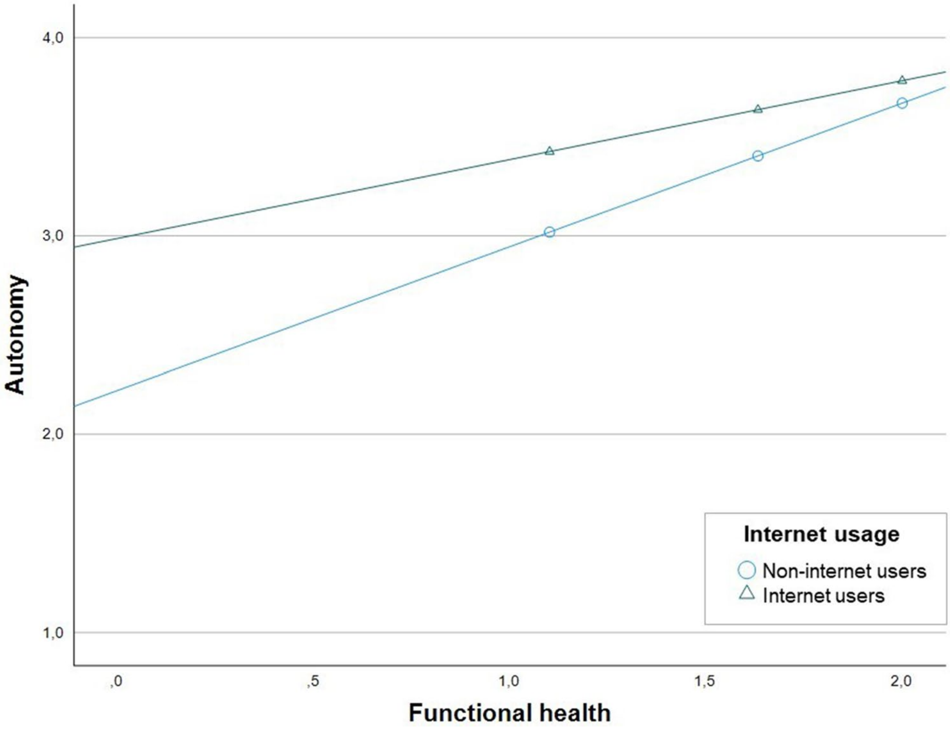

Fig. 1 Moderation of functional health on the relationship between internet usage and autonomy

Table 2 Functional health on the relationship between internet usage and autonomy

Independent variables	*M*1			*M*2			
	b (SE)	*t*	*p*	*b* (SE)	*t*	*p*	*B*
Constant	1.93 (.08)	24.43	< .001	2.15 (.36)	6.03	< .001	.02
b_1 : Internet usage (ref. no usage)	1.07 (.31)	3.45	< .001	.77 (.30)	2.52	< .05	.11
b_2 : Functionalhealth	.90 (.04)	21.13	< .001	.72 (.05)	15.66	< .001	.42
b_3 : Internet usage x Functional health	− .47 (.16)	− 2.96	< .01	− .33 (.16)	− 2.10	< .05	− .08
Conditional effects of internet usage at values of functional health							
b_{m-SD} : mean-SD	.55 (.14)	4.02	< .001	.41 (.13)	3.02	< .01	.19
b_m : mean	.30 (.06)	5.20	< .001	.23 (.06)	3.93	< .001	.11
b_{m+SD} : mean + SD	.12 (.03)	3.72	< .001	.11 (.04)	3.05	< .01	.05
Control variables							
Social support	–	–	–	− .10 (.06)	− 1.69	.091	− .03
Housing (ref. private home)	–	–	–	− .68 (.07)	− 9.17	< .001	− .25
Education level: medium (ref. low)	–	–	–	.02 (.04)	.51	.607	.01
Education level: high (ref. low)	–	–	–	.04 (.05)	.64	.520	.02
Gender (ref. male)	–	–	–	.03 (.04)	.71	.479	.02
Age	–	–	–	.00 (.00)	.44	.662	.01
Model fit	*N* = 1772 $F(3, 1768) = 197.05$, $p < .001$, $R^2 = .33$ Change in R^2: $F(1, 1768) = 8.78$, $p < .01$, $R^2 = .01$			*N* = 1772 $F(9, 1762) = 86.75$, $p < .001$, $R^2 = .38$ Change in R^2: $F(1, 1762) = 4.40$, $p < .05$, $R^2 = .00$			

Heteroscedasticity consistent standard errors (HC3), 95% confidence intervals, and 10,000 bootstrap samples are used. *b* unstandardized regression coefficient. *SE* standard error. *ref.* reference. *B* standardized coefficients

With increased functional health, the gap, and thus the association between internet usage and autonomy, became smaller. Accordingly, the estimated association between internet usage and autonomy was stronger for individuals with a lower level of functional health than for individuals with a higher level of functional health.

Discussion

This paper aimed to answer the question of whether internet usage by the oldest-old is associated with their autonomy, and whether this relationship is moderated by their functional health. Human Development Theory was used to derive the hypotheses about the relationship between internet usage, functional health, and autonomy. Accordingly, we assumed that internet usage predicts a higher level of autonomy than non-usage, and that this association becomes greater with a lower level of functional health. The bivariate analyses indicated that internet users had a significantly higher level of autonomy than non-users. Moreover, the moderation analyses provided evidence of a positive association between internet usage and autonomy, which became greater with lower functional health. These results are in line with those of prior research (Fang et al. 2018; Seifert et al. 2017) and can be interpreted within the presented theoretical framework that individuals with increasingly challenging functional health limitations are more dependent on the physical–social environment. Thus, for these individuals, the internet has greater utility as a resource.

While the internet is certainly not the only resource older individuals use to cope with the challenge of maintaining their autonomy while having limited functional health (cf. Warner et al. 2011), it can contribute to the coping process. This is also indicated by the small increase in the explained variance by the interaction with less than 1% in both models. However, the interaction remained significant after controlling for covariates. The descriptive results showed that only 20% of the participants in the sample were using the internet. This low usage rate is in line with the findings of previous research on the “grey digital divide” (Friemel 2016; Morris 2007). This research found that because the internet is a relatively new medium, older individuals have had fewer opportunities to evaluate this environmental factor. Diffusion Theory assumes that older individuals are the last group to adopt new technologies in a society (Rogers 2003). However, older individuals may start to use a technology if they perceive it to be useful (BMFSFJ 2010).

For the present analyses, we used functional health as a moderator. In the method section, we argued that functional health is a more appropriate measure. However, it could be argued that multimorbidity is more appropriate, because it is associated with more heterogenic challenges for autonomy than simply the decline in functional health (e.g., mental health outcomes, health care use) (cf. Smith et al. 2018). Therefore, we have also calculated the models with multimorbidity as the moderator variable. The moderation was significant in the first model, but became insignificant after controlling for the covariates. Therefore, it can be assumed that the challenge of declining functional health is more likely to be tackled with internet usage than the other challenges of multimorbidity, or that the number of a person’s chronic diseases is not a valid measure for capturing the impact of the diseases. This assumption is underlined by the high correlation of functional health with autonomy ($r = 0.57$, $p < 0.001$), and the relatively low correlation of autonomy with multimorbidity ($r = -0.15$, $p < 0.001$).

Strengths and limitations

The present investigation makes an important contribution to the current state of research, because the previous studies have rarely examined the association between internet usage and autonomy in detail, and health limitations have rarely been included in these studies. Additionally, a representative sample of the frequently underrepresented oldest-old age group was examined. Even oldest-old individuals who were not able to answer the questions themselves could be included through the use of proxy interviews. These proxy interviews were included in the present analysis in the interests of representativeness.

Our data contained a number of missing values within the education variable (cf. Table 3). These missing data could lead to biased coefficient estimates and inaccurate hypotheses tests (Newman 2014). To rule out this possibility, we calculated the model without the education variable. The results are similar to those of the main model.

Another limitation refers to the measurement of autonomy by using a single item. This parsimonious usage of an autonomy measurement may have affected the validity of the measure. However, the high internal consistence of the items in the overall scale indicates that the single item provided sufficient representation. In measuring internet usage, the analysis did not address the frequency and the purpose of internet usage. According to prior research, the purpose as well as the frequency can be crucial for measuring the association between internet usage and well-being outcomes (e.g., Erickson and Johnson 2011; Szabo et al. 2019). Likewise, as the current results are based on cross-sectional data, the calculated associations represent patterns, and not causal relationships. It is also conceivable that higher levels of autonomy and/or functional health predict the probability of internet usage. The moderation of functional health helps to shed light on the association between internet usage and autonomy, but it does not contribute to the clarification of the

Table 3 Missing values of all included variables

	Autonomy	Internet usage	Functional health	Social support	Housing	Gender	Age	Education
Valid	1860	1862	1863	1861	1858	1863	1857	1783
Missings	3	1	0	2	5	0	6	80

Table 4 Zero-order correlations between all included variables

	1	2	3	4	5	6	7
1. Autonomy							
2. Functional health	.57**						
3. Internet usage	.22**	.23**					
4. Social support	− .12**	− .16**	− .08**				
5. Housing	− .45**	− .43**	− .15**	.06**			
6. Education	.15**	.20**	.36**	− .09**	− .12**		
7. Gender	− .11**	− .13**	− .25**	.12**	.15**	− .41**	
8. Age	− .20**	− .30**	− .21**	.08**	.25**	− .08**	.07**

$N = 1772$. ** Correlation is significant at the level .001 level (2-tailed) significant

causal direction. Additionally, as was already noted by other researchers, there might be selection effects in the structure of internet users and non-internet users (cf. Schlomann et al. 2020). In our analyses, we tried to control for such effects by including the moderator of functional health and control variables. For example, it is reasonable to assume that there is more scope for older individuals to make self-determined decisions, and therefore to maintain their autonomy, if they are living in a private household rather than in a long-term care institution (cf. Hajek et al. 2021; Schüz et al. 2013). Although the included control variables aimed to control for such effects, there might be additional selection effects. For example, internet self-efficacy is a crucial factor in internet usage, and helps to explain why the internet is rarely used in old age, even though the potential for usage is high (Jokisch et al. 2021).

Implications and directions for further research

Based on our results and the outlined limitations, further research should investigate the relationship between internet usage and autonomy in the oldest-old age group, with a moderation of functional health using longitudinal data, to improve our understanding of the direction of the relationship between internet usage, autonomy, and functional health. Moreover, the use of experimental designs to rule out confounding variables is proving helpful for clarifying reverse causation (cf. Hartanto et al. 2021).

Some practical implications can be derived from the evidence showing a stronger association between internet usage and autonomy among individuals with lower functional health. Our results indicate that the “grey digital divide” has not yet been overcome in the oldest-old age group, even though the potential benefits of internet usage are especially large for individuals with functional health limitations. Based on the theoretical and empirical reasoning that older individuals use the internet to cope with developmental losses, policies should aim to promote interest in internet usage by highlighting the (age- and health-related) opportunities it provides. One example is a brochure published by a federal ministry that emphasizes the opportunities of internet use, and that provides answers to several questions about the internet (BMFSFJ 2019). Moreover, as other researchers have stated, “[…] the increasing prevalence of virtual health care services and considering at the same time the comparatively large prevalence of multimorbidity and functional limitations […] does strongly speak for the necessity of developing interventions with the purpose of providing internet access that are tailored to this specific group” (Huxhold et al. 2020). Furthermore, to promote internet competencies, learning strategies should be adapted to the preferences of older individuals (e.g., guided learning or self-regulated learning) (cf. Schlomann et al. 2022).

Conclusion

The current study analyzed the association between internet usage and autonomy among the often underrepresented oldest-old age group by taking their functional health limitations into account. The investigation has provided robust evidence for a moderation by functional health on the association between internet usage and autonomy. Our findings contribute to the small number of studies on the relationships between internet usage, health status, and autonomy in the oldest-old age group, and provides directions for further research. More research is needed to understand the conditions under which internet usage can promote autonomy in old age. Such research is important, because the internet is an extremely diverse medium that is constantly changing. Internet usage can contribute to active aging and autonomy in old age by optimizing opportunities for improving health, participation, and security.

Appendix

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Author contributions All authors have participated in (a) the conception and the design of the study or the analysis and interpretation of the data; (b) the drafting of the article or its critical revision for important intellectual content; and (c) the approval of the version to be published.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest.

Ethics approval The survey NRW80+has an ethical permit (17-169) from the Ethics Commission of Cologne University's Faculty of Medicine.

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ORIGINAL INVESTIGATION

Preservation of long-term memory in older adults using a spaced learning paradigm

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Abstract

How much information we retain depends on type/schedule of training. It has been widely acknowledged that spaced learning is advantageous compared to massed learning for cognitively healthy young adults and should be considered an educational standard. Literature would suggest that the spacing effect is preserved with age, though it is unclear whether this effect translates to more ecologically valid concepts such as face-name associations, which are particularly susceptible to deterioration with age. Two experiments were conducted to investigate the effects of spacing across recent/remote retention intervals, and the effect of age on spacing in cognitively healthy older adults using the Face-Name Pairs task. Experiment 1 results suggest that the beneficial memory effects of spacing are particularly observed with long-term memory. Experiment 2 results suggest that older adults are impaired at learning compared to younger adults, that the spacing effect influences both older and younger adults at longer intervals, and that spaced-trained participants display similar forgetting patterns at longer intervals, irrespective of age. These results may have some implications regarding improving the conditions under which optimum retention occurs (namely, whether spacing is beneficial when learning ecologically valid concepts at longer intervals outside of laboratory settings), and may provide insight into the effect of age on our ability to learn and remember face-name associations.

Keywords Spaced learning · Distributed practice · Massed learning · Long-term memory · Retention

Introduction

It has been widely acknowledged that spaced learning (repeated learning sessions separated by intervals) holds a distinct advantage over massed learning (learning occurs in one sitting), even when overall encoding time does not differ (Benjamin and Tullis 2010; Kapler et al. 2015; Delaney et al. 2018). The spacing effect has been widely reproduced across many domains (Goverover et al. 2009; Wang et al. 2017). For example, Kapler, et al. (2015) found that undergraduate students who reviewed lecture material after an interval of multiple days performed better on tests than those who reviewed the content after only one day. Similarly, research has shown that spaced learning also benefits the retention of practical skills at two-weekly and one-yearly intervals in surgical trainees (Spruit et al. 2014). The findings are so robust that Kapler et al. (2015) have suggested that repeated sessions should be considered as an educational standard. Despite this, individuals consistently rely on massed schedules of learning over spaced, even going so far as to formally judge massed learning as better than spaced when presented with alternative evidence (Kornell and Bjork 2007; Kornell 2009; Son and Kornell 2009). This may be due to the fact that massed learning can be less time-consuming than spaced (Baddeley and Longman 1978).

Encoding is an active and constructive process; memories are not perfect portrayals of events, rather they are a combination of new sensory information and our existing knowledge and world views. As a result, successful encoding is often heavily dependent on both existing knowledge and our ability to draw associations between that knowledge and new information (Brown and Craik 2000). There is significant research to suggest that the medial temporal lobe, specifically the hippocampus, is imperative in the formation of associative memories (Suzuki 2007; Gould and Davis

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2008). Research demonstrates that spacing is particularly advantageous when engaging in associative learning (Richter and Gast 2017; Wang et al. 2020; Nakata and Elgort 2021; Penaloza et al. 2022). Among the most commonly used stimuli in spacing research are simple word or image/character pairs (Cepeda et al. 2009; Kupper-Tetzel 2015; Richter and Gast 2017; Wang et al. 2020). Associative learning may be the key as to why spacing is so advantageous.

Three fundamental theories have been proposed to explain the benefits of spacing: deficient processing, study-phase retrieval, and encoding variability. Deficient processing assumes that information is processed and encoded differently under spaced schedules of learning. Due to the lag between spaced study sessions, individuals experience a reduced sense of familiarity with to-be-learned material compared to massed study sessions. As a result, spaced-trained individuals are more likely to engage in deeper processing and encoding which allows for a stronger long-term memory trace (Hintzman 1974; Limons and Shea 1988; Benjamin and Tullis 2010; Delaney et al. 2010; Maddox 2016). Study-phase retrieval refers to the likelihood of subsequent study sessions separated by time prompting the retrieval of initial study sessions, thus strengthening a memory through constant retrieval that is not present in massed training schedules (Thios and D'Agostino 1976; Benjamin and Tullis 2010; Maddox 2016). Encoding variability theory suggests that an increase in time between study sessions allows for greater variability in encoding. This can refer to a number of factors, such as encoding strategy, context, and the possibility of each study session leaving a distinct and individual memory trace (Bray et al. 1976; Glenberg 1979; Benjamin and Tullis 2010). The key component of encoding variability theory is that individuals are more likely to form strong associations between target information and various contextual cues, thus enhancing retrieval. Combining the aforementioned theories suggests that spaced learning is superior due to more efficient processing and creation of a stronger long-term memory trace upon successful retrieval, as retrieval becomes more difficult when study sessions are spaced apart. Additionally, spaced study sessions allow for the encoding of greater contextual cues which may be associated with target information, thus allowing for a stronger overall memory trace, particularly at longer intervals.

Despite the robustness of the effect, spacing research has been criticized, with some suggesting that laboratory-based tasks are too simple and therefore not indicative of the complex cognitive abilities required in real-world settings (Hochhalter et al. 2005; Logan and Balota 2005; Rohrer and Pashler 2010; Kapler et al. 2015). This raises questions about whether spacing may be of benefit when learning more ecologically valid concepts, such as face-name associations. Reason and Lucas (1984) and Cohen and Faulkner (1986) demonstrated that individuals find it more difficult to recall names than occupations or hobbies and that retrieval blocks are more common with regard to names than any other words. Cohen (1990) concluded that in general, names are only well-remembered when they have meaning; names that lack personal significance are inconsequential and often, individuals have nothing or no one with whom they may be associated, thus making them harder to recall then other semantic concepts. Carpenter and DeLosh (2005) found that participants were better at recalling face-name pairs following the utilization of a spaced, tested schedule when compared to those in the massed condition, suggesting that spacing is beneficial when learning face-name associations.

Furthermore, though spacing has been demonstrated at longer intervals (Price Kerfoot et al. 2010; Spruit et al. 2014), there has been somewhat limited research with regard to the long-term effects of spaced versus massed training schedules when learning more ecologically valid concepts, with many studies performing retests within a week of learning. Simanton and Hansen (2012) evaluated the ability of medical students to retain relevant knowledge across four years depending on the use of different educational models. Their results suggest that clinical application and spaced training schedules may lead to better retention of medical knowledge over a four-year period. These results complement those of Spruit et al. (2014). Similarly, Price Kerfoot et al. (2010) divided urology residents into online spaced training and web-based teaching (massed) schedules, whereby students received information to be studied at scheduled daily intervals, or all together in one single email. Participants were then tested periodically over a forty-five-week period. Results indicated that although participants in the massed condition tended to perform better in the short-term (weeks fourteen to sixteen), participants in the spaced condition demonstrated significantly better long-term retention of material (weeks eighteen to forty-five). These findings suggest that spacing may not be particularly beneficial in the short-term but can lead to significant long-term retention over greater periods of time (Price Kerfoot et al. 2010). This could also explain why many individuals believe that massed learning is preferable to spaced.

Across two experiments, we set out to extend the current knowledge with respect to spacing effects across short- and long-term recall intervals and across different age cohorts. We have chosen to use a face-name association task as this task has been shown to be impacted by age (Martschuk and Sporer 2018)—the task is also known to be hippocampal-dependent (a brain region particularly vulnerable to old age and age-related diseases) (Smith et al. 2014). The face-name pairs task is also more abstract and ecologically valid compared to other commonly used learning tests. In experiment 1, we examine face-name retention at 24 h, 1 week, and 1 month in young adults that have been either spaced- or massed-trained. We hypothesize that spaced learning will preserve memory primarily at longer intervals. In experiment 2, we examine recall of face-name pairs at 24 h and 1 month in a cohort of younger and older adults that have been either spaced- or massed-trained. We hypothesize that younger adults will learn and recall more information generally but that spacing benefits will be observed in both age cohorts.

Experiment 1

Methods

Participants

A priori power calculations were done to estimate the number of participants required to determine a main effect of spacing. Using fixed effects ANOVAs and an effect size of 0.3 (see Strickland-Hughes et al. 2020) with power of 0.9, $p = 0.05$, and 6 groups (spaced/massed at 24 h/1 week/1 month recall, see below) estimates 118 participants. One-hundred-and-eighteen participants (60 males, 58 females) aged 18–25 (mean = 23.08, standard deviation (SD) = 8.501) participated in the experiment. An exclusion and inclusion criteria were used before recruitment, so all participants were healthy, cognitively healthy, and had normal or corrected-to normal vision. No participant had a known history of drug or substance abuse, and no other relevant medical conditions.

Materials

Three control tasks were used to ensure that both training conditions (massed & spaced) were similar in terms of IQ, executive functioning, and general memory ability: The National Adult Reading Test (NART; Nelson 1982) gave an estimate of verbal IQ, the Trail Making Tasks (TMT; Reitan and Wolfson 1992) tested executive functioning, and the Rey Auditory Verbal Learning Test (RAVLT; Rey 1941) evaluated memory and learning strategies. A version of the Face-Name Pairs task (similar to that used by Zeineh et al. (2003)) was used to assess associative memory and was carried out using a Sony laptop. Eight female faces with associated names were presented twice in a block. Each face, a black and white photograph and without hair, was presented on screen for 5 s with the accompanying name. There were 4 blocks in total which were either presented sequentially on the same day (massed condition, $n = 57$) or one block of face-name pairs was presented each day for 4 days (spaced condition, $n = 61$). After each block, retention was assessed. Retention consisted of the 8 faces presented once without their corresponding name. The number of correctly recalled names associated with each of the 8 faces (out of 8) was used to measure memory performance.

Procedure

Participants were initially presented with a consent form to be read and signed. The experiment took place in a quiet room, free of distractions. Participants were asked to complete the NART, TMT, and RAVLT prior to partaking in the experiment. Participants were randomly assigned to either the spaced or massed condition and then to a 24 h, 1 week, or 1 month recall condition. Each condition included 4 study blocks and 1 retention block. Participants in the spaced condition completed the 4 blocks over four consecutive days. Participants in the massed condition completed the 4 blocks on one day. Those in the 24 h condition completed a single retention block 24 h after completing the study block, those in the 1 week condition completed the retention block 1 week after completing the study block, and those in the 1 month condition completed the retention block 30 days after the study block (see Fig. 1 for details of conditions, N/condition, and breakdown by gender).

Statistics

Microsoft Excel and an IBM SPSS statistics software programme (version 28) were used to calculate the results. Mixed and between factorial ANOVAs were used to compare the learning and recall phases, respectively. Tukey HSD test was used for between group *post-hoc* comparisons and Bonferroni corrected *t*-tests were used for further within-group comparisons. Independent and paired samples *t*-tests were used where appropriate. Results were determined as statistically significant when $p < 0.05$.

Ethics

The American Psychological Association and Psychological Society of Ireland codes of ethical conduct were observed throughout. Participants were provided with an information sheet in advance of the experiment, explaining the procedure in detail. All participants were over 18, consented to taking part, and were informed that they could withdraw at any time. Data were anonymized for privacy. All experiments were approved by Maynooth University ethics committee (reference SRESC-2017-097).

Results

To ensure that both spaced- and massed-trained conditions were matched across age and control tasks, we used a MANOVA to compare participants from both conditions with respect to age and scores on the NART, TMTs, and

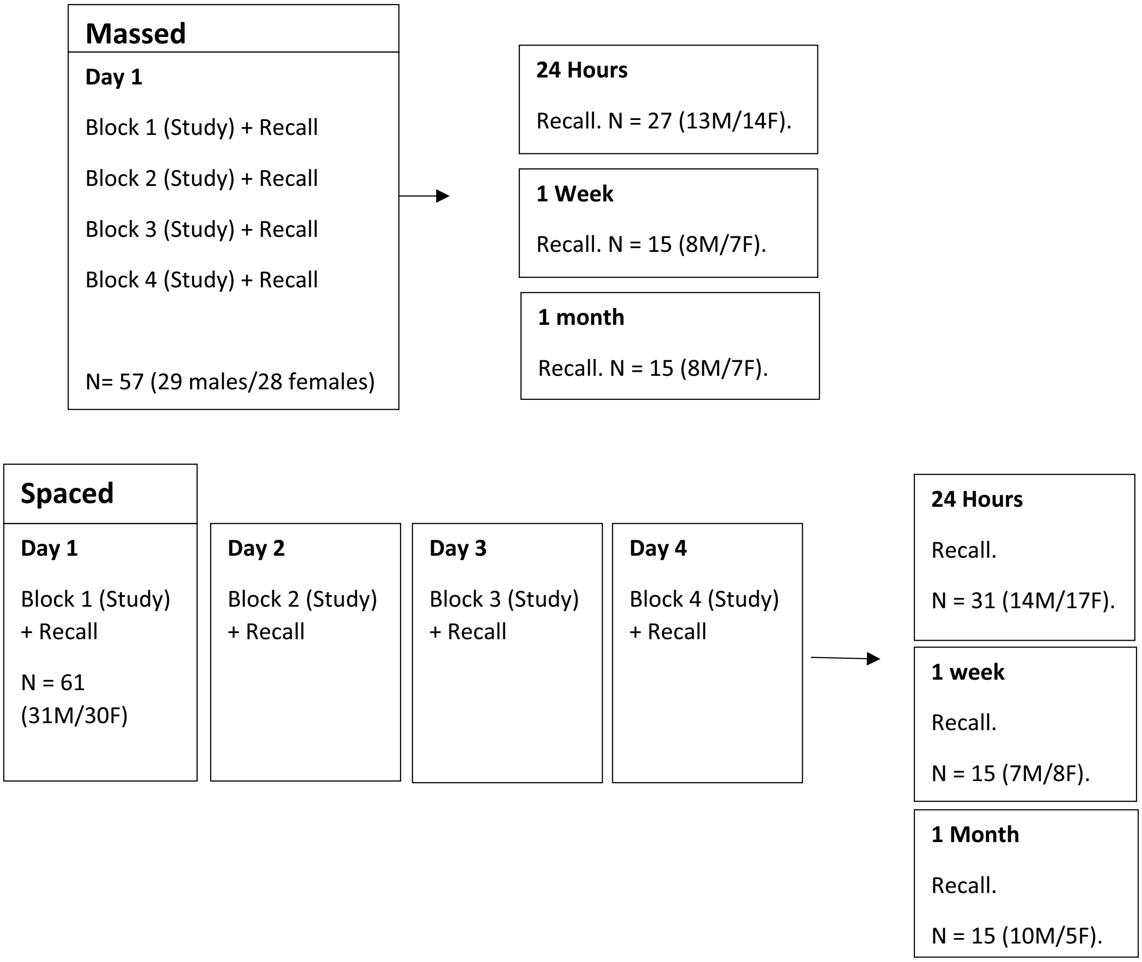


Fig. 1 A visual representation of the experimental design and a breakdown of the spaced and massed conditions including the N/interval (experiment 1)

RAVLT (see Table 1). The results indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(6, 106) = 0.749$, $p = 0.611$). There was also no significant difference between conditions when the results were considered separately, suggesting that participants were cognitively-matched and that further results were not affected by these variables.

To ensure that both spaced- and massed-trained conditions were matched across IQ, we conducted a further MANOVA to compare participants from both conditions with respect to age and predicted full scale, verbal, and performance IQ scores on the NART (see Table 2). The results indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(4, 108) = 1.071$, $p = 0.375$). There was also no significant difference between conditions when the results were considered separately, suggesting that participants were IQ-matched and that further results were not affected by these variables.

Table 1 Mean age, NART, TMT, and RAVLT scores (standard deviation) for both spaced and massed conditions, and their *p* values

	N	M/F	Age	NART	TMTa	TMTb	TMTb-a	RAVLT
Spaced (SD)	61	31/30	23.59 (9.314)	24.27 (12.466)	25.00 (5.737)	45.88 (15.798)	20.84 (16.015)	52.71 (7.620)
Massed (SD)	57	29/28	22.86 (7.684)	23.47 (12.388)	24.18 (8.892)	46.44 (14.955)	22.30 (13.062)	50.60 (8.088)
p values	–	–	0.650	0.735	0.560	0.846	0.596	0.155

Table 2 Mean predicted full scale, verbal, and performance IQ scores (standard deviation) for both spaced and massed conditions, and their *p* values

	N	M/F	Age	Full Scale IQ	Verbal IQ	Performance IQ
Spaced (SD)	60	31/30	23.59 (9.314)	114.09 (5.564)	112.05 (5.086)	113.09 (4.959)
Massed (SD)	57	29/28	22.86 (7.684)	113.77 (6.182)	111.79 (5.653)	112.77 (5.510)
p values	–	–	0.650	0.775	0.795	0.748

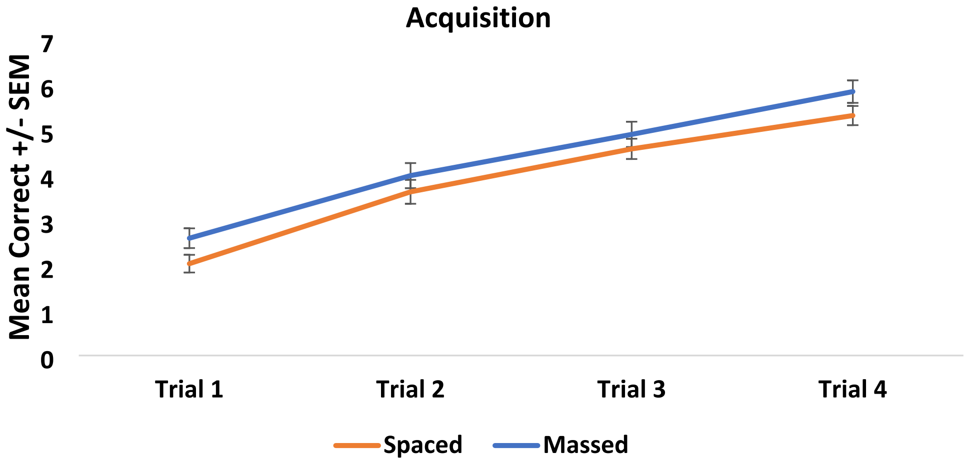


Fig. 2 Mean acquisition score (and standard error of the mean, SEM) for both spaced and massed conditions across the four learning blocks

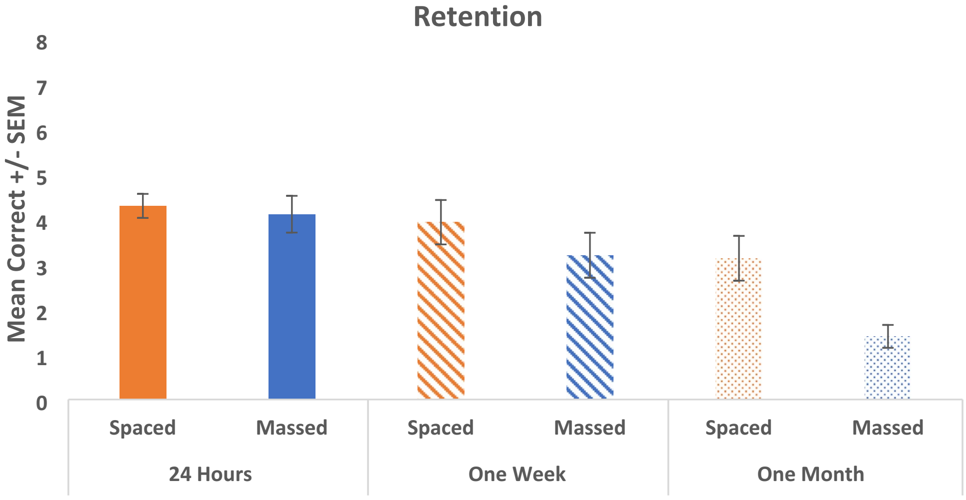


Fig. 3 Mean retention score (and standard error of the mean, SEM) for both spaced and massed conditions when retested at 24-h, 1-week, and 1-month post-learning

Acquisition phase

An initial 2 × 4 mixed between-within factorial ANOVA was conducted to compare learning across the 4 trials for both the spaced- and massed-trained conditions. A significant main effect of Trial (F (3, 114) = 164.176, $p < 0.001$, partial eta squared = 0.812), but no effect of Condition (F (1, 116) = 2.322, $p = 0.130$, partial eta squared = 0.020) was found. There was no significant interaction between trial and condition (F (3, 114) = 0.393, $p = 0.758$, partial eta squared = 0.010) (see Fig. 2).

Retention phase

A two-way between groups ANOVA was conducted to explore the difference between the ability of those in the spaced and massed conditions to recall the face-name pairs following an interval of 24 h, 1 week, or 1 month. The results indicate a main effect of Condition (spaced/massed)

(F (1, 112) = 9.464, $p = 0.003$, partial eta squared = 0.078) and a significant main effect of Retention Interval (F (2, 112) = 14.673, $p < 0.001$, partial eta squared = 0.208). There was no significant interaction effect (F (2, 112) = 0.619, $p = 0.540$) (see Fig. 3).

Two one-way ANOVAs were conducted to examine whether there were any differences between the performance of participants in the spaced and massed conditions, respectively, at the three different time intervals. Results for the spaced condition indicated that there was an overall significant difference between performance at each of the three intervals (F (2, 58) = 5.110, $p = 0.009$). Tukey HSD *post-hoc* comparisons indicated that performance for the spaced condition was not significantly different at 24 h and 1 week ($p = 0.183$) but there was a significant difference between recall at 24 h and 1 month ($p = 0.009$). *There was no significant difference between performance at 1 week and 1 month* ($p = 0.505$). Similarly, the results of the massed condition indicated that there was a significant difference between performance at each of the three intervals (F (2, 54) = 10.482, $p < 0.001$). *Post-hoc* comparisons indicated that performance for the massed condition was significantly different at 24 h and 1 month ($p < 0.001$), and *significantly different at 1 week and 1 month* ($p = 0.026$). There was no significant difference between performance at 24 h and 1 week ($p = 0.281$).

Brief discussion

These results would suggest that with spaced training there is a small decline in memory performance after 1 week but a limited decline after this. Whereas with massed training, there is a gradual decline in performance throughout the month, and particularly between 1 week and 1 month. The beneficial memory effects of spaced training are particularly observed at long-term intervals (i.e., 1 month). Our results are in line with the original hypotheses and many of the aforementioned studies in that we observed a spacing effect at longer retention intervals, however, according to existing literature we should also expect to observe spacing at shorter intervals which was not the case (Goverover et al. 2009; Benjamin and Tullis 2010; Kapler et al. 2015; Wang et al. 2017; Delaney et al. 2018). This discrepancy may be due to the type of material (face-name associations) or the schedule of spacing implemented. In particular, these results are not dissimilar to those of Price Kerfoot et al. (2010), who found that participants in the massed condition performed better than those in the spaced condition at shorter time intervals, but at longer time intervals, those in the spaced condition retained significantly more information than those in the massed condition. However, it is worth noting that Price Kerfoot et al. (2010) conducted retests at significantly longer intervals in comparison with this experiment (16 and 45 weeks, respectively). Differences in results may be attributable to different types of to-be-learned information (medical knowledge versus face-name associations). Having established that spacing optimizes retention in younger adults using a face-name pairs task, it raises the question of whether the same is true for cognitively healthy older adults, and if so, can spacing be used to help combat natural memory decline with age?

Experiment 2

Introduction

Though most studies examining the spacing effect include younger participants, there are a few that focus on cognitively healthy older adults. Bercovitz et al. (2017) concluded that, although younger adults remember more than older adults overall, there is evidence of the spacing effect in both participant groups at 10-day intervals. Similarly, Balota et al. (1989) found that older participants were influenced by the spacing effect, particularly at longer intervals. Therefore, like younger adults, older adults may also benefit from implementing spaced schedules when attempting to learn face-name associations, particularly at longer intervals.

Retention of face-name associations becomes a key difficulty with age (Ozen et al. 2010; Humphries et al. 2015; Hromas and Bauer 2019). For example, D'Argembeau and Van der Linden (2010) found that older adults had more difficulty recalling unfamiliar faces compared to younger adults, while Martschuk and Sporer (2018) noted that younger participants performed better than older participants across a number of different face recognition measures. Age is not always indicative of memory performance. Chalfonte and Johnson (1996) found no difference between the ability of older and younger participants to remember individual objects and colors. However, when asked to recall object/color associations, older adults performed significantly worse than younger adults. Similarly, Grady (2012) acknowledges that while episodic, verbal, and working memory deteriorate with age, semantic memory is largely preserved. Indeed, Naveh-Benjamin et al. (2004) suggest that when it comes to remembering faces and names, older adults particularly struggle with associative memory. Their results indicate that older adults are just as capable as younger adults at remembering names, and exhibit only a slight decline in performance when recalling faces. However, older adults were significantly worse than younger adults when recalling face-name associations. This begs the question of whether spacing may be beneficial to older adults in attempting to recall associative concepts?

Recently, research tends to shy away from encoding variability as an explanation of spacing as it is difficult to control for and thus prove (Benjamin and Tullis 2010; Maddox 2016). However, encoding variability may explain why older adults do not benefit from spacing to the extent of younger adults (Bercovitz et al. 2017). It has long been suggested that natural memory decline with ageing may be a result of an inability to adequately associate information when creating complex memories (Chalfonte and Johnson 1996; Naveh-Benjamin et al. 2000). Furthermore, there is evidence to suggest that older adults are unable to apply context-specific cues in the way that younger adults can, implying that while encoding variability may be beneficial to an extent, older adults cannot make full use of encoded contextual elements (Smith et al. 1998). More recent evidence suggests that older adults are susceptible to hyper-binding, an effect where associations are formed between target information and distractors, which younger adults would be more likely to successfully reject (Powell et al. 2018). In this scenario, encoding variability could work against older adults, allowing for too much association and thus making it difficult to recall the target stimulus. This raises questions about the suitability of spacing as a learning technique for both older and younger adults. There is evidence to suggest that older adults also benefit from spacing (Balota et al. 1989; Bercovitz et al. 2017); however, if the benefits are minimal spacing may not be worth the time and effort required. Experiment 2 will examine this further.

Methods

Participants

A priori power calculations were done to estimate the number of participants required to determine a main effect of spacing and age group and an interaction effect between the two. Using fixed effects ANOVAs and an effect size of 0.3 (see Strickland-Hughes et al. 2020) with power of 0.9, $p=0.05$, and 8 groups (younger/older, spaced/massed, 24 h/1 month recall, see below) estimates 118 participants. One hundred-and-forty-one participants (67 males and 74 females) were recruited for this study. Based on the recommendation of the World Health Organisation (2015) at the time of data collection, we classified older adults as those aged 55+. In our sample, older adults were aged 55–87 (mean = 64.63 SD = 9.004). Those classified as younger adults were aged 18–29 (mean = 21.85 years, SD = 2.294). An exclusion and inclusion criteria were used before recruitment, so all participants were healthy, cognitively healthy, and had normal or corrected-to normal vision. No participant had a known history of drug or substance abuse, and no other relevant medical conditions.

Materials

Four control tasks were again used to ensure that both conditions (massed and spaced) within each age cohort were similar in terms of IQ, executive functioning, and general memory ability. These tasks included the NART (Nelson 1982), the TMT (Reitan and Wolfson 1992), and the RAVLT (Rey 1941). The Montreal Cognitive Assessment (MoCA; Nasreddine et al. 2005), which tests general cognition and for mild cognitive impairment, was given to the older adults to ensure that all were cognitively healthy. The Face-Name Pairs task used in experiment 1 was used again to assess associative memory.

Procedure

All participants were presented with a consent form to be read and signed. The experiment took place in a quiet room, free of distractions. Participants were asked to complete the NART, TMT, RAVLT, and MoCA prior to partaking in the experiment. Each test was explained in full, and results were given upon completion if requested. Similar to experiment 1, participants in each age cohort were randomly assigned to spaced or massed conditions and then to the 24 h or 1 month intervals (see Table 3 for details of N). Each condition again included 4 study blocks and 1 retention trial block. Participants in the spaced condition completed the 4 trial blocks over 4 consecutive days. Participants in the massed condition completed the 4 trial blocks on 1 day. Those in the 24 h condition completed the retention block 24 h after completing the study block and those in the 1 month condition completed the retention block 30 days after the study block. This experiment was also approved by the Maynooth University ethics committee (reference SRESC-2017-097).

Results

To ensure that both younger and older spaced- and massed-trained participants were matched across control tasks, we used two MANOVAs to compare participants from both conditions with respect to scores on the NART, TMTs, and RAVLT (see Table 4). The results of the younger MANOVA indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(6, 28)=1.008$, $p=0.440$). There was also no significant difference between conditions when the results were considered separately. The results of the older MANOVA indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(5, 52)=1.376$, $p=0.249$) (see Table 4). There was also no significant difference between conditions when the results were considered separately. Again, gender was matched for both age cohorts.

Table 3 Number of participants in each condition (massed and spaced) and time interval (including gender breakdown)

	24 h	One month
Spaced		
Older adults	14 (9 female/5 male)	15 (7 female/8 male)
Younger adults	22 (11 female/11 male)	15 (10 female/5 male)
	36	30
Massed		
Older adults	15 (9 female/6 male)	15 8 female/7 male
Younger adults	23 (11 female/12 male)	22 (12 female/10 male)
	38	37
Total number	74	67

To ensure that both spaced- and massed-trained younger and older adults were matched across IQ, we conducted a further MANOVA to compare participants from both conditions with respect to age and predicted full scale, verbal, and performance IQ scores on the NART (see Table 5). The results of the *younger* MANOVA indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(4, 84) = 0.662$, $p = 0.620$). There was also no significant difference between conditions when the results were considered separately, suggesting that participants were IQ-matched and that further results were not affected by these variables. The results of the *older* MANOVA indicate that there was no significant difference between the spaced and massed conditions on the combined dependent variables ($F(4, 53) = 1.569$, $p = 0.196$). There was also no significant difference between conditions when the results were considered separately, suggesting that participants were IQ-matched and that further results were not affected by these variables.

Table 4 Mean age, NART, TMT, RAVLT and MoCA scores (standard deviation) for both spaced and massed conditions, and their *p* values

	N	M/F	Age	NART (No errors)	TMTa (S)	TMTb (S)	TMTb-a (S)	RAVLT No correct (Sum 1–5)	MoCA (Score)
Young spaced	37	21/16	22.32	15.59	32.2	38.4	18.8	48.8	28.6
(SD)			(2.11)	(3.362)	(15.85)	(13.8)	(9.55)	(8.349)	(0.894)
Young massed	45	22/23	21.47	13.63	24.83	45.22	20.88	56.73	28.43
(SD)			(2.39)	(5.468)	(7.737)	(13.25)	(11.043)	(12.17)	(1.455)
p values	–	–	–	0.492	0.104	0.297	0.694	0.172	0.807
Older spaced	29	13/16	65.17	11.36	31.54	81.54	48.68	47.75	27.13
(SD)			(10.1)	(6.623)	(12.55)	(54.07)	(46.71)	(8.077)	(1.807)
Older massed	30	13/17	64.1	9.13	32.47	65.45	32.49	47.10	27.57
(SD)			(7.99)	(3.646)	(9.980)	(13.92)	(12.955)	(11.040)	(1.633)
p values	–	–	–	0.116	0.753	0.121	0.073	0.8	0.422

Acquisition phase

An initial 4 × 4 mixed between-within factorial ANOVA was conducted to compare learning across the 4 trials for both the spaced- and massed- trained conditions and for both the younger and older cohorts. There was a significant main effect of Trial (F (3, 135) = 84.323, $p < 0.001$, partial eta squared = 0.652) and a significant effect of Cohort (older/younger) (F (3, 137) = 39.135, $p < 0.001$, partial eta squared = 0.461). There was a significant interaction between Trial and Cohort (F (9, 328.705) = 3.019, $p = 0.002$, partial eta squared = 0.062) (see Fig. 4). Bonferroni-corrected t-tests indicate that the mean number of correct responses on trial 4 were significantly higher than trials 1, 2, and 3 ($p < 0.001$), suggesting that all groups learned the task. *Post-hoc* comparisons using the Tukey HSD test indicated that there was an overall significant difference between the performance of the young and old cohorts ($p < 0.001$). There was also a small but significant

Table 5 Mean predicted full scale, verbal, and performance IQ scores (standard deviation) for both younger and older adults in the spaced and massed conditions, and their *p* values

	N	M/F	Age	Full Scale IQ	Verbal IQ	Performance IQ
Young spaced (SD)	37	21/16	22.32 (2.11)	111.41 (5.297)	109.69 (4.928)	110.72 (4.774)
Young massed (SD)	45	22/23	21.47 (2.39)	112.16 (6.816)	110.35 (6.264)	111.35 (6.108)
p values	–	–	–	0.591	0.607	0.615
Old spaced (SD)	29	13/16	65.17 (10.1)	116.76 (8.149)	114.59 (7.562)	115.45 (7.129)
Old massed (SD)	30	13/17	64.1 (7.99)	119.24 (4.580)	117.00 (4.234)	117.76 (3.997)
p values	–	–	–	0.158	0.139	0.134

difference between the performance of the young spaced and massed conditions ($p = 0.022$), but no significant difference between the performance of the old spaced and old massed conditions ($p = 0.973$).

Retention

An initial 2 × 2 × 2 factorial ANOVA was conducted to explore the difference between the ability of those in the spaced and massed conditions and the ability of younger and older participants to recall the face-name pairs following an interval of 24 h or 1 month. There was a significant main effect of Time (F (1, 132) = 20.246, $p < 0.001$, partial eta squared = 0.133), a significant effect of Age (F (1, 132) = 48.087, $p < 0.001$, partial eta squared = 0.267), and an effect of Condition (F (1, 132) = 4.667, $p = 0.033$, partial eta squared = 0.034). There was a significant interaction between Age and Time (F (1, 132) = 3.954, $p = 0.049$, partial eta squared = 0.029), but no significant interaction between Condition and Age (F (1, 132) = 0.912, $p = 0.341$, partial eta squared = 0.007), no significant interaction between Condition and Time (F (1, 132) = 3.846, $p = 0.052$, partial eta squared = 0.028), and no significant interaction between Condition, Time, and Age (F (1, 132) = 0.714, $p = 0.400$, partial eta squared = 0.005) (see Fig. 5).

To examine the differences in retention in more depth, we carried out two further 2 × 2 factorial ANOVAs. Recall at 24 h indicated that there was a significant main effect of Age (F (1, 69) = 37.197, $p < 0.001$, partial eta squared = 0.350), with older adults recalling less names compared to younger adults. However, there was no effect for Condition (F (1, 69) = 0.019, $p = 0.892$, partial eta squared < 0.001) and no interaction effect between Age and Condition (F (1, 69) = 1.514, $p = 0.223$, partial eta squared = 0.021). Recall at 1 month also showed a significant effect of Age (F (1, 63) = 13.373, $p = 0.001$, partial eta squared = 0.175), with older adults again showing poor recall. There was also a significant effect of Condition (F (1, 63) = 9.287, $p = 0.003$, partial eta squared = 0.128), with *those in the spaced condition*

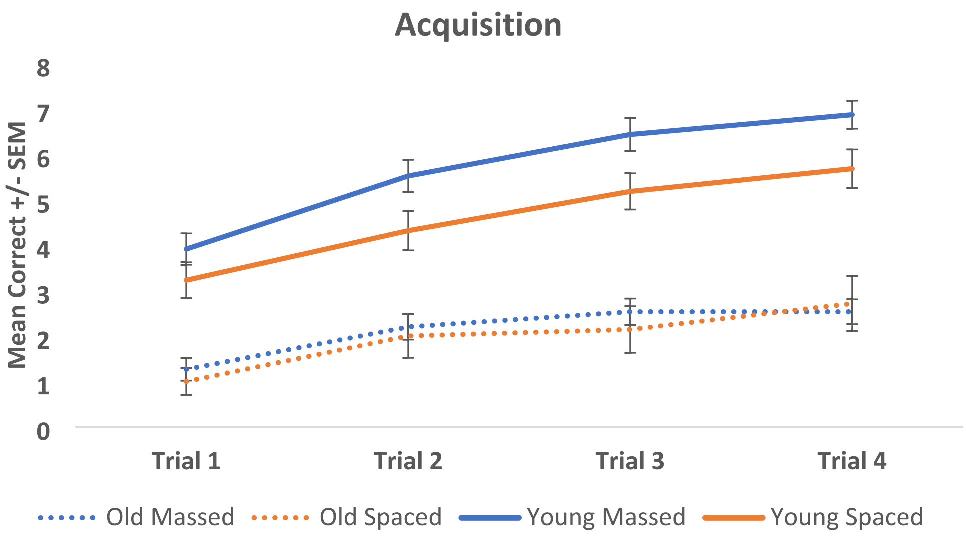


Fig. 4 Mean acquisition (and SEM) for both spaced and massed, and older and younger cohorts across the four learning blocks

recalling significantly more than those in the massed condition (irrespective of age). There was no interaction between Age and Condition (F (1, 63) = 0.007, $p = 0.935$, partial eta squared < 0.001) (see Fig. 5).

Forgetting

Our results suggest that participants in the spaced condition (irrespective of age) recalled more compared to those in the massed condition and that this effect was observed at 1 month recall. As such, we would expect a greater forgetting effect (between the final learning trial compared to the recall trial) for the massed condition compared to the spaced condition, particularly at the 1 month recall. Figure 6 shows a large and significant forgetting effect for both the younger (t (21) = 9.970, $p < 0.001$) and older cohorts (t (14) = 7.159, $p < 0.001$) in the massed condition. Interestingly, the rate of decline is significantly worse for the younger compared to the older adults (mean slope for younger adults is − 4.18 ± 0.4 and for older adults is − 2.4 ± 0.33, t (35) = 3.074, $p = 0.004$).

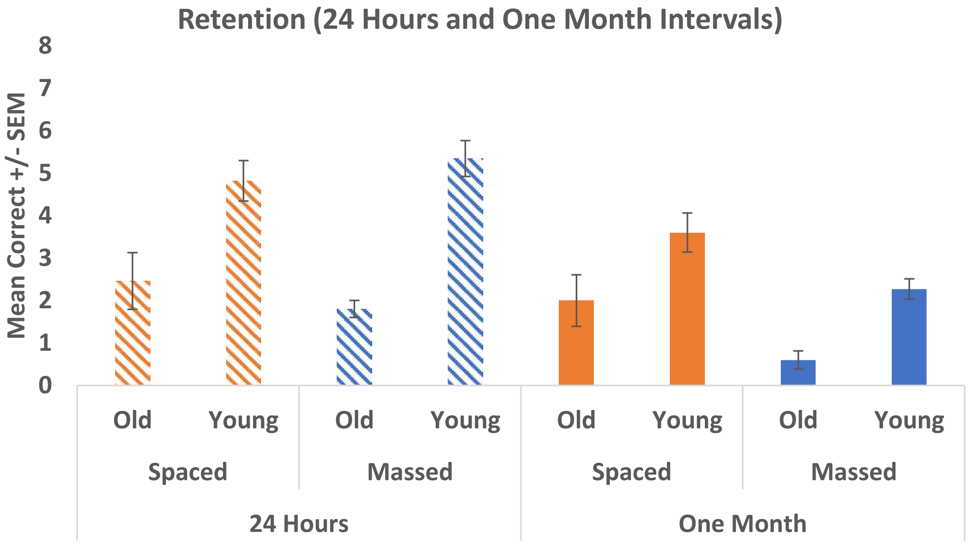
Figure 7 also shows a significant forgetting effect for both the younger (t (14) = 3.67, $p < 0.001$) and older cohorts (t (14) = 5.29, $p < 0.001$) in the spaced condition. In contrast to the massed condition, the rate of decline for both age cohorts (mean slope for younger adults is -1.266 ± 0.33 and for older adults is − 1.33 ± 0.25) is similar with no significant difference (t (28) = − 0.156, $p = 0.877$). Overall, the rate of decline is significantly worse for the massed condition compared to the spaced condition (F (1,63) = 28.4, $p < 0.001$).

A further 2 × 2 factorial ANOVA was conducted to explore the differences between older adults at both intervals in terms of percentage of correctly retained face-name pairs from Trial 4 to the Retest. Results indicated that there was a significant main effect of Interval (F (1, 56) = 16.207, $p < 0.001$, partial eta squared = 0.224), with older adults recalling a lower percentage of face-name associations at 1 month. However, there was no effect for Condition (F (1, 56) = 1.934, $p = 0.170$, partial eta squared = 0.033) and no interaction effect between Interval and Condition (F (1, 56) = 0.057, $p = 0.813$, partial eta squared = 0.001) (see Fig. 8).

Discussion

Findings from experiment 1 show a strong effect of spaced learning at long-term intervals (1 month). This is somewhat in line with our original hypothesis and other studies; however, we would also have expected to see evidence of spacing at shorter intervals which was not the case (Goverover et al. 2009; Benjamin et al. 2010; Kapler et al. 2015; Wang et al. 2017; Delaney et al. 2018). In particular, these results are somewhat similar to those of Price Kerfoot et al. (2010), who found that participants in the massed condition performed better than those in the spaced condition at shorter time intervals, but at longer time intervals, those in the spaced condition retained significantly more information than those in the massed condition. This finding would suggest that at shorter intervals, the schedule of learning makes little to no difference in terms of overall performance and could potentially lend some insight as to why individuals are inclined to trust cramming over spacing (Kornell 2009). If, at 24 h or weekly intervals, participants actually perform just as well having learned in one sitting, it is easy to understand why people might find this option more desirable when compared to spacing (Baddeley and Longman 1978; Son and Kornell 2009). It is also possible that the results of this study were underpowered and that is why there is no effect at shorter intervals.

Fig. 5 Mean retention scores (and SEM) for both spaced and massed, and older and younger cohorts when retested at 24 h and 1 month



The results of the second experiment show the beneficial effects of spaced learning for older adults when learning face-name associations, particularly at longer retention intervals. Although younger participants generally learned more and thus demonstrated better recall, older adults that had been spaced-trained were better able to retain the information that they had learned. Therefore, participants, irrespective of their age, who were spaced-trained performed significantly better than their massed-trained peers. These results are in accordance with the original hypotheses and the existing literature (Balota et al. 1989; Benjamin and Tullis 2010; Bercovitz et al. 2017). These other studies also suggest that older adults tend to perform poorly compared to younger adults, but they exhibit similar patterns of retention.

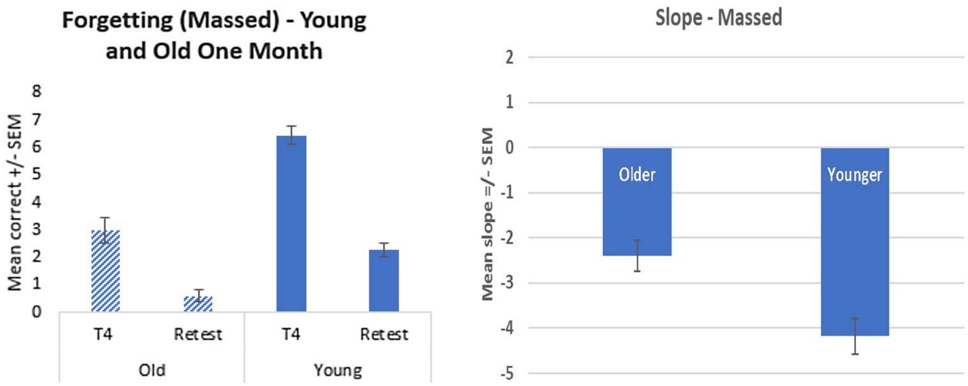


Fig. 6 Mean recall scores comparing the final trial of learning to scores recalled 1 month later (left), and the equivalent forgetting slope (right), for the older and younger massed conditions

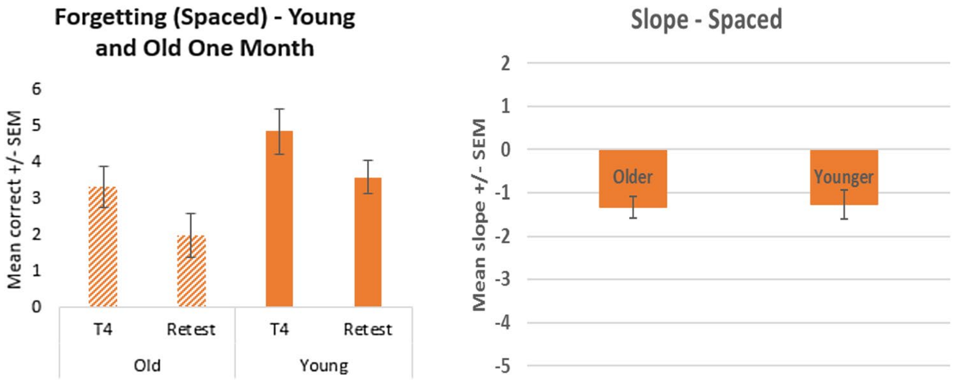


Fig. 7 Mean recall scores comparing the final trial of learning to scores recalled 1 month later (left), and the forgetting slope (right), for the old and young spaced cohorts

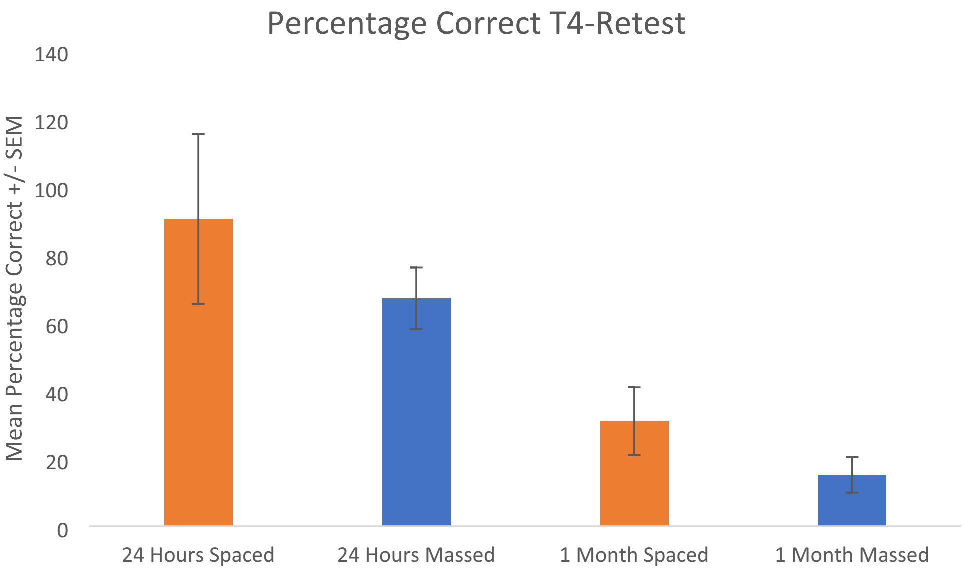


Fig. 8 A comparison of the percentage of correctly recalled face-name pairs between Trial 4 and the Retest in older adults at both 24 h and 1 month

Again, it is worth noting that the lack of findings at shorter intervals may be due to lack of power.

These findings could potentially be explained by encoding variability theory (Crowder 1976; Maddox 2016). Due to the delay between study intervals, spaced-trained participants have the opportunity to associate greater context with learned material, thus potentially making it easier to retrieve said material under various circumstances. Given that older adults are known to struggle when presented with context-specific cues, this could explain why younger adults perform better (Rabinowitz et al. 1982; Smith et al. 1998). However, encoding variability theory would suggest that older adults should not benefit from spacing at all, which is clearly not the case. Why, then, is spacing preserved with age? Findings of Callan and Schweighofer (2010) are consistent with deficient processing theory, the idea that spaced-trained individuals are more attentive to subsequent presentations when compared to massed-trained individuals. Due to the involvement of working memory at each stage in learning, massed-trained individuals are more inclined to believe themselves familiar with the material and therefore are less attentive on consecutive presentations. In contrast, spaced-trained participants are inclined to feel less familiar with the material which leads to more vigilant encoding with each presentation (Cepeda et al. 2006). If increased frontal activity is also present in older adults, this might explain the presence of the spacing effect, as well as aligning with other neuroimaging studies, for example, the posterior-anterior shift in ageing (PASA) model (Davis et al. 2007). Additionally, it is possible that due to over-activation or compensation-related brain activity, older adults are not able to distinguish between relevant and irrelevant contextual information the way young adults can, thus forming associations between target information and distractors (Campbell et al. 2010; Powell et al. 2018).

Furthermore, given that the face-name pairs task is thought to rely on the hippocampus (Smith et al. 2014), it is also possible that spaced advantages are due to the activation of this structure. For example, Li and Yang (2020) found that young spaced-trained participants showed significantly greater hippocampal activity when recognizing face-scene pairs compared to massed-trained participants. This activity was particularly pronounced at 1-month intervals. Given also the involvement of the hippocampus in consolidating long-term memories (Scoville and Milner 1957; Bercovitz et al. 2017; Delaney et al. 2018) and the importance of sleep in this process (Smolen et al. 2016), this could explain why distributed practice is so advantageous. It would be worth examining whether the same levels of hippocampal activation are observed in older adults.

In conclusion, these experiments have demonstrated that spaced learning is more advantageous than massed learning for both younger and older adults when attempting to retain face-name associations, particularly at longer intervals of 1 month. Furthermore, older adults perform significantly worse than younger adults under all conditions. However, spaced-trained individuals display similar patterns of forgetting at 1 month, regardless of age. Future studies may want to analyze face-name retention more specifically. The current studies only recorded correct versus incorrect responses. Analyses of specific face-name retention between trial 4 and the retest may shed further light on forgetting.

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Declarations

Conflict of interest The authors did not receive support from any organization for the submitted work. The authors have no relevant financial or non-financial interests to disclose.

Data availability statement The data that support the findings of this study are available at: https://osf.io/x6esd/?view_only=fe1a5e36f8ce41bb81e6076041218a2f.

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ORIGINAL INVESTIGATION

Social relations and exclusion among people facing death

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Abstract

In line with current policies and service developments related to palliative care, more people are dying at home. This situation has provoked discussions about the importance of non-medical issues related to death. The process of dying is often long, with many phases, and the social aspect is a major part of it. Our focus in this article is on dying as a social process. Social relationships are significant and play a meaningful role in enhancing the well-being of older adults approaching the end of life. Meaningful social relationships tend to change over time; however, and the process of dying may exacerbate such changes in and challenge these relationships. The aim of our study was to examine how social relationships are experienced and (re)constructed among older adults (70–83 years old) during the process of dying, in a Finnish context. We were interested in the nature and type of these relationships, and in the possible new forms of expression that may emerge during this process. Our empirical data were based on interviews with seven older adults who were close to death. The analysis revealed processes of exclusion from existing relations. At the same time, we observed new and unexpected relations being initiated, which sometimes became meaningful and supportive. The results highlighted the role of expectations and importance of analysing exclusion from a life-course perspective.

Keywords Death · Dying · Social relationships · Family · Exclusion

Introduction

Death returns home

The number of patients receiving home-based end-of-life care has been increasing in European countries, including Finland, in recent decades. Among Western societies, the place of death is influenced by individual factors such as age, cause of death and ethnic origin, and social factors such as the organisation of services and cultural expectations (Lloyd 2010). Keeping people at home in their old age in spite of illness is an explicit policy goal in Finland (Outila et al. 2019). Even though these ageing- or dying-in-place policies include multiple contradictory aspects (Sixsmith and Sixsmith 2008), in the view of many people the home is, in fact, the preferred option. Nevertheless, the most common place of death in Finland is in a health facility (Forma et al. 2020).

Death became medicalised and institutionalised during the transition from a traditional to a modern society (Exley 2004). The place of dying shifted from homes to hospitals and institutions, and death became isolated from everyday life (Miettinen 2006; Elias 1985). In line with current policies and service developments related to palliative care, death has “returned” home (Outila et al. 2019; Jeppsson Grassman and Whitaker 2007). This situation has provoked discussions on the importance of non-medical issues related to death, and questions regarding what constitutes a good death have been posed anew. The need for a holistic view of the dying, which emphasises the psychological, social and spiritual needs of individuals, has become acute (Lloyd 2010). Moreover, scholars have suggested broader conceptualisations of the end of life (Bern-Klug 2004), and have proposed social models for end-of-life care (Brown and Walter 2014).

An understanding of dying as a social process, and of the home as the context of that process, highlights the

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importance of informal care. Informal care is often provided by family members, for example partners or adult children (Åkerman et al 2021). However, the social aspect of dying includes more than the care dimension, which nevertheless tends to predominate. Social relationships are meaningful for older adults, and constitute a substantial part of well-being and fulfilment in life (Burholt and Aartsen 2021), even to those approaching its end. Hence, the social aspect of dying is an important part of the process, which may be long with many phases. Moreover, the process of dying may cause changes in and challenge meaningful social relationships, which changes over time.

Dying as a social process

Time and approaching the end of life are significant factors in the ageing process, as is acknowledged in the theoretical discussion within the field of social gerontology (Lloyd 2010). Despite their proximity in old age, research on death and dying has not attracted as much attention as could be expected. However, death-related research has gradually expanded in recent decades and there is growing scholarly interest in the phenomenon of dying, which is increasingly likely to occur at a very advanced age. Contemporary research has investigated palliative care, with a focus on death in nursing homes and other institutions (Macgregor et al. 2021; Ullrich et al. 2019), and an emphasis on the roles and perspectives of professionals. The Covid-19 pandemic further induced research into end-of-life-care (Mitchell et al. 2021; Porter et al. 2021). The role of informal relationships has also been discussed in this context, although mainly in relation to formal care. Nevertheless, the literature on the sociology of death has been expanding, with contributions initially coming from multi-disciplinary teams (Howarth 2007; Kellehear 2008; Holmberg et al. 2019).

Although the idea of a good death is understood to comprise a holistic view of the dying, including their psychological, social and spiritual needs (Lloyd 2010), scholars point out that the “disadvantaged dying” (such as older people without access to sufficient support) need more attention in research (Exley 2004). It has been found in some studies that social support is directly connected to the fear of death: when it is available, there is less anxiety and fear regarding death and dying (Chopik 2017; Cicirelli 1999, 2002). Lloyd et al. (2011) conclude that relationships with family and friends are essential to a good or “bad” death. The availability of social support for the dying may relate to lifelong circumstances, but there may also be changes in social relationships just before death. This paper focuses on changes in social relationships over the course of dying, from the conceptual perspective of social exclusion. This paper focuses on social relationships in the context of dying, and especially on changes in them, from the conceptual perspective of exclusion.

Social exclusion and exclusion from social relationships

In recent years, the concept of social exclusion has been developed in connection with research on older adults. Exclusion has been conceptualised in different yet related ways, but the key elements in the definitions are its relative and dynamic nature. Consequently, exclusion should be seen in the context of the society in which people live and as something that changes over time (e.g. Walsh et al. 2021; Macleod et al. 2019). The definition suggested by Levitas et al. (2007: 25; see also Walsh et al. 2021, 11) reflects these key elements: a lack or the denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities that are available to the majority of people in a society.

The concept of exclusion has been criticised on the grounds of a lack of clarity in connection with operationalisation, but it is argued that its strength lies in the focus on processes rather than outcomes, which in turn enhances understanding of inequalities and social injustice (Sealey 2015). At the core of the concept is multidimensionality: exclusion may operate in different (interrelated) domains, one or several at the same time. The key domains of social exclusion in different definitions (see Walsh et al. 2021; Keating and Scharf 2012) include economic circumstances, social relations, services, community & spatial issues and civic exclusion. The focus in empirical research tends to be on one of them, but taking into consideration the multidimensional nature of the phenomenon. Although in the context of political discourse exclusion is often connected to economic difficulties, exclusion from social relations has been strongly present in conceptual discussion (Waldegrave et al. 2021; Walsh et al. 2021; MacLeod et al. 2019; Burholt et al. 2017; Keating and Scharf 2012; Walsh et al. 2016).

Being excluded from social relations touches on the fundamental aspects of social life and is considered a serious threat to well-being (Burholt and Aartsen 2021; Waldegrave et al 2021; Vaara et al. 2016). Such exclusion has been defined as follows:

> … we define exclusion from social relations as a situation in which people are disconnected from adequate levels of quality of intimate relationships, social networks, social support, and/or social opportunities to participate in wider society. (Burholt and Aartsen 2021, 77)

Even though key events that are more likely to occur in old age, such as the death of family members or friends, increase the risk of exclusion (MacLeod et al. 2019), a life-course approach is important (Van Regenmortel 2017) in analyses of exclusion from social relations. However, its potential remains underutilised (Burholt and Aartsen 2021). It would be useful, for instance, to see and understand people's current social needs and relationships in relation to the life course, and to recognise the impact of potential adversities experienced throughout the lived life (Ejlskov et al. 2019; Tiilikainen and Seppänen 2017).

Potential drivers have been identified in the theoretical development of the concept of exclusion in later life. According to Scharf and Keating (2012, 6–9), key drivers operate on three different levels. First, structural drivers (such as ageism, discrimination and both social and economic policies) can be identified on the national level; second, environmental drivers relate to the living environment of older persons and include aspects such as the changing nature of urban communities; third, examples of individual-level drivers include a migratory life course, disruption in social networks and ill-health (see also De Jong Gierveld et al. 2009; Aartsen et al. 2004).

As stated above, the main aspects of exclusion as a concept are multidimensionality and relativity. Another key element is its dynamic nature. In the context of exclusion from social relationships, for example, we believe that the aspect of process is paramount. A more contested although less prominent notion is the involvement of agency, in other words that individuals, consciously or sub-consciously, may choose to exclude themselves (Walsh et al. 2021). The concept of *solitude*, or voluntary withdrawal, was developed earlier to describe situations in which individuals voluntarily decide to withdraw from social connections (Nguyen et al. 2017). In that exclusion tends to be understood as a negative phenomenon, it differs from the concept of solitude, and rather connotates the idea of *social death* with its implications of a loss of social identity and connectedness (Králová 2015; see also Pirhonen et al. 2021). Just as losing all social contacts could be referred to as social death while living, living "in social death" could also result in dying alone without conscious intention, or even choosing to die alone (Caswell and O´Connor 2015). Our focus in this article is on exclusion understood as an unvoluntary state of being.

A recent literature review (ten Bruggencate et al. 2018) focusing on the social needs of older people divided the analysed empirical articles according to the themes of diversity, proximity, the meaning of relationships and reciprocity. The relationships of older adults were described as (i) intimate relationships that bring love and belonging and (ii) peripheral relationships (such as contacts at clubs, churches and pubs) that make older adults feel part of life and of society.

Both types (intimate and peripheral) of social relations could be considered essential to well-being. However, it is argued that family relationships are at the core of the domain of exclusion from social relationships (Keating and Scharf 2012). Discussions in Europe have emphasized—in addition to the centrality of family relationships—the quality and complexity of family interactions. The idea of family has undergone a transformation and new kinds of familial patterns prevail (Jallinoja and Widmer 2011). Families are constellations of individuals that change continuously and could be understood as the result of negotiated family practices (Chambers et al. 2009), which highlights the importance of relations and relatedness in research on families. Older adults define social relations, especially family relations, and health as the key factors of well-being (Vaara et al. 2016). Consequently, exclusion from social relations could be a major threat.

This article is based on the understanding that exclusion from social relationships as a phenomenon is connected to reduced social opportunities, a low quality of social relationships, a lack of social networks and support, and feelings of isolation and loneliness (Walsh et al. 2016). Both the quantity and quality of social relations matter (Burholt and Aartsen 2021; Burholt et al. 2017). Whether or not approaching death influences the exclusion of the dying person is an interesting and underexplored question. In our study, therefore, we examined the kinds of social relations a dying older adult has, and how approaching death changes such relationships. We did not focus on care arrangements or palliative care as such, even though they are strongly present in the lives of dying older adults.

The research question

The aim of our study was to examine how the social relationships of older adults are constituted and how they change during the process of dying. We were interested in the nature and types of relationship, and in the possible new ways in which social relations are expressed during this process. We focused specifically on changes that occur when death is approaching, which we analysed from the exclusion perspective to shed light on how dying affects exclusion from existing relations.

The research questions were as follows:

1. What kind of social relationships do dying people have?
2. What changes in social relationships occur during the process of dying?

We were interested specifically in the relationships that dying older adults have with family members, relatives, friends, acquaintances, neighbours and people related to work and hobbies. In other words, we examined both intimate and peripheral relationships (see ten Bruggencate et al. 2018).

Data and methods

Our empirical data, collected in Finland, consisted of semi-structured interviews with seven older adults (aged 70–83 years) who were approaching death. The data were collected as part of a multidisciplinary study on the meaningful relationships of older adults (MeRela) in palliative care following a decision made by a doctor, or who had been diagnosed with an illness that would lead to death and who were spending their final days in a private home. The participants were recruited via private hospices and a public at-home hospital network in southern Finland (see also Saarelainen et al. 2020). Social and health care workers, typically nurses, inquired whether their clients would be interested in participating in the study. With the clients' permission, the workers then passed on the relevant contact information to the research group. A researcher contacted the potential participant to give more information about the study and to discuss the interview in more detail. In addition, an announcement about the study was published in an online and print newspaper of the Evangelical Lutheran Church of Finland in the Helsinki area, which made it possible for potential participants to reach out if they wished to contribute. A few participants were also contacted using the snowball method.

The semi-structured interviews were carefully planned to integrate the different backgrounds of the multidisciplinary research team that included representatives of theology, nursing, social sciences and law. Two interviewers conducted the interviews, which allowed researchers with different disciplinary backgrounds to participate. One of them assumed the role of primary interviewer in acknowledgement of the power dynamics of an interview. The interviews were conducted in pairs because they were potentially emotionally draining for the interviewers, given that the interviewees were facing death (Valentine 2007). The two researchers had a reflexive discussion after each interview to ensure that ethical aspects were considered throughout the process, during which they also evaluated the participants' need for support.

Each interview covered the following main themes: life here and now following the palliative-care decision, the home as an environment, social relationships, life before the illness, services and support, values and worldview, personal rights and the narrative of the future. In addition to the thematic interview, we used visual aids (Pictor: see, e.g. King et al. 2013) as a tool (Saarelainen et al. 2020). However, the drawings were not part of the data analysed in this article: we used the Pictor method only as part of the interviews to define how the participants located their social relationships.

This article is based on seven interviews with dying older adults, two males and five females. The data are part of a total of 32 interviews that were conducted for the research project. The participants of this study were in palliative care, or had been diagnosed/living with a terminal illness but still coped primarily independently at home. Three of them lived with their spouse and four lived alone. All except one had adult children with whom they frequently interacted.

The participants were assigned pseudonyms to ensure confidentiality and anonymity, and any details that could jeopardise their anonymity were left out. The interviews were conducted in Finnish and the quotations were translated into English for the purposes of this article: every attempt was made to preserve the original form of expression.

For the purposes of this article we used the phenomenological-hermeneutical method to facilitate understanding and interpretation of the participants' lived experiences (Laverty 2003). Our aim was to achieve an in-depth understanding of the meaning that dying older adults attribute to social relationships, and the changes that such relationships undergo during the dying process.

Using Atlas TI, we subjected the transcribed interviews to thematic analysis (Nowell et al. 2017). First, we identified the participants' social relationships and coded them accordingly. Next, we grouped the social relationships into different categories to describe the nature of the relationships. Then we analysed the data descriptions and the expressions connected to the meanings and changes in the relationships. We identified essential topics and themes, dividing them according to our analytical framework of intimate and peripheral relationships. The exclusion concept provided the basis for our abductive analysis.

Ethical considerations

Members of the research team recruited the participants in co-operation with local care providers. The participants were assured that they were free to express their thoughts openly and that the interview would have no effect on the services they received. Most of the participants were interviewed once, but one was interviewed twice, having requested a second meeting. The interviews lasted less than two hours, and the researchers always asked the interviewees if they wanted to pause or end the interview before all the themes had been covered. The participants were also given the option to leave questions unanswered, and were assured that they could withdraw from the research at any stage. The researchers were constantly aware of the need to protect the participants' well-being. Moreover, the significance of methodological issues for both participants and researchers was carefully considered: death is a sensitive or even "taboo topic" in research, which could thus be emotionally laden (Lee 1993). At the end of each interview, the participants were asked if a researcher could make a follow-up call a week later to ask how they were doing. The phone calls allowed the researchers to find out whether the interviews had caused emotional distress and to obtain support for the participant if needed. The two researchers had a reflexive discussion after each interview to ensure that ethical aspects were considered throughout the process, during which they also evaluated the participants' need for support. The research project was approved by the Ethical Review Board in the Humanities and Social and Behavioural Sciences at the University of Helsinki. At the beginning of each interview, the participants were informed about the purposes of the study and the ethical considerations, and were assured of compliance with General Data Protection Regulations (EU 2016/679).

Results

The analysis revealed various relationships and changes in them, and the separate and different roles of (intimate) family and peripheral relationships (ten Bruggencate et al. 2018) were strongly visible in the data. The participants generally classified their family relationships as intimate, although sometimes they also included long-term friendships. Other social relationships were considered peripheral. Below, we describe the findings related to these two types of relationship. All seven participants are included in the analysis, but examples from the data are best illustrated in the transcripts of six different interviews.

Intimate relationships

The interviewees commonly named family members as the most important people in their social networks. The most visible role was that of caregiver, typically a spouse. In a couple of instances, an adult child had taken an active role as a family caregiver when the dying person was living in a single household. Therefore, approaching death affected the social relations of the dying person and their family members the most, as caregiving became an integral part of all family relationships. Caregiving and the responsibilities it entailed included both concrete and practical help, as well as comprehensive care and concern for the dying person. Various arrangements had to be made to ensure that the dying had the assistance they needed at all times, such that different family members became involved during the absence of the primary caregiver. Consequently, care needs brought out elements that had not previously been part of the family relationship. Established roles, responsibilities and tasks changed, particularly between spouses but also between adult children and their parents. The dying person's care needs also raised expectations related to family relationships and receiving help. These included aspirations to establish closer relationships, particularly with adult children, with a view to having more visits and receiving more assistance:

> Maili: When my husband was having that choir practice, Juha visited me because I gave up the car so it was no longer here for me to go and do shopping and other things. Juha took care of things that week when my husband was away at choir practice. Even if [*the other son*] Jari is close by, he doesn't want to [*help, be in contact]* I don't really understand.

Approaching death also affected interactions among family members: it was a new topic that families needed to discuss. Some families found ways of talking about it. The communicative approach was often co-created during the interactions and reflected certain values or meanings attributed to death within the family. For example, some participants said that there was no need to talk about death, or pointed out that death was discussed openly but matter-of-factly, creating distance from sadness or more emotional responses. However, complicated unspoken feelings associated with death could be challenging and create distance between family members:

> Interviewer: How does your wife feel about this latest stage of your illness?
> Juhani: Well, it's one of those things that she never talks about. I just noticed that she takes tranquilisers. Pure accident, we were just in (name of a foreign country) and I had, in my opinion, packed enough medicine. It turned out that there wasn't enough, so she gave me her own...

We also discovered that relationships do not inevitably change as death approaches. In particular, difficult, broken and distant family relationships are not repaired, nor do they become close, but continue to be overshadowed by previous difficulties within the family. Consequently, changes in family relationships reflected the histories of the families. If the relationships had previously involved conflict, approaching death did not change this. Moreover, communication and interaction among family members did not necessarily increase. The divided nature of family life among different generations accentuated the lack of connection in some families, even when there were no significant challenges in the relationships. If family members lived relatively close, their visits to and social interaction with the dying person could be infrequent. Such distant relationships and the lack of visits or assistance often caused pain:

> Maili: Jari lives nearby, but his nature is one of those things, I don't know. Ever since he was a kid, but now somehow, in some way, he doesn't want to be in any way, how can I say… Even if it's my own child, he doesn't really want to be close to us like that. Even though he's right there, he's different in character. But Juha is very... When my spouse wasn't here and I was here by myself, Juha came to see me every day and brought food and stuff, but Jari not at all.
>
> Tyyne: And then I really refused to fight, I don't usually do that. Then I wished him happy birthday and happy name day in text messages. Well, thank you, they answer, but that's all. And the grandchildren, there is no connection there either. I would send them text messages as well, but I start to do it and I don't have their number. I call directory enquiries, but they can't give me the number. That is an infinitely painful thing… It still hurts, but I will keep on doing it, when I turned 70 I sent him the invitation, and I will send it again now, but it isn't up to me whether he comes or not.

Nevertheless, some previously close family relationships remained and brought significant comfort to the dying person. More specifically, a family member with professional expertise, combined with availability, is able to support the dying person by providing them not only with a safety net, but also with much needed advocacy:

> Maria: But the fact that I'm so privileged because of my family and my daughter, I don't need to wait in line at the health centre. […] I am satisfied. My care comes from her [daughter]. Many older people here are in a much worse position. I'm pretty privileged in that sense. Just because I have this family and all of this.

Family members with medical expertise, for example, are able to provide concrete care and assistance as well as to ensure access to treatment and the right kind of medication.

Peripheral relationships

The interviewees also described other kinds of social contacts they maintained in addition to intimate family relationships. For many, long friendships were among the most important social resources. They brought joy and a sense of meaningfulness to the dying person's everyday life, even if the number of contacts and friends had decreased:

> Anja: And then I have one friend, and our calls can be, and almost often are, an hour to two hours long. We discuss our lives and the way the world is going, and we work in such a way that when one says something, the other can continue the phrase so that you know what the other is talking about, you get along so easily. And it's going to take so long on the phone, time just flies.

In addition to maintaining long friendships, keeping in contact with former workmates was mentioned as important by many participants. Some former workmates maintained regular contact with them after retirement, and sometimes even thinking about workmates or colleagues was a source of joy and aroused positive feelings.

New relationships may also be formed towards the end of life. Information technology facilitates social interaction and staying in touch with people even when face-to-face meetings are no longer possible:

> Anja: Well... It can be very small. When I look at my tablet and there are all these groups, I will add comments in those groups. And when people like things, I make very brief comments there that I'm the one that's at the heart of the matter, and they're very often commented on, so I laugh at them all, a bit of funny stuff all. So even a small thing can be welcome.

Previously distant relationships may also become more meaningful, and new supportive relationships, including peer-to-peer friendships, may be initiated. Sometimes, however, the dying person might voluntarily and consciously initiate withdrawal from social relationships:

> Interviewer: Is it the case, though, that you have always found a person you could talk to if you wanted to talk, whether it's your wife or daughters, or a doctor, or researchers?
>
> Henrik: Yes, it is, of course. I'm not exactly abandoned, even though I've put a few relationships on hold.

Communication in previously close and meaningful relationships in different communities may be less frequent for other reasons, such as discretion, which may leave the dying person and the caregiver feeling isolated. At times the caregiver regulated the maintenance of social relationships, or help from others, for example, acting as a gatekeeper for social interaction. However, the presence of the caregiver shielded the dying person from feeling alone.

Supportive and help-giving social networks could offer concrete assistance, such as sharing care-taking roles within the family. In addition, they could meet the social needs of both the dying person and the caregiver: the maintenance of social ties supports the mutual relationship between them.

However, the participants mostly referred to a growing distance in non-intimate relationships. They described various social networks to which they used to belong through work, hobbies, friendships and family relations. Some had had particularly active social lives. With the approach of death, however, social relationships underwent changes, and many social contacts weakened:

> Maili: Yes, it has changed a lot for me so we had a lot of friends like that, so we were together and we had fun together, but now we're not. They're older, too, and maybe it's mutual. You can see these old friends and friends at church on Sundays. A little chat with them, but they're also kind of like that, living their own lives, when they're lonely and things like that, I'm not the closest friend they had. So maybe because those people change and...

In many cases, approaching death reduced the opportunity to socialise via informal relationships, which negatively affected the maintenance of social relationships. Weakening physical capacities and the need for care prevented participation in social activities. The interviewees described feelings of fatigue that limited their ability to tolerate particularly burdensome social interactions, therefore they kept to themselves:

> Maria: I don't try to keep in touch with people, I can't do it anymore. I was in a very good working community, […] but the people have died with whom... that working community was unbelievably good. We had things to do all the time. It was after retirement, but a few moved to other cities, or then they're dead. With my illness now, it's so hard to move that I'm not so much out there. I don't even want to be anymore...

Moreover, reactions to approaching death negatively affected some social contacts. The dying as well as their caregivers recalled that sometimes friends and other people could not pay them a visit because they felt too uncomfortable and scared.

Discussion

Approaching death affects the social relations of the dying. In our study, we identified processes of exclusion from existing relations. The dynamic nature of exclusion (Walsh et al. 2021) was strongly present in the data. On the other hand, new and sometimes unexpected relations were initiated, which became meaningful and supportive.

The transition of the relationship between the dying person and the caregiving family member into a care relationship increased the risks of exclusion due to dependence and the perceived burdensomeness of the care. Although the physical bond between the dying person and their family caregiver often became stronger, the emotional distance might grow. Additionally, symbiotic features emerged in relationships involving care needs.

A major aspect was the question of expectations and how social relations met them. Expectations, in turn, are connected with the relative nature of exclusion: they arise from what is considered to be adequate in society (Burholt and Aartsen 2021). Even when intimate relationships existed, they were not necessarily fulfilling. Unmet needs and expectations embedded in family relationships were highlighted with the approach of death. In particular, expectations of receiving care from family members were sometimes unfulfilled, despite attempts to rationalise and explain away their needs and the lack of help by emphasising the hectic lifestyles of adult children, for example. Nevertheless, inherent in such explanations were expectations of connection and support from family members. Our results match findings reported in other studies indicating that older adults in Finland worry about and, to some extent, hope for care from their family members (Outila et al. 2019). However, many families do not discuss end-of-life matters. They do not explicitly plan for end-of-life care and dying, even if such questions occupy the thoughts and reflections of older adults (Outila et al. 2019: 118).

According to our data, a lack of communication within families regarding different aspects and feelings connected to death and dying increased emotional distance. Rather than bringing people together, the approaching death could also reactivate difficult family histories and bring to the surface negative experiences or conflicts that had gone unresolved, which in turn increased the distance between family members and prevented interactions among them. The absence of functioning intimate relationships and networks of care and support increased the risk of exclusion when facing death. This finding underlines the importance of analysing exclusion from a life-course perspective (Ejlskov et al. 2019). Long-lasting adversities in family histories were strongly present in our data, and approaching death did not delete the experiences: on the contrary, the problems were experienced as even more painful in the current life situation.

However, social support and reciprocity among family members seemed to decrease the risk of social exclusion. More specifically, satisfying and well-functioning intimate relationships, and the possibility to use their professional expertise to meet the needs of the dying person constituted the most effective forms of support from family members. The shared life situation sometimes also strengthened and deepened relationships, as families found their own ways of dealing with and communicating about dying. Furthermore, the needs of the dying caused changes in family dynamics, and in family practices (Chambers et al. 2009), which were re-negotiated in adapting to the new situation.

In terms of non-family (peripheral) relationships, the participants described how approaching death increased the risk of feeling lonely and isolated. Exclusion from meaningful relationships resulted as previously close contact became less frequent or stopped completely. Such changes were mainly attributable to the dying person's decreasing physical and mental capabilities, which did not support maintaining contact. Exclusion was especially apparent in social relationships related to activities outside the participants' homes. It was also apparent if the approach of death scared other people, if former friends and acquaintances distanced themselves out of discretion, or if they were unable to handle their own feelings when meeting and communicating with a dying person. In some cases the caregiver acted as a gatekeeper and reduced social contacts to protect the dying person, sometimes without taking into consideration the person's own wishes.

On the other hand, facing death in the near future could even decrease the risk of exclusion from social relationships. As mentioned earlier, the presence of the caregiver meant that the dying person was not alone. Moreover, previously loose relationships could become tighter and become meaningful, and new, supportive relationships, including on the peer-to-peer level, were even initiated during the dying process.

Finally, we found that spending more time alone could be experienced as a positive factor in terms of well-being instead of increasing feelings of exclusion from social relationships, which is attributable to voluntary withdrawal, also known as solitude (Nguyen et al. 2017). The participants pointed out that it gave them the possibility to rest and to adapt to the new life situation without social pressure. Voluntary withdrawal from social relationships could also reflect being more selective in one's choice of social and other activities. This is one of the main premises in the theory of gerotranscendence (Tornstam 2005) in old age, according to which people evaluate the importance of relationships, wishing to distance themselves from those that are burdensome and less meaningful.

Conclusions

It became apparent during our study that dying is not only a physical process. The ending of life in old age—knowing that life will end in the near future due to an incurable illness—is a social process as well, which includes both increasing and decreasing risks of exclusion from social relationships. Approaching death also affects the social relations of both the dying and the care givers. Therefore, the social dimensions of the process should also be taken into account in the development of policies that affect the organisation of support for a dying older adult. Indeed, the social needs of dying people and their care givers should be considered in the system to include different services connected to death and dying. The focus, therefore, should be not only on physical care, but also on supporting both dying people and caregivers, the relationship between them and the possibilities of maintaining social relationship as death approaches.

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