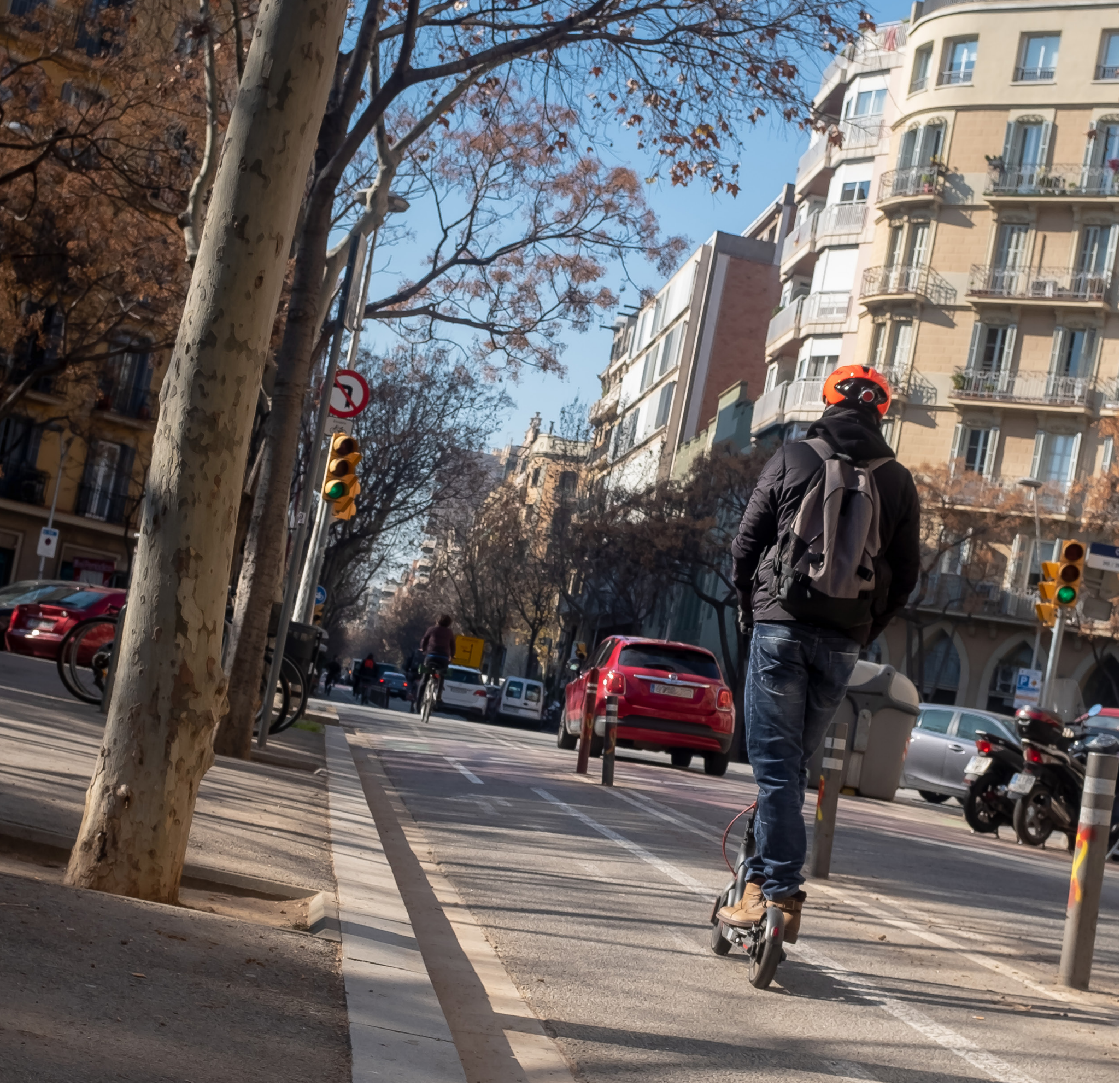

Crash test of electric scooters and risks associated to charging process: safety recommendations

Fundación MAPFRE

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Foreword

Sometimes, when we publish a study on traffic accidents, risks, injuries, etc., we are accused of trying to 'scare people' or 'hinder innovation and the road to sustainability'. We do not believe this is the case. We are certain that health and injury prevention must lead the way to sustainability and the promotion of active, sustainable modes of transport. It is impossible to have sustainability without injury prevention. We believe that every injury which leaves permanent damage is important, that every life is irreplaceable, and that the vast majority of injuries and risks are avoidable. Our working philosophy is Goal Zero, and naturally we do not intend to step away from that path.

As in all our studies, we put a focus on risk: in this case, the risk of electric scooters, a new mode of travel that is becoming increasingly popular, something that became particularly noticeable during the pandemic. It is obvious that these scooters offer a number of advantages compared with other less sustainable modes of transport (they are cheaper to buy, use and maintain; more lightweight, less polluting, take up less public space, etc.), although in recent months voices have also been raised to remind us that active travel modes such as walking or cycling are healthier and even more sustainable than electric scooters.

On this occasion we joined forces with our colleagues at CESVIMAP to compile, process, summarize and present in a clear and understandable way the latest data on road fatalities, the risks associated with the battery charging process and, above all, the risk of injury in the event of an accident. Using computerized simulations and laboratory crash tests (in other words, under controlled conditions), we reproduced what we believe to be the two most common types of collision: the impact of an electric scooter going at 25 km/h against the side of a minivan-type vehicle, and hitting a crash test dummy representing a child pedestrian, also at the same speed.

The conclusions of these crash tests and other areas of research are as follows:

1. At a speed of 25 km/h, there is already a considerable risk of serious injury from the point of view of both the rider of the electric scooter and any pedestrians it might hit. They should NOT be driven any faster.

2. As with bicycles, helmets must always be worn as they effectively protect the most important part of our body (the head), which is clearly exposed to the danger of receiving an impact, as witnessed in the simulations and crash tests.

3. Without due precautions, and as in the case of charging a cellphone or tablet, the charging process of the electric battery is not free of risk, especially if the battery area has been knocked or damaged, or following inappropriate or inadequate interventions or repair work. Overnight charging without supervision should be avoided, and the charging area must be cleared of anything that might catch fire or burn easily. It is essential to always use the charger supplied by the manufacturer.

4. In terms of both the danger of driving at speeds higher than 25 km/h, as mentioned above,

and the risk of overheating or short-circuiting, the speed and power controls must NEVER be manipulated. There are numerous videos on social media explaining how to do this, but this leads indirectly to a much greater risk of injury or fire.

5. In particular, companies that offer mobility services involving shared electric scooters have an added responsibility in relation to their customers' safety; consequently, they must take these conclusions very much into consideration and be proactive in informing their users, whose safety must always be the number one priority of their business.

On a positive note, these conclusions:

a) Validate and underline everything already stated in our previous report in 20191, the first study of its kind in Spain, which has been presented at international forums: most notably, the recommendations that these vehicles should not be allowed to use sidewalks, the speed limit of 25 km/h, and the essential use of helmets to avoid injury. All these recommendations feature in our manual on safe, healthy and sustainable mobility that was launched in September last year2.

b) Point to the new regulations approved by the General Directorate for Traffic that went into force in early January 2021. This regulation also features the earlier recommendations of Fundación MAPFRE and the Spanish Highway Association from 2019.

c) Provide brand new information, at a global level, on electrical fire-related and other risks associated with this type of individual mobility solution.

We strongly recommend that the safety monitoring of this new mode of transport, and any other new mode that appears such as shared motorcycles and cars, is made possible not only through news articles in the media but also through official local and national statistics on road safety, with their corresponding identifying codes.

We also ask that education and awareness-raising in safe, healthy and sustainable mobility pays much greater attention to this mode of transport in the future, and we hope to play an active and leading role in this respect. Within the next few weeks, we hope to announce partnerships and collaborations with shared mobility companies, town and city councils, public administrations, and all other groups and entities interested in guaranteeing people's safety on their journeys.

Finally, we also believe that this study should be taken very seriously by the manufacturers of these kinds of vehicles so they can move forward in the continuous improvement of their products and, most importantly, their safety. This should include advice on safe use (including the wearing of helmets) in their instruction manuals, the introduction of design improvements to better protect users and pedestrians in the event of a crash, systems to prevent the manipulation of their controls or batteries, the introduction of temperature sensors in the battery pack and the controls (some models already have these, but others do not, as shown in the report), etc.

To end where we began, identifying and minimizing the risks will help us to move towards

better and more sustainable mobility in our cities without having to pay an unacceptable and, above all, avoidable price in terms of serious or irreversible injuries.
I hope that you will continue to keep safe and healthy, and that soon we will be able to leave the ordeal of the COVID-19 pandemic behind us.

Jesús Monclús
Director of Prevention and Road Safety
Fundación MAPFRE

Think twice, you only live once

1. Executive Summary

This study presents information on accident rates and their consequences of Personal Mobility Vehicles (PMV), providing data on the type of accidents, the vehicles involved, the age of the drivers, the setting in which the accident happened, and its seriousness.

The analysis of these data provides guidance on the most common aspects of accidents involving PMVs in cities, firstly by creating simulations that reconstruct traffic accidents with special software and then, based on their analysis, designing and implementing actual crash tests in the CESVIMAP facilities.

The information drawn from these crash tests with dummies at CESVIMAP, which examined potential collisions with a vehicle and with a child pedestrian, provided information on the direct and indirect damage caused to the body parts of the dummies that can be directly extrapolated to real-life cases with people, as well as advice from the medical/forensic perspective.

The safety study was rounded off with recommendations drawn from all the previous dynamic situations studied, as well as from studies and experiments conducted from the perspective of modifying elements of the PMV and their overheating potential due to the use of portable batteries and chargers.

2. Background

Fundación MAPFRE and CESVIMAP have been working on everything that pertains to the use of these new personal mobility vehicles since 2018. Since that time we have compiled information on the different safety systems of these kinds of vehicles, their accident rates, the different types of PMVs on the market, the brands and models, and their different structures, among other aspects.

The work already undertaken in the crash test facility with cars and motorcycles helped us to develop a specific test and system for conducting PMV tests at CESVIMAP.

We also analyzed the different regulations that govern the use of these vehicles, which range from Regulation 16/V 124 in 2016 and its interim ruling, Instruction 2019/S-149TV-108 in 2019, and the most recent regulation, passed just a couple of months ago, which amends the General Traffic Regulation and the General Vehicle Regulation, which went into force on 2 January 2021.

3. Medical analysis of CESVIMAP crash test and simulations

4.4.4. Medical analysis of the CESVIMAP crash tests and simulations

Thanks to the collaboration agreement between CESVIMAP and the Legal Medicine, Psychiatry and Pathology department of the Complutense University of Madrid (Dr. Ladrón de Guevara), we were able to analyze the simulations and crash tests to extrapolate the information to injuries to people in real-life scenarios.

All the injuries described in the following sections, which refer to possible injuries to certain body parts of the rider and pedestrian dummies, were obtained from a medical and forensic perspective.

The analysis corroborated that the mechanics of the simulations and crash tests undertaken matched those that might happen in real-life accident situations in which PMVs might be involved when driving in urban areas.

We also took into account a report by SEMICYUC (the Spanish Society of Intensive, Critical and Coronary Unit Medical Care), as more and more cases of people injured while using PMVs are reaching Spanish intensive care units. Accidents involving PMVs can cause injuries that need ICU treatment for both the rider and the pedestrian in the event of a collision[1].

3.1. Collisions between PMVs and vehicles

After analyzing all the data obtained from the simulated collision between a PMV and a minivan, the following conclusions were drawn:

Wrists and hands: These parts of the body are exposed to fractures and injuries as in this particular case they are used as a defense mechanism to avoid harming vital areas of the body and thus minimize the severity of the injury.

Knees: There is a direct impact on both knees against the back door of the vehicle, which could lead to the fracture or shattering of the kneecap.

This is due to not turning the lower part of the vehicle in the moment before impact to use the pelvis as a defense mechanism.

Chest: In this case, no vital internal organs were involved due to the fact that in this type of accident the chest absorbs kinetic energy very well.

Head and face: The frontal and parietal bones of the head were not injured due to the use of a helmet, but the face is one of the worst-affected areas and the one with the most damage.

1 SEMICYUC report of 3 March 2020

According to SEMICYUC, up to one-third of the patients admitted for accidents involving PMV have cranioencephalic injuries of varying degrees of seriousness.

In these cases, they might even have lost consciousness, which exacerbates the situation as it means they have no means of avoiding any subsequent impacts.

Cervical area: A risk of whiplash can be seen in the moment just after the collision as an indirect injury when the head and cervical area hit the ground. This could lead to cephalic injuries.

Damaged area	Direct hit	Indirect hit	Direct hit (image)
Head	X	X	
Face	X		
Cervical area	X	X	
Chest	X		
Hips	X		
Wrist	X		
Hands	X		
Knee	X		
Internal organs			

Table 8. Areas of the body affected by direct and indirect hits

3.2. Collisions between PMVs and pedestrians

During a collision involving a PMV and a pedestrian, the pedestrian is the one who comes off worst as they have no kind of individual protection system.

The most significant damage caused to the pedestrian is detailed below:

- Knee: The first thing we noticed in this case is that the front wheel of the PMV 'pins' the pedestrian in place while the steering column simultaneously hits the pedestrian's knees, which can lead to breakage.

- Head: When the front wheel hits the pedestrian's feet, their head is forced down towards the handlebars, causing a direct and violent impact against them.

In the SEMICYUC study, sidewalks were shown to be the areas where the highest number of serious accidents took place, most notably affecting pedestrians.

This kind of impact can cause serious internal injuries, as it impacts directly against the parietal bone and part of the right cheekbone. This is due to the fact pedestrians do not wear any form of head protection.

- Shoulders: After the impact on the head, there is an accelerated fall; in other words, the masses of both the driver and the scooter crush the pedestrian during the fall, exacerbating the impact in the shoulder area when the pedestrian hits the ground.

- Hips: In this case, the pedestrian receives various impacts to the hips, both directly from the

driver and the PMV and indirectly from hitting the ground, leading to potential injury or fracture.

- Spine: No injury is caused to the spine, although the area that is most likely to be affected is the cervical area if there is any whiplash.

- Elbows, wrists and hands: These are the three parts of the body that are likely to be very badly affected during a collision, as we use them as a defense mechanism. These three areas can also be affected if the pedestrian is dragged along after the collision itself.

Damaged area	Direct hit	Indirect hit	Direct hit (image)
Head	X	X	
Face	X	X	
Cervical area		X	
Chest		X	
Hips	X	X	
Shoulder		X	
Hands		X	
Knee	X		
Ankle	X		
Internal organs of head	X		

Table 9. Areas of the body affected during direct and indirect impact.

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