Recommendations on Safety of E-scooters

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Introduction

E-scooters have become an increasingly common sight on European roads since the launch of the first rental e-scooter schemes in several countries in 2018. In parallel, sales of e-scooters to private buyers have increased dramatically. In 2021, more than 900,000 e-scooters were sold in France, an annual increase of 42%.[1] In the UK, where private e-scooters are currently illegal to use on public roads, total imports by November 2022 were over 1.3 million. [2]

The rise of this novel mode of transport, together with related changes in the so-called micromobility sector, such as high-speed electric bikes, small electric cargo delivery vehicles as well as rarer sights including monowheel vehicles and electric skateboards, present a range of new challenges for policymakers. How these challenges are resolved could have significant impacts on road safety, the environment, urban design and public health in the coming years.

This report will not address all of these challenges. Its aim is to set out recommendations for improving the safety of probably the largest and fastest-growing of these new micromobility vehicles: the e-scooter.

Public debates, as seen primarily through the media, tend to present a polarised view of e-scooters: for or against. [3] At ETSC, we are led by the Safe System approach, which looks at all aspects of the road transport system: vehicles, driver or rider and pedestrian behaviour, infrastructure and post-crash response.

The question is not therefore, are e-scooters safe or dangerous? But rather, how do they compare to other vehicles currently in use, what risks do they present to their riders and other road users, and how can they be made safer, not only in terms of design, but also in terms of usage?

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[1] https://www.bfmtv.com/auto/deux-roues/900-000-trottinettes-electriques-vendues-en-france-en-2021_AV-202203150274.html
[2] https://www.uktradeinfo.com/trade-data/ots-custom-table
[3] This is literally the case in the city of Paris, which has announced a referendum to be held in April 2023 on whether to allow shared e-scooter rental schemes to continue.
https://www.theguardian.com/world/2023/jan/15/parisians-to-vote-on-banning-e-scooters

Acknowledgments

This report is based, to a large extent, on a comprehensive research project and report (published in March 2022) led by Margaret Winchcomb at our UK founding member PACTS and funded by the Road Safety Trust. That project took into consideration a broad array of European and UK research and data. [4] ETSC participated as a source of information and data from across Europe.

ETSC also participated in the development of EU-funded guidelines for the safe use of micromobility in cities, which informed several of the recommendations in this report. We are grateful to Tanja Hohenstein at our member the German Road Safety Council (DVR) for her assistance with that project.

We have also carried out surveys on e-scooter legislation among our member organisations and ran a webinar in January 2022 to start to inform the recommendations set out in this report. [5]

[4] https://www.pacts.org.uk/the-safety-of-private-e-scooters-in-the-uk-pacts-research/
[5] https://etsc.eu/etsc-online-event-e-scooter-safety/

Context: urban road safety, and the safety of vulnerable road users

Cities and towns are home to 72% of the population of the European Union. These are the places where the majority of journeys begin and end. These urban centres face multiple, often conflicting needs and challenges when it comes to managing the way people and goods move around. The nature of these challenges is also evolving.

Urban populations are increasing, the population is ageing, people are being encouraged to walk and cycle more as concerns over congestion and air pollution move up the political agenda. New forms of mobility, such as e-scooters, are on the rise.

Road safety is not always the top priority. Deaths and serious injuries on urban roads are not declining as fast as on other types of roads in many countries.

Another related trend is that deaths of vulnerable road users are not declining as fast as those of motor vehicle occupants. In urban centres, the statistics are stark, 70% of reported road deaths are pedestrians, cyclists and powered-two-wheeler (PTW) users. It is not yet clear how e-scooters fit into this picture, due to a lack of data.

While new vehicle technologies such as Intelligent Speed Assistance (ISA), Automated Emergency Braking (AEB) with pedestrian and cyclist detection, and turning assistance systems on heavy goods vehicles may help reduce these numbers in the future – it will take decades for their full benefits to become apparent.

In the meantime, it will be up to national and local authorities, with support from the European Union to address the main causes of deaths and serious injuries on roads in our urban centres. Infrastructure changes will be central to this challenge, but enforcement of speed limits, drink-driving laws and other key risk factors are also crucial.

Cities can be dynamic and innovative environments. Many have welcomed the dazzling array of new mobility options that have launched in just the last few years. Shared bicycle and e-bicycle schemes, shared e-scooters that can be picked up and dropped off anywhere, app-based taxi services, bicycle and motorcycle food delivery companies – these are just a few of the services that have developed increasingly over the last decade. But policy and regulation are slow to catch-up.

Innovation can also be harnessed for the purpose of improving the safety of the people who live and work in cities. There are towns and cities in Europe that are getting close to Vision Zero or have a clear strategy on how to get there, but they are few and far between. In most European cities and towns, the transport modes that cause the least risk to other people, i.e. walking and cycling carry the highest risks for those that use them. What can be done to make our urban roads safe for all road users, not just those in cars and other large vehicles fitted with the latest safety technology?

The scope of this report is to look at some elements of the design and safe use of e-scooters, but it should be read as a complement to ETSC's comprehensive recent work (and recommendations) on urban road safety, pedestrians and cyclists, and young road users. [6] [7] [8] The Safe System approach to road safety and Vision Zero define our approach. Many aspects of road safety such as keeping vulnerable road users separate from heavy motor vehicles in traffic, setting appropriate speed limits, tackling drink-driving, and education and training, will create a safer urban environment for all road users, including e-scooter riders. But there are also unique and particular characteristics of current e-scooter design and use that need special attention. Those aspects are the focus of this report.

What is an e-scooter?

With the technology of light electric micromobility advancing quickly, the vehicle form is, to a degree, fluid. Indeed, e-scooters available on the EU market are constructed in a range of dimensions and power outputs, reflecting the breadth of machines available to purchase through physical and online retail outlets. There are some elements which are common to most e-scooters: a deck on two wheels (set one behind the other), a motor powered by an electric battery, a steering column, and a set of handlebars.

E-scooters are propelled with a 'twist and go' throttle and do not need any other physical input to power them.

Manufacturers need to self-certify that their e-scooter meets specific standards of

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[6] Safer Roads, Safer Cities: How to improve urban road safety in the EU (PIN Flash 37), http://etsc.eu/pinflash37
[7] How safe is walking and cycling in Europe? (PIN Flash 38), http://etsc.eu/pinflash38
[8] Reducing road deaths among young people (PIN Flash 41), http://etsc.eu/pinflash41

product safety before they can be sold on the EU market. These are the General Product Safety Directive (GPS), the Machinery Directive (MD), and the Electromagnetic Compatibility Directive (EMC). The vast majority of manufacturers use the BS EN 17128: 2020, type c product standard for personal light electric vehicles, as the method for demonstrating compliance. [9] However, these product safety requirements do not include factors such as speed, braking and power that are fundamental to vehicle safety regulations.

Several EU countries have now set standards for the e-scooters that are permitted on public roads, and set rules for how and where they can be used.

Current national regulations

Legislation for e-scooters started being drawn up, in Europe, through 2018 and 2019.

E-scooters were legalised in Belgium and Germany in June 2019 and in France regulations came into force in September of that year. Private e-scooter use is now permitted across most countries with the UK and the Netherlands notable European exceptions.

As new technologies are developed, and e-scooters are introduced in an ad hoc manner, European institutions and standardisation bodies have not agreed unified safety standards for micromobility. The European Commission acknowledges that the 'micromobility revolution' requires more effort in terms of sharing best practice and providing guidance, especially as these vehicles pose significant safety challenges. [10]

Standards for the construction of e-scooters are set in EN 17128: 2020, the type c (product) standard for Personal Light Electric Vehicles (PLEV). This voluntary standard has been developed by the European Committee for Standardisation. This includes e-scooters but it comes with a number of caveats. Vehicles excluded are 'those considered as toys; vehicles without a self-balancing system with a seat; Electrically Power Assisted Cycles (EPACs) electrically- powered assisted cycles (EPAC), electric

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[9] https://ec.europa.eu/info/business-economy-euro/product-safety-and-requirements/product-safety/consumer-product-safety_en, https://osha.europa.eu/en/legislation/directives/directive-2006-42-ec-of-the-european-parliament-and-of-the-council, https://ec.europa.eu/growth/sectors/electrical-and-electronic-engineering-industries-eei/electromagnetic-compatibility-emc-directive_en, https://www.en-standard.eu/bs-en-17128-2020-light-motorized-vehicles-for-the-transportation-of-persons-and-goods-and-related-facilities-and-not-subject-to-type-approval-for-on-road-use-personal-light-electric-vehicles-plev-requirements-and-test-methods/

[10] Questions and Answers: European Urban Mobility Framework, europa.eu, 14 December 2021

vehicles having a maximum design speed above 25 Km/h (15.5mph) and those not subject to type-approval for on-road use'. [11]

These standards are being taken into law by some governments. For example, from January 2022, Spain's General Directorate for Traffic approved a 'Manual of characteristics of the vehicles of personal mobility'. This subsumed standards from EN 17128:2020 with lighting and electrical requirements as well as minimum 203.2mm (8 inch) wheels and the inclusion of anti-tampering measures. [12]

There are no common standards for use. However, by following EN 17128: 2020, capping the speed of e-scooters to 25km/h or below is one regulation on which most European countries agree. In Finland, rental scheme operators limit e-scooter speeds to 20 km/h, and 15 km/h at night, and in Paris the speed of rented e-scooters is limited to 10 km/h within certain central areas.

While regulations in some countries were initially like those for pedal cycles, amendments are being made to align e-scooters more closely with motor vehicles. Limits on power, use on pavements, age restrictions and the need for insurance vary.

At least 12 countries have a compulsory helmet requirement either for children, under 18s, or all riders. The creation of a new category of motor vehicle has been mooted in France.[13] As such e-scooters would need to obtain type approval (they would need to meet specified performance standards) and their riders would need to comply with specific regulations.

In Germany e-scooters are already considered as a new category of motor vehicle and must be type approved. Riders are required to have insurance but, unlike mopeds, the e-scooters can be used on cycle paths. Regulations mean that all e-scooters should have a maximum speed of 20km/h and power of 500W.

A regularly updated list of the key e-scooter rules in different European countries, as provided by ETSC member organisations, can be found at:

https://docs.google.com/spreadsheets/d/14oxJ4KOWbrTsRFYeNGQb65GHtTniQ0Ob1d5QqC4SKT8/

[11] CEN - CEN/TC 354, Light motorized vehicles for the transportation of persons and goods and related facilities and not subject to type-approval for on-road use, cencenelec.eu

[12] General Directorate of Traffic, Manual of characteristics of the vehicles of personal mobility, Resolution No. 18, of 21 January 2022, pages 6882 to 6915 (34 pp.), Spanish Government

[13] New moped category in traffic code created in France - Bike Europe, bike-eu.com

E-scooter casualties in Europe

There are a number of ways in which the safety of a mode of transport might be assessed and each is based on a record of casualties. However, as e-scooters are such a new mode of transport in most countries they have not yet, or have only recently, been included as a distinct vehicle category in road traffic casualty records.[14] Data have instead been collected from hospital records, which do not capture details of the collision itself but rather give details of the type and nature of injury, or from small research studies where police data are scrutinised for relevant information.

Studies have found that in most e-scooter collisions no other road user is involved. Poor road surface conditions, e-scooter speed, riders intoxicated by alcohol or drugs, inexperienced users and lack of helmet use combined with the instability of an e-scooter contribute to the cause and severity of the injuries. Head injuries are prevalent, followed by injuries to the upper limbs. Other road users have been injured and these are most often pedestrians and cyclists.

Casualties involving e-scooters are by no means the major type of casualty in these countries. Casualties involving cars, motorcycles and pedestrians will account for far greater numbers. Comprehensive data on casualties and vehicle usage across the modes and including e-scooters is not available. The data and studies below are provided to give an indication of the scale and nature of casualties involving e-scooters. While it is not possible from these sources to provide a full context, we believe these records show the safety issues are not trivial and need to be addressed.

Improving data collection is essential. E-scooters should be classified as a separate category in both police and hospital records.

Shared e-scooter providers have access to substantial data on usage of their vehicles. Consideration could also be given to agreeing on a shared road safety data and assessment framework among all rental e-scooter operators in Europe to make it possible to monitor and evaluate safety-related factors for rented e-scooters.

[14] Study on market development and related road safety risks for L-category vehicles and new personal mobility devices, TRL, Guy I, Appleby J, BallP, But B, Chowdhury S, Jenkins D, Kent J, Obazele I, Radcliffe J, Sharp R, Wardle A, March 2021

Austria

A retrospective study was carried out of patients presenting at three major trauma departments in Vienna between May 2018 and September 2019.[15] Of the 175 patients who had sustained an injury from a collision involving an e-scooter 40.6% sustained major injury (including fracture or concussion). For those who suffered head injuries the proportion of serious injuries was greater than the proportion of those who suffered serious injuries to the extremities.

Belgium

A study in Belgium found that casualties were predominantly beginners and occasional users of an e-scooter, with more incidents recorded in fine weather when there is more e-scooter use. Head injuries and jaw fractures were the most common injuries to the riders (few wore a helmet). Fractures of the upper limbs, especially the wrists, were also common injuries. While most of the injuries were minor, their impact could be significant, for example a broken wrist leading to an absence from work of up to eight weeks.[16]

Czech Republic

From January 2023 the Czech police will distinguish e-scooters and e-bicycles. This will enable information on collisions with e-scooters to be obtained using the dedicated web application "Traffic accidents in the Czech Republic" which is based on police records. [17]

Denmark

In 2019, the year e-scooter rentals were launched in five cities in Denmark, two-thirds of the e-scooters were rented and one-third in private ownership, although there were differences across the five cities. Evaluations were set up assessing e-scooter rider behaviour, casualty rates for anyone involved in a collision with an e-scooter and the carbon footprint of the schemes.

A study of injuries resulting from e-scooter collisions was carried out retrospectively

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[15] Incidence and severity of electric scooter related injuries after introduction of an urban rental programme in Vienna: a retrospective multicentre study Timon Moftakhar · Michael Wanzel · Alexander Vojcsik · Franz Kralinger · Mehdi Mousavi · Stefan Hajdu · Silke Aldrian · Julia Starlinger. Published online: 27 August 2020

[16] Electric scooters: helmets are of vital importance, press release from VIAS institute (Belgian Road Safety Research Institute), 28 May 2020

[17] https://nehody.cdv.cz/

looking at data from emergency departments in Copenhagen from January 2016 to July 2019.[18] The vast majority presented between August 2018 and July 2019 and were most likely to be riders aged 18–25 years. The most common injury was from falling off the scooter: 97 (86.6%). E-scooters resulted in high energy impacts with 23 (20.5%) of riders sustaining head injuries and 43 (38.4%) suffered facial injuries.

Finland

In the first six months of 2021 the emergency department at Helsinki's Töölö hospital recorded 74 e-scooter related casualties, the same number as for the whole of 2020. Riders were treated for head and limb injuries, 50% of them were intoxicated.[19]

France

The French Academy of Medicine has reported that the number of e-scooter injuries increased by nearly 180% between 2019 and 2022.

24 people died following a scooter collision in 2021 in France and 11,256 others were injured. In 2022, by the end of August, there had been 19 deaths involving e-scooters. In 9 out of 10 cases, e-scooter users were not wearing a helmet.

75% of collisions were isolated falls. Excessive speed, consumption of alcohol, inattentiveness, one-handed driving and cell phone use were all factors.

Injuries often concerned the forearms, elbows and wrists, but head injuries were also very common. Brain injury, and fracture of the jaw and nose are much more frequent after a fall from an e-scooter than after a fall from a bicycle, the report found.[20]

A study in Rhône found a 478% increase in e-scooter casualties from 2018 to 2019. This led to e-scooter riders becoming the fourth most injured road users, above pedestrians. Head injuries were common. Within inner Paris during the first nine months of 2021, two women were killed and 329 people were injured in accidents involving e-scooters.[21]

Germany

The Federal Statistical Office (Destatis) has included reports of e-scooter casualties

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[18] Blomberg SNF, Rosenkrantz OCM, Lippert F, et al. Injury from electric scooters in Copenhagen: a retrospective cohort study. BMJ Open 2019;9:e033988.
[19] E-scooters speeding towards uncertain future | News | Yle Uutiset
[20] https://www.academie-medecine.fr/accidentologie-des-trottinettes-electriques/
[21] Road safety in France Summary of the accident rate of the year 2020, ONISR 2021

from January 2020. Over the whole of 2020 a total of 2,155 collisions involving e-scooters resulting in personal injury were documented.[22] In 2020, just over 40% of the injuries were from a single-vehicle collision and 18% of the casualties were intoxicated.[23] Where a pedestrian was involved in a collision with an e-scooter (in 162 collisions), far more pedestrians were hurt than e-scooter riders (74% of the casualties were the pedestrian).[24] In 2021, the number of collisions involving e-scooters resulting in personal injuries rose to 5535, 4.882 riders were injured and 5 died.[25] 41% were younger than 25 years old, only 3,4 % were older than 65 and 2/3rds were male. Even though only one person is allowed to ride an e-scooter in Germany, 205 co-riders were injured, 165 of them between the ages of 6 and 24. Provisional data from January to October 2022 showed that 7583 people were injured in collisions involving e-scooters, 6216 being the riders. 11 people died, 9 of them were e-scooter users.

Overall in Germany in 2020, e-scooter injuries accounted for only 0.8% of collisions where someone was injured. In 2021 the proportion had risen to 2%. There is a concern that police data miss many collisions involving e-scooters which result in injury. An epidemiological study in one trauma centre in Essen recorded 68 patients between June 2019 and October 2020.[26] Of these, only eight (11.8%) were also included in police records.

Data records from hospital patients informed two studies in Berlin and Munich during 2019 and 2020. In four emergency departments in Berlin, 248 patients presented with injuries incurred in collisions involving e-scooters between July and December 2019. Notably, the primary cause of injury was from falling off the e-scooter and nine patients were pedestrians who had been hit by an e-scooter. A positive breath test was associated with a fivefold increase in the odds of traumatic brain injury and a doubling in the odds of hospital admission, even if the drivers were experienced in handling e-scooters.[27]

From July 2019 to April 2020 60 patients were prospectively recorded in one hospital

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[22] 2,155 e-scooter accidents with personal injury in 2020 - Federal Statistical Office, destatis.de

[23] Road safety of e-scooters, Unfallforschung der Versicherer, GDV, Research report No. 75, M Ringhand, J Anke, T Petzoldt, T Gehlert, April 2021

[24] Traffic Accidents in Germany, Federal Statistical Office (Destatis), published August 2021 for the year 2020

[25] Traffic Accidents of e-scooters in Germany 2021, Federal Statistical Office: https://www.destatis.de/DE/Presse/Pressekonferenzen/2022/unfallgeschehen_pedelec_e-scooter/statement-pedelec_e-scooter.pdf

[26] Meyer, HL., Kauther, M.D., Polan, C. et al. E-scooter, e-bike and bicycle injuries in the same period – a prospective comparative study of a Level 1 trauma center. Trauma surgeon (2022)

[27] Uluk D, Lindner T, Dahne M, et al, E-scooter incidents in Berlin: an evaluation of risk factors and injury patterns Emergency Medicine Journal Published Online First: 07 June 2021.

in Munich. 59 patients had rented their e-scooters and the one patient riding a private e-scooter was the only one wearing a helmet. Nearly 40% of patients were intoxicated and 52% suffered head or facial injuries.[28]

Norway

In the summer of 2020 865 people, 374 e-scooter riders and 491 non-users, were surveyed in Norway.[29] Of the riders, 14% had had a collision while riding an e-scooter and 37% had had at least one near miss. Of the non-users 72% had had a near miss, 38% as a pedestrian. These data are important as the experiences of pedestrians, especially near misses, are generally under reported.

Maybe unsurprisingly more people who owned their own e-scooter wore a helmet when riding than those riding rental e-scooters. However, nearly half (47%) of the 101 private e-scooter riders still never wore a helmet, and 70% of rental e-scooter riders never wore a helmet.

Spain

The MAPFRE Foundation recorded four deaths in 2018, and five in 2019 according to a review of news reports. The Spanish Directorate for Traffic (DGT) has collected official statistics on e-scooter deaths since 2020. Eight deaths were recorded in that year and nine in 2021.[30]

By reviewing news reports the MAPFRE Foundation found that there were 13 e-scooter-related deaths in 2021, four more than the official figures show. Their analysis showed that there were five falls, five collisions with other vehicles, and three pedestrians struck. Of the 13 people killed, 11 were men and two were women. The three deceased pedestrians were elderly: two women aged 78 and 79 and a man aged 80.

The report also included recent data from researchers at Hospital Universitario 12 de Octubre in Madrid that refer to 198 e-scooter riders treated between January 2018 and January 2022. 70% were men and 30% women; the age ranged from 18 to 62 years, with a mean of 32 (though only patients above 18 years of age were included in the study group). The mechanism of the most frequent injury was a fall (77%),

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[28] Mair, O., Wurm, M., Müller, M. et al. E-scooter accidents and their consequences. Trauma surgeon 124, 382–390 (2021)
[29] Elsparkesykler til glede og besvær, Katrine Karlsen, Aslak Fyhir, TØI 1828/2021, Elsparkesykler til glede og besvær - Transportøkonomisk institutt (toi.no)
[30] https://www.dgt.es/export/sites/web-DGT/.galleries/downloads/dgt-en-cifras/24h/Las-principales-cifras-2021_vf_LI_vf.pdf

followed by collision with another vehicle (14%), collision with another object (5%) and impact with the structure of the scooter (4%). During the period studied, an exponential increase in patient numbers was observed: 4 in 2018, 35 in 2019, 48 in 2020 and 101 in 2021. Within the subgroup of patients with severe trauma, in 82% the most serious observed injury was head trauma and in the remaining 18% abdominal trauma. The researchers concluded that "a clear relationship is observed between the absence of a helmet and head trauma, the need for its use seeming reasonable". [31]

Sweden

Using data collected from both the police and hospitals, the Swedish National Road and Transport Research Institute gathered casualty numbers amongst e-scooter riders. From 2014 to 2018 there were no more than fifteen e-scooter rider casualties in a year. In 2019 there were 490 casualties.[32] 50% of riders suffered head injuries and 87% were injured in single vehicle collisions. 10% of the casualties were other road users.

UK

As private e-scooters are currently illegal in the UK (though widely used) – the injured may be wary of reporting a collision to the police.

However, the UK is collecting data on injuries and deaths involving private and shared e-scooters which show that in the year ending June 2022:

- there were 1,349 collisions involving e-scooters, compared to 978 in the year ending June 2021
- of all collisions involving e-scooters, 346 included only one e-scooter with no other vehicles involved in the collision (single vehicle collision), compared to 200 in the year ending June 2021
- there were 1,437 casualties in collisions involving e-scooters, compared to 1,033 in the year ending June 2021
- of all casualties in collisions involving e-scooters, 1,095 were e-scooter users, compared to 811 in the year ending June 2021
- there were 12 killed in collisions involving e-scooters (11 of whom were e-

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[31] https://documentacion.fundacionmapfre.org/documentacion/publico/es/media/group/1116513.do.

[32] Per Henriksson, Åsa Forsman and Jenny Eriksson, Accidents involving cyclists, electric cyclists and electric scooter riders: Analysis of Strada data, VTI (Swedish National Road and Transport Research Institute), December 2019

scooter riders) compared to 4 in the year ending June 2021

- the best estimate, after adjusting for changes in reporting by police, is that there were 429 seriously injured and 996 slightly injured casualties in collisions involving e-scooters, compared to 288 and 741 respectively in the year ending June 2021 [33]

Summary

Legislation for e-scooter use has been in place in several Europe countries since 2019. Since then the regulations have been developed to improve safety for riders and other road users. Sources for data recording e-scooter collisions are still maturing, but currently underreport casualty numbers. Findings from studies into the numbers and natures of injuries indicate:

- 20-50% of casualties attending hospital suffer head injuries, very few riders wore helmets
- More riders fall in single vehicle collisions than by colliding with another road user
- Intoxication is a problem

[33] https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-e-scooter-factsheet-year-ending-june-2022/reported-road-casualties-great-britain-e-scooter-factsheet-year-ending-june-2022#reported-collisions-and-casualties-involving-e-scooters

E-scooters vs bikes

While pedal cycles and e-bikes require the rider to pedal to move forward, e-scooter riders can accelerate to their maximum speed within only a few seconds.[34] [35] They also travel at a faster constant speed than a pedal cyclist. The speed of most e-scooters at 25 km/h is higher than the average speed of many pedal cycles in urban areas which has been measured as 18.2km/h for men and 17.0km/h for women in a range of 18-29-year-old pedal cyclists.[36]

They are also constructed very differently, with different safety consequences. The wheel size and the location of the centre of mass has implications on the stability of a pedal cycle or e-scooter. The larger wheels of a pedal cycle and more centrally located centre of mass make it more stable than an e-scooter especially when navigating changes in the road surface.

Speed is almost always a factor in crash frequency and crash severity.

Some European locations have used data, both from police and hospital records, to present comparisons between the safety of e-scooters and pedal cyclists. It should be noted that more rental e-scooters than private e-scooters are in use in most European cities.

Denmark

Preliminary figures from the Danish Road Directorate for 2019 showed that the police recorded 24 e-scooter casualties. From this small sample set, an estimate of the accident rate per kilometre travelled put the risk of a collision on an e-scooter at seven times that of a bicycle. The authors of the report noted the limited available data and statistical uncertainty.[37] Nonetheless, Denmark has introduced mandatory helmet wearing for all e-scooter riders from January 2022.

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[34] Billstein L, Svernlöv C, Evaluating the Safety and Performance of Electric Micro-Mobility Vehicles Comparing E-bike, E-scooter and Segway, Department of Mechanics and Maritime Sciences Chalmers University of Technology Gothenburg, Sweden 2021, www.chalmers.se

[35] Eyers V, Parry I, Zaid M, In-Depth Investigation of E-Scooter Performance, TRL, January 2023

[36] Aldred R, Elliott B, Woodcock J, Goodman A, Cycling provision separated from motor traffic: a systematic review exploring whether stated preferences vary by gender and age, Published online. 14 Jul 2016

[37] Minister for Transport, Denmark, *Evaluation of the pilot schemes for small motorised vehicles*, Faerdselsstyrelsen Denmark, 2020

Finland

A Finnish research team investigating e-scooter related injuries said their data show a higher rate of e-scooter injuries compared to other transport modes analysed in earlier studies.

The research identified 331 patients with e-scooter-related injuries who were admitted to the accident and emergency department in Tampere, a city of some 226,000 people in Finland, between April 2019 and April 2021.

Data from scooter rental companies operating in the Finnish city revealed that e-scooter riders took over 1.8 million trips during that period, meaning there were roughly 18 emergency room admissions per 100,000 rides or 7.3 per 100,000 km ridden, which implies an average ride of about 2.5km.

While comparable figures are scarce, this rate is much higher than previously estimated injury rates for other modes of transport including walking, cycling and motorcycling, the study's lead author, orthopaedic surgeon Aleksi Reito, told the news channel Euronews.[38]

Germany

From January until October 2022 7583 people were injured in 7024 collisions involving personal injury with an e-scooter, 6216 among them were e-scooter riders. Nine of them were killed, 938 were severely injured and 5269 slightly injured. During the same period, 408 cyclists including pedelec-users were killed, 14353 were severely injured and 71.525 were slightly injured. However, the DLR Institute of Transport Research estimate, based on usage, that for any given journey the risk of being seriously injured when using an e-scooter is more than twice as high as if a bicycle had been used. Another study arrived at the rather different estimate that the risk of serious injury per kilometre travelled when using an e-scooter is five times that when riding a bicycle.[39] [40]

Injury patterns for e-scooter, e-bike and pedal cyclists were analysed at a trauma centre in Germany across 2019 and 2020.[41] In all three groups, the most injuries were to the head (38% of e-scooter riders, 35% of e-bike riders and 25% of pedal cyclists).

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[38] https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2791039
[39] First accident record for e-scooters - What do the figures say about their safety? DLR Portal, www.dlr.de
[40] Accident risk for e-scooters is higher than for bicycles, springerprofessional.de
[41] Meyer, HL., Kauther, M.D., Polan, C. et al. *E-scooter, e-bike and bicycle injuries in the same period – a prospective comparative study of a Level 1 trauma center*. Trauma surgeon, 2022.

For both e-scooter riders and e-bike riders the proportion of the injured that were seriously injured was significantly higher than for cyclists.

Norway

An assessment of e-scooter collisions in 2019, published in Norway and based on preliminary figures from Oslo, Denmark and the US, found that the rate per kilometre travelled of collisions resulting in an injury was ten times higher for e-scooters than for bicycles.[42] In Oslo, 89 injuries resulting from e-scooter collisions were recorded per million kilometres travelled. In contrast, there were around eight injuries resulting from cycle collisions per million kilometres cycled.

UK

In London, TfL obtained collision data for the first six months of 2021. They found that for the casualties attributed to privately owned e-scooters in London 0.8% were fatal, 25.4% were serious injuries and 73.8% were slight injuries. For casualties attributed to cycling in London, 0.2% were fatal, 16.7% were serious injuries and 83.1% were slight injuries. [43]

Provisional data from an evaluation report of the first 18 months of the rental trial e-scooter schemes in England, July 2020-December 2021, found that the casualty rate for rental e-scooters is about three times that for pedal cycles.[44] This is based on police records, known as STATS19 data, rather than operator-reported casualties.

Thatcham Research has estimated that for the year 2019, car to e-scooter collision frequency was nine times higher than car to cyclist collision frequency.[45] If these rates are broadly correct, they indicate that casualty rates for e-scooter riders are closer to those for motorcyclists than to those of pedal cyclists.

[42] Fearnley N, Berge S H & Johnsson E., *Shared electric scooters in Oslo, An early survey*, TOI report 1748/2020, 2020
[43] TfL, Safety, Health and Environment Quarterly report, Quarter 2 2021/22, Appendix 1 p18
[44] Department for Transport National evaluation of e-scooter trials Findings report December 2022
[45] Holmes A and di Cugno D, Reviewed by: Grover C, Young A and Brookes D, *Assessing e-scooter risk to motor insurers*, Thatcham Report July 2021

Testing e-scooter performance

There has been little calibrated crash testing or computational modelling of e-scooters currently on the consumer market. That which has been carried out gives an insight into the stability of an e-scooter and the likelihood and severity of injury to both the rider and a pedestrian.

E-scooter ride testing

Vehicle testing is essential for determining safety and validating the suitability and appropriateness of e-scooters as a means of transport. Commercial companies have an incentive to demonstrate the road worthiness of their products when in use, rather than necessarily testing the e-scooter to destruction. Stability during braking and the effectiveness of brakes is important. The stability over road imperfections is also important for e-scooter riders.

Research analysing the performance of a range of private e-scooters through test riding made findings about the acceleration and deceleration of e-scooters in relation to their power and brake design.[46] It was found that e-scooters with a power of 250W, 300W and 350W had an acceleration of around $2.5ms^{-2}$. e-scooters with double the power, 500W, had nearly $2ms^{-2}$ the rate of acceleration. In theory riders could apply the throttle less quickly to reduce the rate of acceleration. However the controls were found to operate either 'on' or 'off' making variation of speed difficult. The report found that deceleration was negatively impacted by temperatures approaching zero, although no cause was identified. Brake design impacted stability, notably that where a mechanical brake was only located on the front wheel the e-scooter was more likely to pitch forward when stopping suddenly.

Testing in the UK of e-scooters with different wheel sizes over a 50mm pothole shows increased stability with increased wheel size. In one example two different sized front wheels were compared: one front wheel was 8-inch (203mm), representing the most common size on the commercial market, and the other 16-inch (406mm), the same diameter as a folding pedal cycle wheel.[47] The results show increased stability with a larger wheel and some tests even showed that the small-wheeled e-scooter was not

[46] Eyers V, Parry I, Zaid M, In-Depth Investigation of E-Scooter Performance, TRL, January 2023
[47] Adult Scooter Safety – Pothole Test Results! | Swifty Scooters, swiftyscooters.com and as advised by S.H.A.D.O Works Partnership – cited in PACTS e-scooter report

only unstable but also incurred damage when traversing surface defects. [48]

E-scooter crash testing

Video evidence from e-scooter testing in Europe and the US indicates that, when an e-scooter collides with an object or a defect in the road surface, the e-scooter riders fall forwards, over the handlebars.[49] [50] [51] [52] Analysis of this testing is limited, in part due to the challenge of eliminating the impact of test-rigs on the rider's position on the e-scooter.

The tests are predominantly a means of demonstrating the way casualties fall. A doctor, commenting on the nature of injuries likely to be inflicted when colliding with a stationary vehicle, describes them as 'body wide' including serious head injuries.[53]

Another test, using crash test dummies, investigated collisions between pedestrians and an e-scooter travelling at 15km/h and 25km/h. At 15km/h the adult pedestrian is first struck at their upper body. Both rider and pedestrian then fall, likely sustaining further injuries when hitting the ground. When testing at 25km/h the adult pedestrian is first struck at the upper body then both rider and pedestrian strike foreheads. The pedestrian is thrown 3.45m and the rider falls. Measurement of the damage to the dummies, using the Head Injury Criterion, shows a 25% probability of fatal injury to the rider when striking the ground and a 90% probability of fatal injury to the pedestrian when striking the ground. [54]

This research indicates that, in the event of a collision between an e-scooter and a pedestrian, the pedestrian is likely to be more seriously injured than an e-scooter rider. This has also been recorded in German casualty data. More research is needed to understand the relative injuries between e-scooter riders and pedestrians when collisions occur.

Crash tests and analysis by the MAPFRE Foundation concluded that at a speed of 25

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[48] Testing by Dipl.-Ing. Roy Strzeletz, Unfallanalyse Berlin for Dr.-Ing. Matthias Kühn, Unfallforschung der Versicherer, Berlin (Accident Research for Insurers, Germany)
[49] Fisher, J, Exponent, (2) Post | Feed | LinkedIn,
[50] Baloise crash test highlights consequences of accidents involving electric scooters and bikes, www.baloise.com
[51] RCAR - Scooter testing, www.rcar.org
[52] Sicher unterwegs mit dem E-Scooter - Unfälle mit Fußgängern - YouTube, German Insurance Association (GDV) YouTube channel
[53] E-Scooter Crashtest! Wie gefährlich sind Unfälle? - YouTube, Deutscher Verkehrssicherheitsrat (DVR), German Road Safety Council in collaboration with Techtastisch YouTube channel
[54] Testing by UTAC Millbrook for Tin Man Communications on behalf of Guide Dogs UK

km/h there is already a considerable risk of serious injury from the point of view of both the rider of the e-scooter and any pedestrian they might hit. Analysis of head injuries demonstrated the benefit of a helmet to protect the frontal and parietal bones. However, facial injuries were still recorded. [55]

Computational modelling: demonstrating falls

Researchers at the Dyson School of Design Engineering, Imperial College London have created computational models of e-scooters ridden over potholes of different sizes. The aim was to understand how falls are influenced by speed and surface conditions and measure the resulting head-ground impact velocity and force.[56]

The results of the modelling showed that when using 10-inch (254mm) wheels the number of falls increased with pothole size. No falls were recorded when the computational model tested e-scooters traversing 30mm depth potholes. 41 out of 60 e-scooter riders fell when traversing potholes with a depth of 60mm. When falls occurred, at any speed, the measured head-ground impact force was larger than skull fracture thresholds.

Further modelling showed that decreasing the e-scooter speed reduced the head impact speed. For instance, reducing the e-scooter speed from 30 km/h to 20km/h led to a 14% reduction in the mean impact speed and 12% reduction in the mean impact force, as predicted by the models. The speed of impact between the riders' heads and the ground was comparable to the speed measured for pedal cyclists. However, the nature of the injuries were different to those suffered by pedal cyclists. 44% of impacts were to the face, which would not be protected by a traditional bicycle helmet.

The implications of a rider hitting their head when falling from an e-scooter have been found to be severe. Further research is needed into the optimal design of helmets to limit the severity and extent of injury.

Computational modelling of e-scooters: assessing stability

Self-stability is the property which makes it easier for a two-wheeler (pedal or motor powered) to ride hands-free, navigate obstacles or sideways winds. E-scooter riders appear to be susceptible to instabilities as injuries due to falling from an e-scooter are more common than collisions with other motor vehicles. To assess self-stability,

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[55] https://documentacion.fundacionmapfre.org/documentacion/publico/es/media/group/1110329.do

[56] Posirisuk P, Baker C, Ghajari M, *Computational prediction of head-ground impact kinematics in e-scooter falls*, Accident Analysis & Prevention, Volume 167, 2022, 106567, ISSN 0001-4575

validated mathematical models were used to analyse the dynamic performance of e-scooters with 8-inch (203mm) diameter wheels. Self-stability, braking effect and steady-state turning were assessed against that of a 26-inch (674mm) diameter pedal cycle.[57]

Big wheel bicycles were found to be self-stable at speeds of 17.0km/h-27.5km/h. However, e-scooters were found to be unstable until travelling at 22.4km/h. This impacted on stability both during deceleration and acceleration on a flat surface.

Slowing-down from a higher, more stable speed, meant transitioning to a slower, less stable speed, making the e-scooter more challenging to control. Deceleration increased any existing oscillation (weave motion). While applying a sudden brake to avoid obstacles, the oscillation amplitude increased much faster, and the chance of losing control became greater. The self-stability of e-scooters was found to be more sensitive to decelerations compared to bicycles.

The effect of acceleration was found to be opposite to that of the deceleration. Acceleration reduced the amount of 'wobble'. However, the self-stability range was found to shrink drastically with the acceleration. The analysis found an acceleration greater than $3m/s^2$ could make the self-stable region disappear completely therefore losing its self-stability property. For example, a hefty acceleration on an e-scooter could cause a sudden loss of the intrinsic self-stability property, making the rider put more effort into balancing.

The results confirmed that e-scooters are easy to manoeuvre as they require much less steering torque than bicycles. However, the steering of e-scooters is more sensitive to external forces and is affected more compared to bicycles when encountering obstacles on the road.

By testing the impact of changing the steering stem angle (sometimes known as the head angle or rake angle) relative to the headtube angle improvements to the e-scooter's stability were achieved. [58] These modifications improve self-stability of the e-scooter relative to a bicycle and improve handling and braking performance.[59] Rider training can also improve stability by teaching the rider how to reallocate their weight

[57] Paudel, M & Yap, F F, Front steering design guidelines formulation for e-scooters considering the influence of sitting and standing riders on self- stability and safety performance. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering. 235. 2021

[58] Paudel, M. An investigation into the design for rideability of small wheel single-track bicycles and e-scooters. Doctoral thesis, Nanyang Technological University, Singapore, 2019

[59] Analysis was carried out on seated e-scooters and these were assessed as being more stable than standing e-scooters. Seated e-scooters are subject to type approval and would need to registered as a moped and ridden subject to the requirements for a moped.

on the e-scooter. Instabilities of the e-scooter are still exacerbated by surface irregularities and potholes.

Summary

E-scooters have been tested for ride stability and, in the event of a collision, on the impact on the rider and other road users:

- e-scooter stability over surface irregularities and potholes is improved with a larger wheel size;
- in a collision with a pedestrian when travelling at 20km/h, both the e-scooter rider and pedestrian are likely to suffer severe injuries, and the pedestrian injuries are more likely to be fatal;
- e-scooter riders impact their heads with a similar force to pedal cyclists but there is a higher likelihood of facial injury compared to pedal cyclists, and
- acceleration and deceleration reduce the stability of an e-scooter. Increased awareness by a rider of their need to manually stabilise an e-scooter may reduce the likelihood of falling. Modifications to the steering assembly could improve self-stability. However, for these test and modelling conditions, e-scooters are inherently less stable than bicycles in many circumstances: when accelerating, braking and negotiating uneven road surfaces.

Conclusions

E-scooters present a new means of mobility. Private e-scooters are selling in large numbers across Europe. Riders of both private and rental e-scooters are vulnerable road users. There are also concerns over the risks to pedestrians from inappropriate use of e-scooters. With a growing maturity in the recording of and understanding of casualties, both of numbers and types of injury, governments are now tightening e-scooter regulations. Lower speed limits, minimum age for riders and mandatory helmet wearing are increasingly common.

Hospital emergency departments and major trauma centres are treating seriously injured patients, many with head injuries. More research and data will be needed to understand the numbers, types and mechanisms of injuries occurring and improve understanding of head and face injury mechanisms. There is significant underreporting of collisions. The pedestrian experience needs to be monitored and increased opportunities given for reporting of collisions. Education and enforcement are also needed.

Research into the stability of e-scooters using crash-testing and computational modelling confirms that riders are prone to fall and impact their heads. These falls are likely due to the design of the e-scooter which influences its stability especially when negotiating changes in the road surface and when braking. From test and modelling conditions, e-scooters have been found to be inherently less stable than bicycles in many circumstances: when accelerating, braking and negotiating uneven road surfaces.

In comparison with casualties involving cars, the numbers of those injured in collisions involving an e-scooter are far fewer. Comparison with another similarly sized mode of transport is more appropriate, and the pedal cycle is the most used example.

Where data are available, the rate of collisions resulting in injury has been found to be up to ten times higher for e-scooter riders than for cyclists. If these collision rates prove accurate for Europe as a whole, they will be more akin to those for motorcyclists. E-scooter journeys are more likely to replace those previously made on foot or by public transport. Both these modes are established safe modes of transport.[60] [61] Data from VOI, a rental operator, and the UK government rental e-scooter trials (all operating in England) shows that e-scooters journeys are replacing walking (36-42%), cycling (10-12%) and public transport (18-30%), as well as car and taxi journeys (12-21%). [62, 63]

This means that the overall casualty burden is increasing, making casualty reduction targets harder to achieve.

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[60] ROAD TRAFFIC FATALITIES IN THE EU IN 2019 by road user and (other) 'main vehicle' involved in the crash, European Commission, 2021, https://transport.ec.europa.eu/system/files/2021-11/collision-matrix-2019.pdf

[61] Webster E and Davies D, *What kills most of the roads*, PACTS report 2020

[62] The survey was sent out by email to a random sample of Voi users in July 2022. 9,898 responses were received from users across all 11 countries Voi operates in. All figures are rounded. https://www.voi.com/blog/impact/

[63] UK Department for Transport, National evaluation of e-scooter trials, Findings report, December 2022

Recommendations to the European Union and national governments – technical standards for e-scooters

Speed

Several countries, including Denmark, Germany, Norway, Sweden and Switzerland limit the maximum speed of e-scooters to 20km/h.[64] Lower speeds mitigate the likelihood of severe injury to e-scooter riders, pedestrians and other road users.

The design of e-scooters places the rider at risk of falls and head injury.

- Loss of control when navigating defects or changes in surface level is more likely at higher speeds and results in more severe head injuries.[65]
- Surface defects caused half of falls in a study of e-scooter casualties.[66]

20 km/h is higher than the average speed of many pedal cycles in urban areas. The average speed for 18-29 year old pedal cyclists has been measured as 18.2 km/h for men and 16.9 km/h for women.[67]

Speed enforcement for e-scooters that is reliant on police resources is difficult to implement effectively. E-scooters, both for rental and private, are not fitted with speedometers as standard.

Speed limits are most able to be enforced when controlled within the e-scooter construction. This means the limit is not reliant solely on driver compliance.

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[64] See ETSC spreadsheet of current national rules. https://docs.google.com/spreadsheets/d/14oxJ4KOWbrTsRFYeNGQb65GHtTniQ0Ob1d5QqC4SKT8/edit#gid=0

[65] Posirisuk P, Baker C, Ghajari M, Computational prediction of head-ground impact kinematics in e-scooter falls, Accident Analysis & Prevention, Volume 167, 2022, 106567, ISSN 0001-4575

[66] Coelho Leal A, Feito P, Corominas L, Sánchez-Soler J, Pérez-Prieto D, Martínez-Diaz S, Alier A, Monllau J, Electric Scooter-Related Injuries: A New Epidemic in Orthopaedics, 2021/07/25, Journal of Clinical Medicine

[67] Aldred R, Elliott B, Woodcock J, Goodman A, Cycling provision separated from motor traffic: a systematic review exploring whether stated preferences vary by gender and age, Published online. 14 Jul 2016

Where e-scooters share space with pedestrians, local speed limits of 10km/h should be implemented. However, enforcement would be reliant on police resources and may be difficult to implement.

Recommendation: set a maximum 20 km/h speed for private e-scooters at the factory. Shared e-scooter providers, while limiting top speed to 20 km/h, should also apply lower speeds, for example in pedestrian zones, using GPS.

Power

The maximum motor power affects the e-scooter's maximum speed and rate of acceleration as well as the weight that can be carried.

Limiting power restricts the maximum speed and the ability to increase speed through tampering is also limited. Limiting power also reduces the likelihood of carrying passengers.

Research analysing the performance of a range of private e-scooters through test riding found that e-scooters with a power of 250W, 300W and 350W had an acceleration of around $2.5ms^{-2}$. e-scooters with double the power, 500W, had nearly $2ms^{-2}$ the rate of acceleration. In theory riders could apply the throttle less quickly to reduce the rate of acceleration. However the controls were found to operate either 'on' or 'off' making variation of speed difficult. [68]

Sweden, Switzerland and Czechia have limited the maximum power of e-scooters at 250w.

A power level of 250w aligns with electrically power assisted cycles (EPACs), however EPACs require rider input to accelerate and have been shown to accelerate more slowly than e-scooters in practice.[69]

Recommendation: e-scooters should have a maximum rated power of 250w

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[68] Eyers V, Parry I, Zaid M, In-Depth Investigation of E-Scooter Performance, TRL, January 2023
[69] Billstein L, Svernlöv C, Evaluating the Safety and Performance of Electric Micro-Mobility Vehicles Comparing E-bike, E-scooter and Segway, Department of Mechanics and Maritime Sciences Chalmers University of Technology Gothenburg, Sweden 2021, www.chalmers.se

Tampering

Anti-tampering measures and penalties for alterations limit the opportunity to increase the maximum speed and acceleration of the e-scooter.

Limits on speed are set to improve safety. A means to restrict those limits being exceeded should be implemented.

Speed limiting using software control alone is not sufficient to prevent tampering.

On road enforcement is made easier when there is a clear violation of regulations. For example, an e-scooter travelling faster than the construction-controlled speed would indicate the e-scooter had been tampered with and justify intervention from the authorities.

Recommendation: anti-tampering mechanisms should be included at the factory for privately owned e-scooters and by the operator for shared e-scooters. Tampering should be prohibited by law.

Wheel size

Riders are at risk of falling due to instability. Larger diameter wheels make e-scooters more able to withstand surface defects, therefore, increasing stability and control.

Regulations should increase the inherent stability of the e-scooter to minimize falls, especially when e-scooters are used amidst other road traffic.[70]

Testing of e-scooters with different wheel sizes over a 50mm pothole shows increased stability with increased wheel size.[71]

Recommendation: set a minimum wheel size of 30.5 cm (12 inches) for private and shared e-scooters.

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[70] Routt A, AAE, MIMI, *Electric Scooters – A Technical Case Study of their Suitability on Roads*, Metropolitan Police Service, UK, 2020

[71] Posirisuk P, Baker C, Ghajari M, *Computational prediction of head-ground impact kinematics in e-scooter falls*, Accident Analysis & Prevention, Volume 167, 2022, 106567, ISSN 0001-4575

Brakes

More than one independent means of braking increases the effectiveness of stopping as well as stability when stopping. Electric braking must be supplemented by a mechanically operated brake in case of electrical failure.

Dual braking is comparable to the requirement for mopeds. Although small motorcycles and scooters in the EU are now required to be fitted with a more advanced 'combined braking system' which also links the front and rear braking devices together.[72]

E-scooters have been found to be unstable when decelerating.[73]

Requirements should also be set for the minimum deceleration or maximum stopping distance for each braking device, and when used in combination.

Speed control can be further improved with a motor brake for regulating downhill speed automatically. This has already been incorporated into some rental e-scooters.

Recommendation: set a requirement for independent front and rear wheel braking devices for private and shared e-scooters.

Lighting

E-scooters are small vehicles that can travel and manoeuvre quickly in traffic. Front and rear lights increase the visibility of the rider in all conditions.

Both front and rear lights should be placed as high on the e-scooter as is practical.

As e-scooters are electrically powered, illumination at all times through integrated lights is not problematic. Many models do so already.

An increased visual presence is needed for e-scooter riders as vehicle detection systems fail to reliably recognise e-scooter riders, especially at speeds over 10km/h.[74]

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[72] https://www.europarl.europa.eu/news/en/press-room/20121116IPR55754/upgraded-type-approval-rules-for-motorbikes

[73] Paudel, M & Yap, F F, Front steering design guidelines formulation for e-scooters considering the influence of sitting and standing riders on self- stability and safety performance. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering. 235. 2021

[74] Holmes A and di Cugno D, Reviewed by: Grover C, Young A and Brookes D, Assessing e-scooter risk to motor insurers, Thatcham Report July 2021

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Indicating, by removing one hand from the handlebars, is particularly difficult when using the hand which controls power to the e-scooter. Integrated indicator lights should therefore be considered. Some rental e-scooters already have this feature.[76]

Recommendation: set a requirement for independent front and rear lights on private and shared e-scooters. Indicator lights should be considered due to the difficulties of using hand signals.

Audible warning devices

The ability of an e-scooter rider to make their presence known increases awareness for other road users. As e-scooters are electrically powered a buzzer could be integrated into the e-scooter's construction.

Blind and partially sighted people are particularly at risk of collisions with e-scooters which move at a faster speed than walking pace, are almost silent and have low visibility. Acoustic Vehicle Alert Systems (AVAS) should be considered. This has been required, since 1 July 2019, for new electric vehicles when travelling at less than 25km/h.[77]

Recommendation: require an audible warning device on all private and shared e-scooters.

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[75] Emergency brake assistants in the test: More protection for the unprotected? | KFV - Board of Trustees for Road Safety (www.kfv.at)
[76] https://www.cambridgeindependent.co.uk/news/new-e-scooter-model-with-turn-indicators-arrives-in-cambridg-9263637/
[77] Regulation (EU) No 540/2014 of the European Parliament and of the Council Annex VIII

Recommendations to the European Union and national governments – road rules for e-scooter riders

Currently, each EU Member State sets their own requirements on road rules for e-scooters, covering aspects such as minimum age, helmet use, riding on pavements, drink-driving limits and insurance requirements.[78] Cities have also implemented local rules in many cases. This has created a patchwork of different regulations.

The EU has provided some guidance to local authorities for safe use of micromobility devices in urban areas and ETSC was consulted in the development of that guidance.[79]

However ETSC considers there is a case for the harmonisation of some basic road user rules across the EU. This could come as a formal 'Commission Recommendation' to Member States – as is currently the case for Blood Alcohol Limits for motor vehicle drivers and riders. [80]

In general, the rules that apply to other motor vehicle drivers and riders, including rules against dangerous or careless driving / riding, should also apply to e-scooter users.

Helmets

E-scooter riders are more likely to impact their head when falling and the rate of serious head injury is higher than that for pedal cyclists.[81]

Studies have found that for riders suffering head injuries, many involved traumatic brain injuries. Many of these injuries could have been prevented or lessened had a

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[78] See ETSC spreadsheet of current national rules. https://docs.google.com/spreadsheets/d/14oxJ4KOWbrTsRFYeNGQb65GHtTniQ0Ob1d5QqC4SKT8/edit#gid=0

[79] https://www.eltis.org/sites/default/files/sump_topic_guide_micromobility_devices.pdf

[80] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001Y0214(01)&from=EN

[81] Meyer, HL., Kauther, M.D., Polan, C. et al. *E-scooter, e-bike and bicycle injuries in the same period – a prospective comparative study of a Level 1 trauma center*. Trauma surgeon (2022)

suitable helmet been worn (the studies have found very few riders wore helmets) [82] [83] [84] [85] [86] [87]

Computational modelling has shown the mechanism of an e-scooter rider when falling and the prevalence of head injuries.[88]

The nature of head injuries is more similar to motorcycle injuries than cycle injuries.[89]

At least 12 European countries have a compulsory helmet requirement for e-scooters, either for children, under 18s, or all riders. [90]

Crash tests with dummies indicate that e-scooter riders fall forwards, over the handlebars when involved in a collision, an impact with a surface defect or when becoming unstable while accelerating or braking. [91] [92] [93]

Further research is needed into helmet design for e-scooter riders. e-scooter riders suffer more facial injuries than pedal cyclists.[94]

Recommendation: helmet wearing should be mandatory for all private and shared e-scooter riders.

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[82] Mair, O., Wurm, M., Müller, M. et al. *E-scooter accidents and their consequences*. Trauma surgeon 124, 382–390 (2021)

[83] Uluk D, Lindner T, Dahne M, et al, E-scooter incidents in Berlin: an evaluation of risk factors and injury patterns Emergency Medicine Journal Published Online First: 07 June 2021

[84] Moftakhar, T., Wanzel, M., Vojcsik, A. et al. *Incidence and severity of electric scooter related injuries after introduction of an urban rental programme in Vienna: a retrospective multicentre study*. Arch Orthop Trauma Surg 141, 1207–1213, 2021

[85] Coelho A, Feito P, Corominas L, Sánchez-Soler JF, Pérez-Prieto D, Martínez-Diaz S, Alier A and Carles Monllau J, Electric Scooter-Related Injuries: A New Epidemic in Orthopedics July 2021

[86] Meyer, HL., Kauther, M.D., Polan, C. et al. *E-scooter, e-bike and bicycle injuries in the same period – a prospective comparative study of a Level 1 trauma center.* Trauma surgeon (2022)

[87] https://www.academie-medecine.fr/accidentologie-des-trottinettes-electriques/

[88] Posirisuk P, Baker C, Ghajari M, *Computational prediction of head-ground impact kinematics in e-scooter falls*, Accident Analysis & Prevention, Volume 167, 2022, 106567, ISSN 0001-4575

[89] As advised by Chris Uff Consultant Neurosurgeon Clinical Lead for Neurosurgery and Molly Hilling, Clinical Nurse Specialist for Neurotrauma at Royal London Hospital within the framework of research by ETSC's UK member PACTS.

[90] A regularly updated list of the key e-scooter rules in different European countries, as provided by ETSC member organisations, can be found at: https://docs.google.com/spreadsheets/d/14oxJ4KOWbrTsRFYeNGQb65GHtTniQ0Ob1d5QqC4SKT8/

[91] Baloise crash test highlights consequences of accidents involving electric scooters and bikes, www.baloise.com

[92] RCAR - Scooter testing, www.rcar.org

[93] Testing by UTAC Millbrook for Tin Man Communications on behalf of Guide Dogs UK

[94] Posirisuk P, Baker C, Ghajari M, *Computational prediction of head-ground impact kinematics in e-scooter falls*, Accident Analysis & Prevention, Volume 167, 2022, 106567, ISSN 0001-4575

Riding on pavements

Very few European countries permit pavement riding. Some allow exceptions to this rule, and/or require a lower speed limit (e.g. 6 km/h) in such cases. Such rules are difficult to enforce. Belgium previously allowed pavement riding at low speeds, but has now prohibited it for this reason. While young children are allowed to ride bicycles on the pavement in some countries, ETSC do not recommend the use of e-scooters by this group in any case (see age limit recommendation below).

Pedestrians, especially the elderly and those who are visually impaired, are at risk of harm from vehicles sharing the same space.

Recommendation: no e-scooters should be ridden on pavements.

Passengers

The weight of the e-scooter is a fundamental part of the risk which the e-scooter creates.

Higher vehicle weight increases the kinetic energy of the e-scooter when ridden, increasing risk of injury to other road users and causing braking to be less effective.

E-scooters are designed, on average, for a maximum carrying capacity of 100kg. Studies have found that adult e-scooter riders suffer abdominal injuries as a result of shock from the handlebars It could therefore be implied that child passengers, standing in front of the rider, are at additional risk of head injury from impact with the stem and handlebars.

Recommendation: e-scooters should only be ridden by one person at a time.

Minimum age

E-scooters arguably have more in common with the moped category than with pedal cycles, therefore ETSC recommends an equivalent minimum rider age to that of a moped rider.

In Belgium and the UK, 16 is the current minimum age. Other countries may justify a lower limit on the basis of alignment with the moped category. Countries that currently allow e-scooters to be ridden by children as young as 10 or 12, or that have no age restriction, should seriously consider adopting a higher limit.

Recommendation: e-scooter riders should be at least 16 years old, or the age restriction should be aligned with the national age requirement for a moped, which ever is older.

Riding under the influence of alcohol / drugs

E-scooter riders are prone to falls especially if riding under the influence of drink or drugs.

As e-scooters are balance based, the alcohol limit which renders a rider unfit to ride will be lower than that for a driver of a motor vehicle.

Evidence shows that a large proportion of e-scooter riders who are treated in emergency departments are intoxicated. [95]

Recommendation: riding under the influence of alcohol or drugs should be prohibited

Mobile phone use

Safety, particular when turning, has been assessed as severely limited by one-handed riding.[96]

Distraction from mobile devices adds to the risk of a collision.

Recommendation: handheld use of a mobile phone while riding should be prohibited.

Rider training

An e-scooter rider should be competent to use the e-scooter and understand the rules

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[95] Blomberg SNF, Rosenkrantz OCM, Lippert F, et al. *Injury from electric scooters in Copenhagen: a retrospective cohort study*. BMJ Open 2019;9:e033988

[96] Bierbach, M; Adolph, T; Frey, A; Kollmus, B; Bartels, O; Hoffmann, H; Halbach, A, Study on small electric vehicles, Federal Highway Research Institute -BASt-, Bergisch Gladbach, Report F 125, November 2018

governing other road vehicles. There is evidence that a high percentage of collisions occur the first time a rider uses an e-scooter.

E-scooters handle in a different way to pedal cycles, which many people are familiar with.

E-scooters are a vulnerable vehicle, especially when used amidst other road traffic.

Existing EU SUMP guidance recommends local authorities to "design micromobility training for micromobility and other road users, including diverse and disadvantaged groups, informing about risks and rules. It is important to educate road users in general on how to keep micromobility riders safe." [97]

ETSC recommends that pedestrians and cyclists should receive at least a minimum level of road safety education and awareness of the risks imposed by the current traffic system through training and education. The full understanding of road signs and signals, especially for cyclists, is a minimum requirement. Additional efforts are needed to train cyclists so that they can correctly predict traffic situations and assess other users' behaviour.[98] This level of education and awareness, as a minimum, should be extended to e-scooter riders.

Recommendation: e-scooter rider training is recommended and consideration should be given to education of all road users in awareness of risk involving e-scooters and other micromobility vehicles.

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[97] https://www.eltis.org/sites/default/files/sump_topic_guide_micromobility_devices.pdf
[98] https://etsc.eu/wp-content/uploads/PIN-Flash-38_FINAL.pdf

FOR FURTHER INFORMATION

European Transport Safety Council
20 Avenue des Celtes
B-1040 Brussels
Tel: +32 2 230 4106

information@etsc.eu
www.etsc.eu

The Parliamentary Advisory Council for Transport Safety
Buckingham Court, 78 Buckingham Gate
Westminster
London SW1E 6PE
Tel: +44 20 7222 7732

admin@pacts.org.uk
www.pacts.org.uk