International Transport Forum

CPB Corporate Partnership Board

Safer Micromobility

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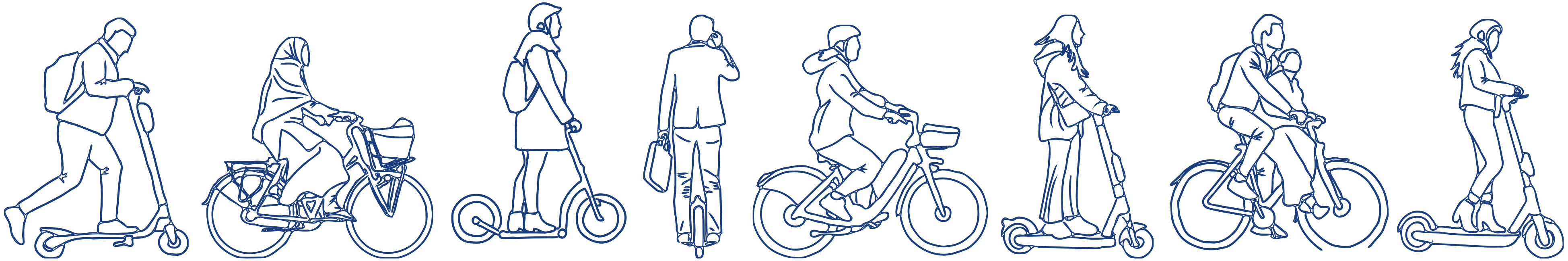

Safer Micromobility

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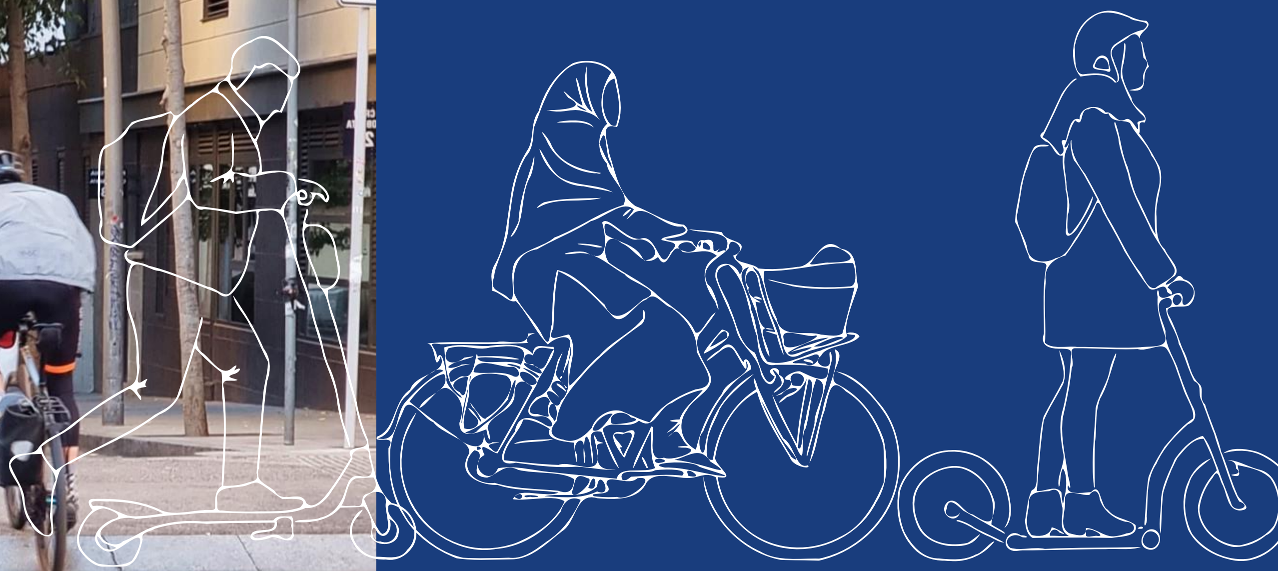


Micromobility is becoming safer

But, an increase in severe injuries from e-scooter crashes is cause for concern. Overall, shared e-scooter crash risk is decreasing as their usage is increasing faster than injuries.

Safe infrastructure and vehicle design matter

A focus on rider behaviour and safety equipment must be complemented by better infrastructure and improved vehicle design – especially for e-scooters.

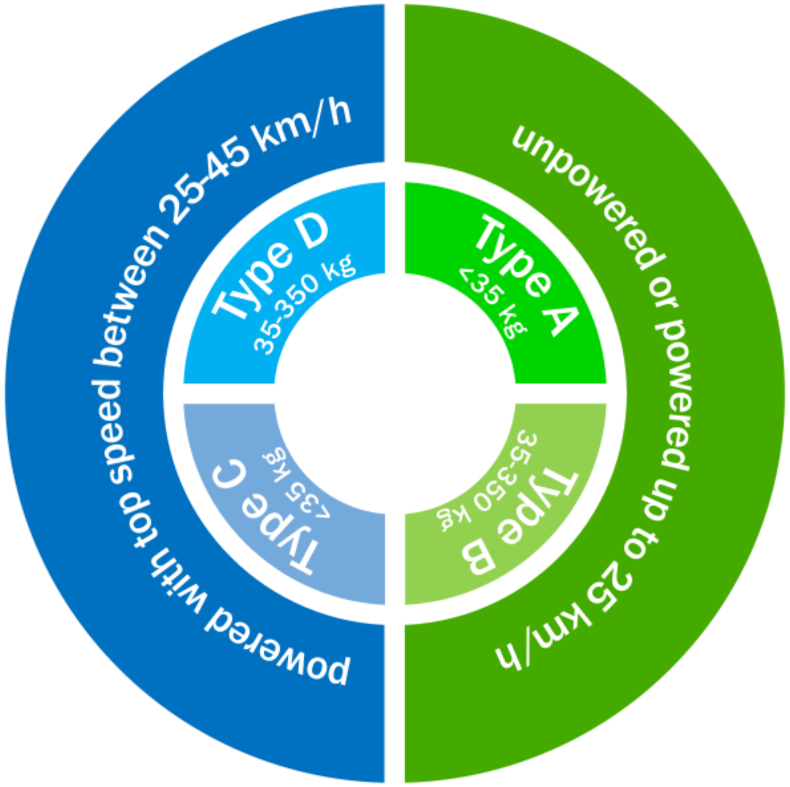
Reinforcing existing policies improves safety

Road safety measures also make micromobility safer – managing speed, providing training to road users and enforcing rules against impaired driving and riding.

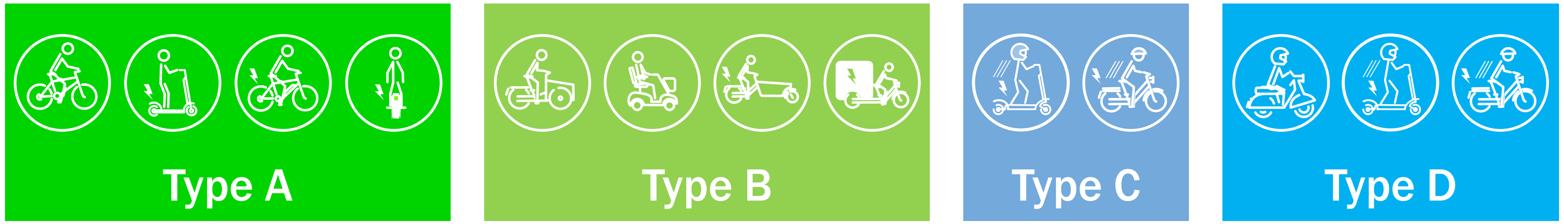
Micromobility provides viable options for car-free travelling and improves first and last-kilometre connectivity to public transport, but it must be safe.

The uptake of micromobility, boosted by the arrival of privately owned and shared e-scooters and e-bikes, benefits people and cities. It offers real alternatives for car-free travel and enhances first and last-kilometre connectivity to public transport. However, the most popular forms of micromobility also raise challenges for safety within busy city spaces largely dominated by cars.

What is micromobility?



This report focuses on e-scooters and e-bikes weighing less than ~35 kg, including models that can travel up to 45 km/h or beyond.



"Micromobility" describes personal vehicles that are much smaller and lighter than cars. There is no standard definition of the term. Micromobility partially intersects with or lies outside various vehicle classification or approval schemes used by public authorities or industry associations.

Micromobility plays an important role in daily mobility on its own or in conjunction with other modes. It is popular in many contexts, is suited to many trips and is more environmentally sustainable than heavier and larger vehicles.

Micromobility vehicles come in a range of established (e.g. bicycles), less established and rapidly evolving form factors (e.g. standing or seated e-scooters, electric unicycles, powered skateboards, etc.).

Some of these vehicles are approved for use on roads, others not. Some are allowed to be used in pedestrian environments in some countries and cities but not in others.

Finally, some micromobility vehicles require human exertion to move (bicycles, pedal-assist e-bicycles, kick-scooters, skateboards, etc.), and others accelerate and move only with direct traction from a motor. The former active modes confer important health benefits, unlike the latter.

There are many ways to classify micromobility according to different features or policy objectives. This report adopts the ITF's generic approach to classifying micromobility from a safety perspective – an approach which is descriptive rather than normative.

Following the Safe System approach and highlighting two key crash severity parameters – speed and mass – the ITF framework identifies four broad micromobility vehicle types:

Type A: powered or unpowered vehicles weighing less than 35 kg and with a maximum powered design speed of 25 km/h.

Type B: powered or unpowered vehicles weighing between 35 kg and 350 kg and with a maximum powered design speed of 25 km/h.

Type C: powered vehicles weighing less than 35 kg and with a design speed between 25 km/h and 45 km/h.

Type D: powered vehicles weighing between 35 kg and 350 kg and with a design speed between 25 km/h and 45 km/h.

Micromobility safety

How to assess micromobility safety?

Micromobility safety must be addressed in the broader context of health since poor safety results in degraded health outcomes.

Safety, according to the World Health Organization, is "the absence of preventable harm [...] and the reduction of risk of unnecessary harm [...] to an acceptable minimum."

Crash risk addresses the probability of harm faced by micromobility users. This means assessing crash occurrences against some measure of people's exposure to those harms. For instance, what is the probability of a serious injury occurring for a given number of trips? This approach goes beyond simply counting crashes, providing a more accurate measure of micromobility safety.

Crashes and injuries are relevant harms. This assessment reviews evidence on their occurrence and nature. It then assesses the factors contributing to the number and severity of crashes – notably vehicles, riders and infrastructure.

According to the Safe System approach, no fatalities or serious injuries are acceptable. The road traffic system must be proactively designed, and the environment should be forgiving so that even when people make mistakes, they are not seriously injured or die. This requires focusing on preventing crashes, including by managing speeds and ensuring traffic separation where appropriate, rather than primarily mitigating their negative outcomes.

From a health perspective, active and passive forms of micromobility are not equal.

Safety and health

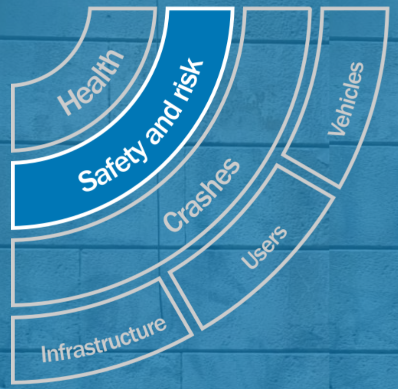
Policy must seek to ensure the highest overall health outcomes. Thus, it must balance the positive health contributions of active modes versus the adverse health outcomes of all micromobility when assessing safety, physical accessibility and other policies.

If safety is a concern for micromobility, it is because crashes and ensuing injuries negatively impact health and impose personal and societal costs. However, physically active forms of micromobility confer significant health benefits across multiple health endpoints.

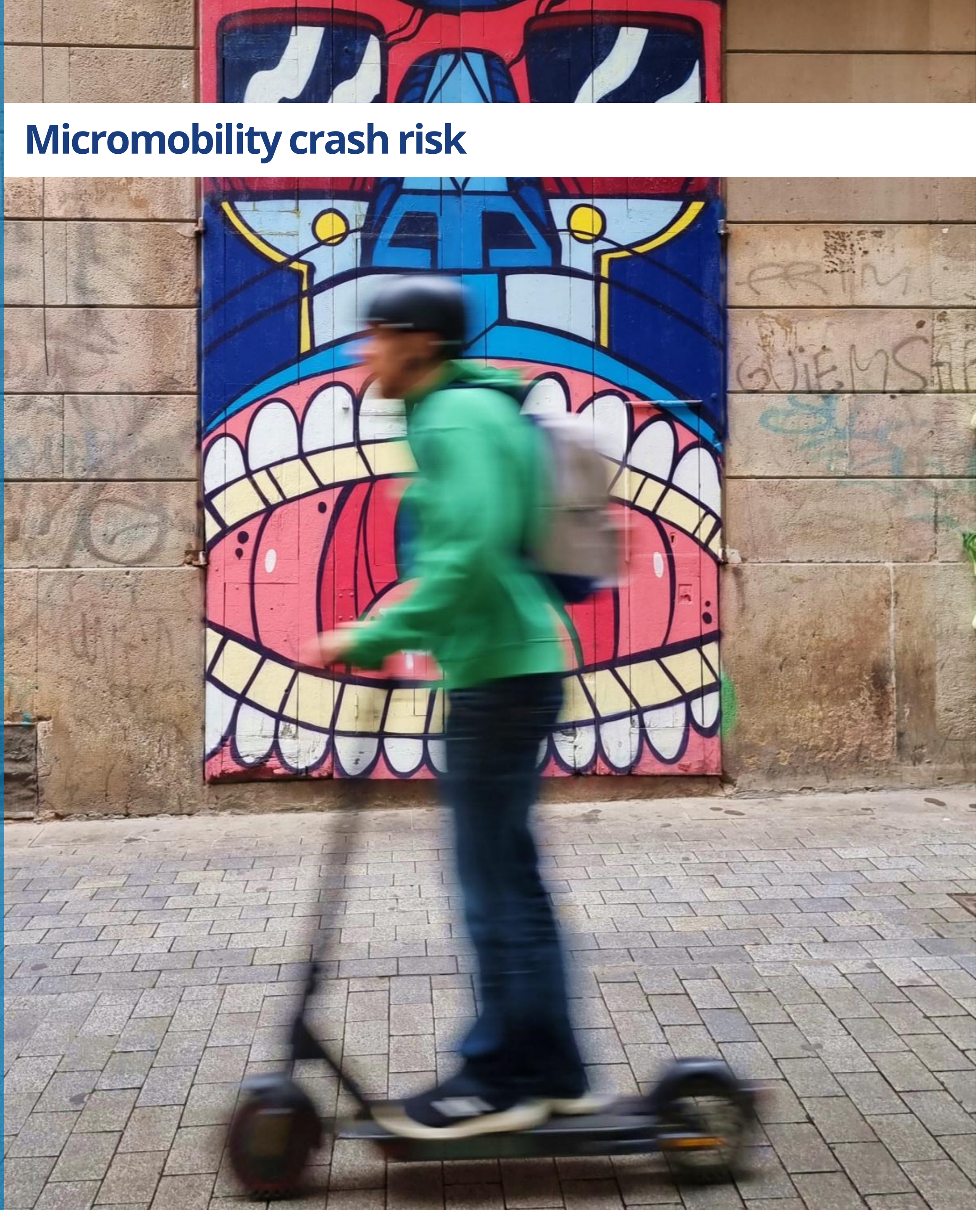
Safety impacts from micromobility use must be considered in the overall context of health. On balance, active travel's positive contribution to good health is far greater than the negative health impacts of crashes and rider exposure to air pollution. From a health perspective, active and passive forms of micromobility are not on the same footing.

While micromobility modes like cycling and electrically-assisted cycling are physically active, other powered micromobility modes, such as e-scooters, require much less physical exertion. Nonetheless, e-scootering and other forms of non-active micromobility are generally associated with more active lifestyles. This is possibly linked to the greater use of micromobility in conjunction with public transport and other non-private car modes.

A key, context-based factor to consider when looking at micromobility-linked health outcomes is how non-active micromobility replaces walking and cycling versus highly sedentary car travel.



Micromobility crash risk

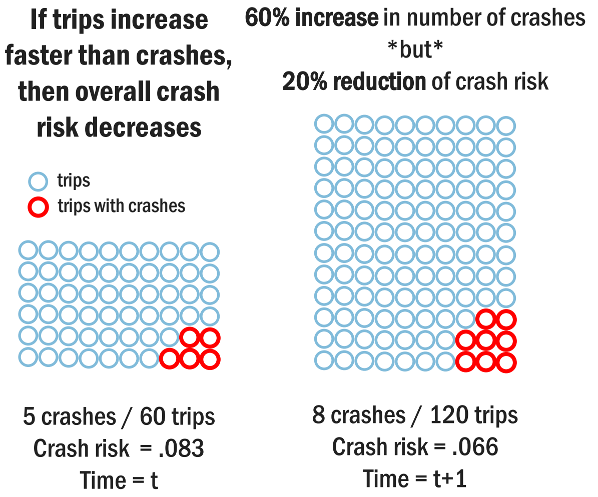


Lack of data on micromobility trips and crashes makes it hard to assess crash risk.

In addition to crash frequency, risk reflects the probability of crashes and their severity. It is characterised as the road safety outcome for an amount of exposure, such as the overall number of trips or distance travelled. This concept recognises that safety is not solely determined by the number of incidents but is also influenced by how much individuals are exposed to potential risks. In fact, risk may diminish even with a rise in absolute crash numbers, emphasising the complex interplay between exposure and road safety outcomes. Policy targets should not only target incremental risk improvements but should also aim to eliminate the risk of severe or fatal crashes.

Assessing crash risk for micromobility is complicated by two factors. First, official crash statistics suffer from underreporting, showing only part of the crash risk. Second, reliable exposure data – especially for privately owned micromobility trips – is rarely available.

Safety risk can diminish even as crash numbers go up



-26%
shared e-scooter casualty risk in Europe

This table illustrates how the casualty risk of shared e-scooters has evolved between 2021 and 2022 in Europe. As this data refers to commercial shared e-scooter services involving certain types of vehicles, users, experience levels and uses, these findings do not reflect the evolution of overall e-scooter crash risk, also taking into account non-negligible underreporting, especially of single-vehicle crashes.

Regulatory measures have been taken to reduce crash risk, yet assessing their impact requires further investigation. These include enforcing minimum age requirements and imposing maximum design speed limits and other vehicle design specifications. Assessing the efficacy of these measures will require monitoring and further investigation.

Comparisons of e-scooter crash risk versus the crash risk of other forms of micromobility are sparse. Micromobility operators report e-scooter risk levels 32% lower than e-bike risk within their fleets across nine European countries. In contrast, other studies indicate that e-scooter risk levels are up to four times higher for e-scooters than for bicycles. Multiple factors may explain these differences, including different types of vehicles, use patterns and contexts. Robust cross-micromobility crash risk assessments are needed to better guide policy.

	Shared e-scooter casualties requiring medical treatment per million trips			**E-scooter Safety Regulations**						
	2021	2022	2022/ 2021	Min age (y/o)	Max speed (km/h)	Max power (w)	Ride on sidewalks?	Drink-ride limit	Helmet required	Mandatory insurance
Austria	4.1	1.5	-63.6%	12	25	600	No[1]	0.8	<12 y/o	No
Belgium	7.1	7.0	-1.8%	16	25	NA	No	Same as car	No	No
Bulgaria	NA	NA	NA	16	25	NA	Yes[1]	NA	<18	No
Cyprus	NA	NA	NA	14	20	NA	Yes[1]	0.5	Yes	No
Czechia	9.2	15.6	69.3%	NA	25	250	>10 y/o	No	<18	No
Denmark	8.6	14.8	72.3%	15	20	NA	No	Same as mopeds	Yes >Jan 2022	Yes
Finland	5.0	2.9	-41.6%	No	25	1 000	No	No	Yes - as bikes	No
France	9.0	12..1	34.8%	12	25	NA	No[1]	Forbidden to ride	Recommended	Yes
Germany	4,3	4,0	-7.7%	14	20	500	No[1]	Same as car	No	Yes
Greece	NA	NA	NA	15	25	NA	Yes[1]	No	Yes	No
Italy	12.1	4.4	-63.3%	14	20[2]	500	No	NA	<18	No[5]
Norway	3.2	2.7	-17.5%	12	20	NA	No	Same as cars	<15	No
Poland	4.9	4.5	-8.0%	10	20	NA	Yes[1]	Forbidden to ride	No	No
Portugal	22.3	25.0	12.0%	No	25	1 000	>10 y/o	Same as cars	No	No
Slovenia	NA	NA	NA	14[4]	25	NA	No	0.5	<18	No
Spain	22.4	14.8	-34.1%	14-16	25	1 000	No	Same as cars	Yes >March 2022	No[5]
Sweden	5.2	5.3	0.5%	NA	20	250	NA	NA	<15 - as bikes	NA
Switzerland	2.2	4.4	100.3%	16[3]	20	500	No[1]	Same as cars	No	No
United Kingdom	31.9	20.6	-35.5%	16	25	500 (trials)	No	Same as cars	No	Trial[5]
Cumulative			**-25.7%**							

[1] "local" authorities can make exceptions (e.g., if no cycling lane, travel speed up to 6 km/h, if the road speed limit is <30km/h or <50 km/h, riders aged 14-16 should only ride them on bicycle lanes etc.), [2] 6km/h in pedestrian areas. [3] 14 with moped license. [4] 12, with cycling licence, [5] required for sharing providers. Sources: MMfE, 2023; ETSC, 2023.

Injury severity is correlated to crash mechanisms, vehicle types and road users.

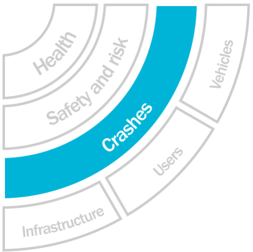
Micromobility crashes

Most reported micromobility crashes result in only minor injuries. Severe injuries comprise a small portion of total reported injuries, and a relatively small percentage of reported micromobility crashes lead to fatal injuries.

According to available data and studies, fatality rates are very low for all injury-inducing crashes (<1%), with no clear difference between e-scooters, e-bikes and conventional bikes. Fatality rates for severe trauma injury crashes are higher (<10%) than rates reported for all-injury crashes. Despite studies assessing fatality and severe injury risk, more granular data is needed to better assess the specific risk of different micromobility modes.

Injury severity is correlated to crash mechanisms, vehicle types and road users. E-scooter riders, adopting a free-standing and upright posture, present a high and forward centre of gravity. Loss of control crashes lead riders to either attempt to hop off the e-scooter (contributing to lower extremity and foot injuries) or, in forward obstacle crashes, be catapulted forward and over the handlebar and steering column. Such vaulting injuries result in upper extremity injuries as riders seek to break their fall. These crashes also result in a high incidence of face and head injuries as face- or head-first ground contact occurs before the rider can brace themselves.

Alcohol consumption further suppresses reaction times, leading to a high incidence of head and face injuries for alcohol-inhibited e-scooter riders.



Micromobility crash types

Most e-scooter-related crashes involve the rider and no other road user. Single road user collisions involve falls due to loss of vehicle control or collisions with stationary objects. Such single road user collisions account for up to 93% of all reported e-scooter-related casualties (persons injured and fatalities). This range is similar to the percentage of cyclist single road user collisions. Another crash type involves pedestrians tripping over e-scooters or fallen bicycles.

E-scooter-related casualties resulting from falls and not collisions with stationary objects constitute a substantial proportion of overall e-scooter-related casualties (64-85%). This range compares with the respective percentage of cyclist single road user collision casualties due to falls (75%). Injuries resulting from e-scooter-motor vehicle collisions account for 8-19% of all e-scooter-related casualties, a slightly higher proportion than for bicycle injuries. Up to 1 in 10 reported motor vehicle crashes with e-scooters or bicycles result in the injury or fatality of the e-scooter rider or cyclist.

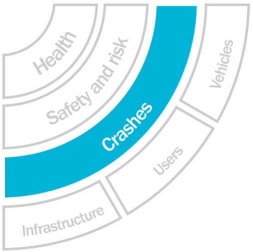
Pedestrians are exposed to e-scooter crash risk in contexts where e-scooters operate legally or illegally on the sidewalk in the presence of pedestrians. This is especially the case in the absence of bicycle infrastructure. The co-existence of pedestrians and e-scooter riders results in pedestrian injuries (1 to 10% of all e-scooter-related casualties). Pedestrians are injured through collisions (30%) or tripping over parked e-scooters (59%).

Collisions		Vehicle type	%
Involved road users (% of casualties)	Single road user	es	93%
	Multiple road users	es	7%
Falls	% of total crashes	es	79-90%
	% of total casualties	es	64-85%
		cb	75%
With objects	% of total casualties	es	1-39%
With motor vehicles	% of total casualties	es	8-19%
		cb	10%
	% of total fatalities	es	>86% (24% hit-and-run)
		cb	93-96%
With pedestrians	Involved pedestrians (% of total crashes)	es	4-17%
	Injured pedestrians (% of total casualties)	es	1-10%
	tripped over (of non-rider casualties)	es	30%
	Struck (of non-rider casualties)	es	59%

es=electric scooter, eb=electric bike, cb=conventional bike

Casualties: persons injured and fatalities.

All sources are detailed in the accompanying technical report.



Micromobility injury patterns

E-scooter injuries are characterised by injuries concentrating in the head and face, particularly the lower third (chin and jaw). Besides head and face injuries, upper and lower extremities injuries are also common among e-scooter crashes. Fractures, particularly involving the lower arm and wrist, are a recurring injury type for e-scooter riders, as is lower extremity trauma.

Most injury categories are not mutually exclusive, and numerous patients presented with more than one injury type or location.

Injuries	Incident description	Vehicle Type	%
Severity	No injury (% of riders)	es	6-9%
	Minor injury (% of casualties)	es	56-70%
		eb	65-70%
	Severe injury (% of casualties)	es	8-13%
		eb	5-17%
	Fatality (% of casualties)	es	<1%
		eb	<1.3%
		cb	<0.2%
Injured Body Region (% of casualties)	Upper extremity	es	25-55%
	Lower extremity	es	23-45%
	Head/ Face	es	Head: 18-41% Face: 30-60%
		cb	Head: 20-24% Face: 20%
		eb	Head: 35%

es = electric scooter, eb = electric bike, cb = conventional bike

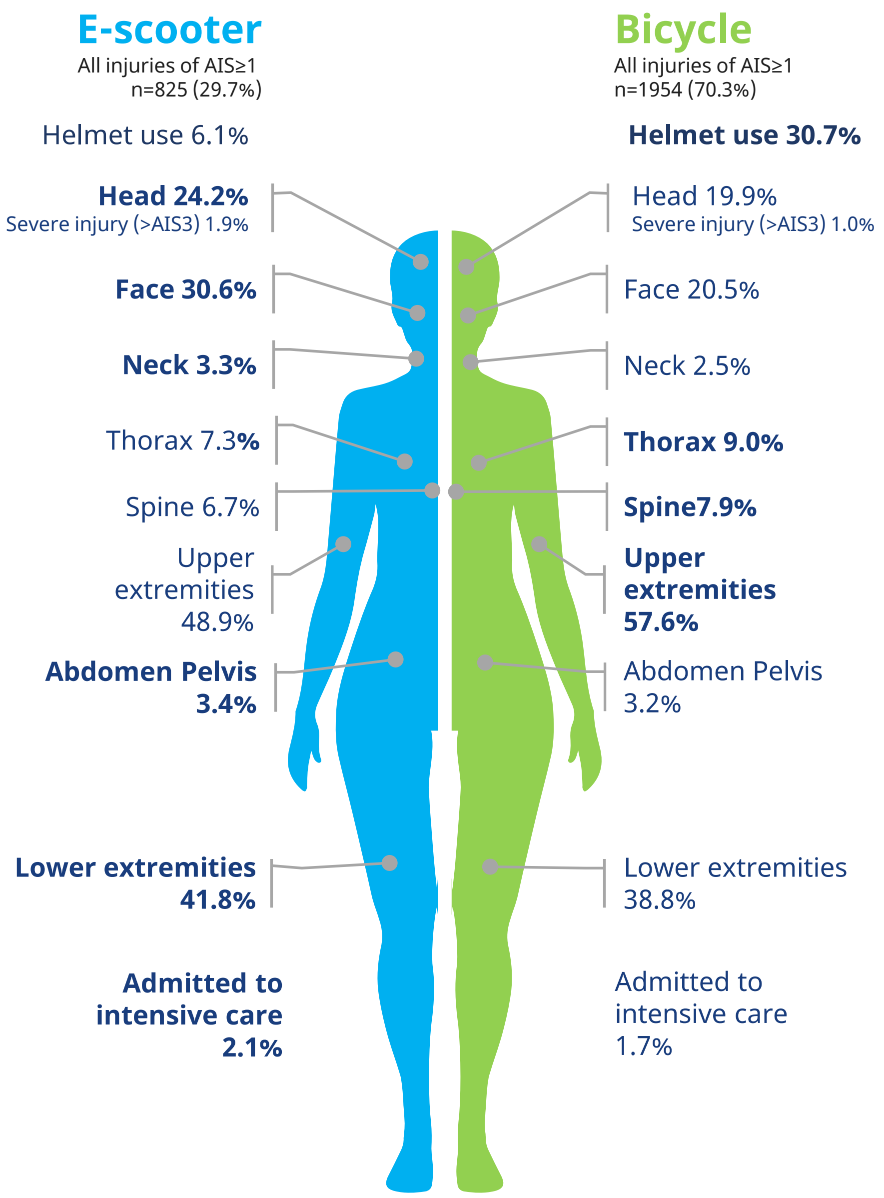
Casualties: injuries and fatalities.

All sources are detailed in the accompanying technical report.

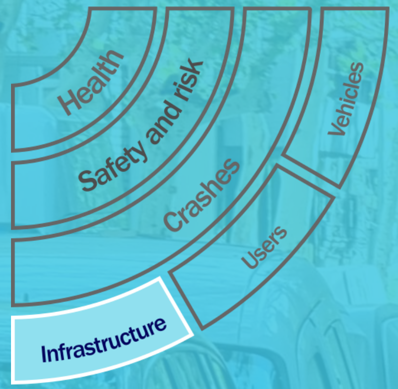
E-scooter and bicycle crash injuries are different

E-scooter riders presented to hospitals with a greater share of head, face and neck injuries than cyclists. They experience up to twice the incidence of severe head injuries and between 50% to 100% more maxillofacial injuries compared to conventional cyclists. Even when wearing helmets, cyclists also present with maxillofacial (face, jaw and neck) injuries, albeit at lower rates than e-scooter riders. This difference may partly be explained by significantly lower helmet use among e-scooter riders, though helmets generally do not prevent maxillofacial injuries. A higher incidence of alcohol-involved crashes for e-scooter riders may also help explain these differences.

Injuries to lower extremities are more prevalent among e-scooter riders than cyclists – possibly reflecting injuries sustained as e-scooter riders hop off their e-scooter just before or at the moment of losing control.

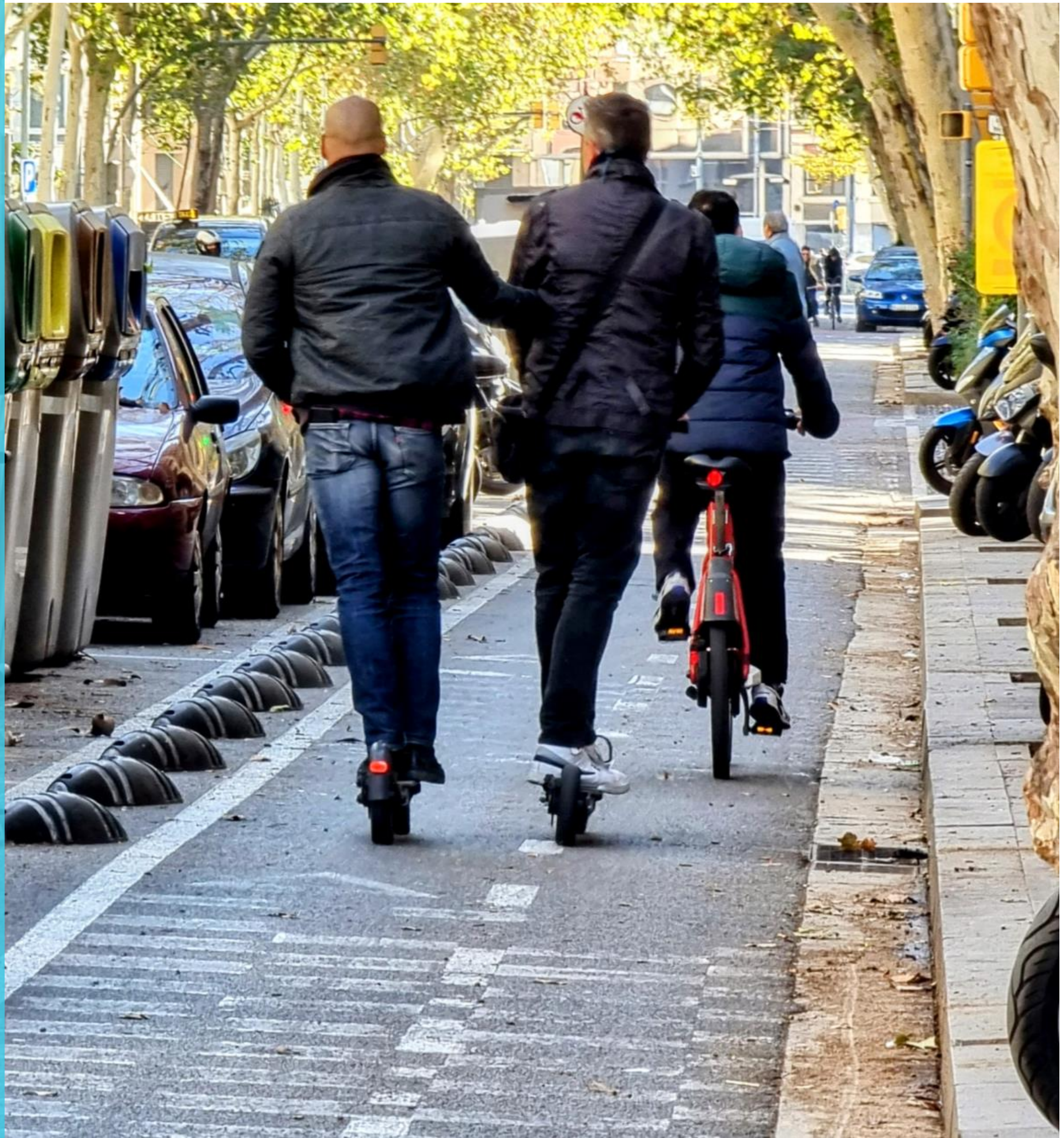


Adapted from Benhamed et al., 2022



Poorly maintained surfaces, with potholes and other irregularities, contribute to 30-40% of e-scooter crashes.

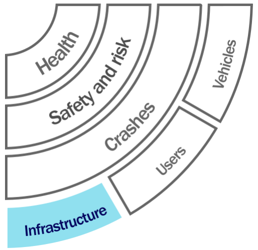
Micromobility crash factors: Infrastructure



The type and quality of road infrastructure have an impact on safety. Safe infrastructure design prevents micromobility crashes, whereas speed management – especially of cars – helps reduce both crashes and their severity.

Safe and convenient cycling infrastructure can attract road users to micromobility. The presence, quality and continuity of bicycle or other micromobility infrastructure contribute to safety outcomes. This is especially the case for infrastructure separated from car traffic and for low-speed streets.

In the United States, e-scooter riders generally ride on bike infrastructure when it is present (27-67%), on the road (20-49%) and on sidewalks, where it is sometimes legal (10-36%). In Europe, the trend is similar, although the shares are different, with a higher prevalence of bicycle infrastructure use (up to 93%) compared to general traffic lanes (11-36%) and sidewalks, where it is rarely legal (4-24%).



Safe infrastructure contributes to safe micromobility

Poor surface quality for cycling and road infrastructure contributes to single road user crashes, particularly for e-scooters. Unpaved surfaces have also been associated with higher crash risk.

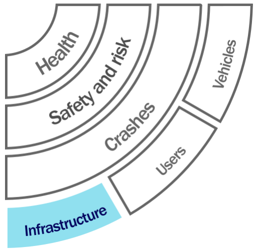
Sidewalks and higher-speed traffic lanes are the least safe locations to ride e-scooters. This is due to the heightened conflicts with pedestrians on sidewalks and the presence of obstacles, cracks and uneven joints. Narrow lane widths can elevate micromobility crash risk due to proximity to stationary and moving motor vehicles. Micromobility tracks separated from car traffic and correctly implemented shared spaces are the safest locations to ride e-scooters and bicycles and are associated with lower injury risk. Micromobility safety can be further improved when micromobility infrastructure is physically separated and when it is connected and easy to navigate on both existing segments and intersections.

Evidence indicates that the conflict rate of e-bikes is higher than that of conventional bikes, irrespective of fault. This evidence suggests that on sidewalks and bike infrastructure, the probability of conflicts is highest between e-bikes and pedestrians and lowest between two conventional bicycles. Overall, however, evidence indicates that the dangerous driving behaviour of car drivers causes the most observed conflicts

Risk factor	Vehicle type	%
Poor road infrastructure (% of tot. crashes)	es	30-40%
Paved vs unpaved road	es	2.66 greater crash risk
Road environment	es	Traffic lane: 23-55% (all)
	es	Sidewalk: 17-58% (all)
	es	Bike lane: 0.04-25% (all)
	es	Intersection: 65% (% of total fatalities)
	cb	Intersection: 67% (% of total fatalities)
	es	Non-junction: 17% (% of total fatalities)
	cb	Non-junction: 17-27% (% of total fatalities)

es = electric scooter, eb = electric bike, cb = conventional bike

All sources are detailed in the accompanying technical report.



Safe infrastructure: Recommendations for authorities

Proactively maintain micromobility infrastructure

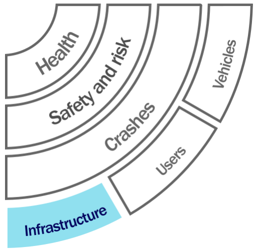
Authorities should implement proactive and regular maintenance for micromobility infrastructure, shared paths and road surfaces, with priority in high micromobility traffic areas. Proactive maintenance ensures that infrastructure elements like bike tracks, sidewalks and roads remain in good condition. This minimises the risk of crashes caused by potholes, debris or poorly maintained surfaces. Prompt reporting of infrastructure issues by road users and near-crash hot spots by micromobility operators contributes to efficient, proactive maintenance. Implementing this measure could reduce falls, a major contributor to e-scooter and (e-)bike-related injuries, and facilitate a smoother learning curve for inexperienced e-scooter riders.

Establish a dedicated and well-connected micromobility network

Authorities should develop a comprehensive urban plan incorporating mixed and protected micromobility infrastructure, ensuring connectivity with existing transportation networks. Specific focus should be given to junction treatments to ensure increased visibility and awareness for car and truck traffic. Seamless connections with public transport, sidewalks and shared mobility services should be encouraged to create a well-connected micromobility network. The effective implementation of this recommendation can reduce collisions of micromobility vehicles with motor vehicles (especially in junctions) and pedestrians on sidewalks.

Establish micromobility parking policy and designate parking areas where needed

Authorities should formulate consistent micromobility parking guidelines that enhance its use. This includes establishing clearly delineated parking zones for e-scooters and bicycles in high-traffic areas. These should be placed at the curb or, where legal and where it does not impede pedestrian activity, in pedestrian or shared zones. Their implementation requires uniform and systematic enforcement. It also involves careful planning and traditional and digital signage to guide riders to these designated zones. This ensures that parked micromobility vehicles do not impede pedestrians, contributing to safer urban environments. Authorities should simultaneously enforce motor vehicle parking policy to ensure micromobility infrastructure and parking zones are not encumbered by illegally parked cars, vans and trucks. Shared micromobility parking should allow sufficient access for operators’ support cargo bikes and vans.



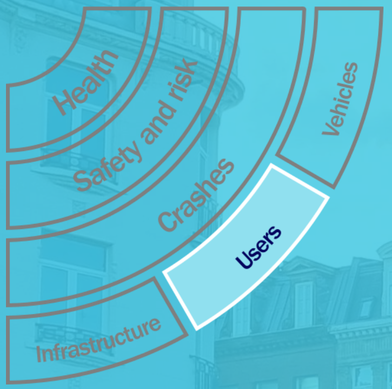
Safe infrastructure: Recommendations for shared micromobility operators

Establish collaborative partnerships with authorities for infrastructure condition reporting

Micromobility operators collect valuable data on potholes, falls, and near-crashes through in-vehicle sensors. They should use this information to help authorities proactively maintain urban infrastructure by identifying and reporting areas with subpar road conditions. This effort, fuelled by data-driven insights, contributes to maintaining and improving micromobility infrastructure, ultimately enhancing overall safety for riders and pedestrians. Additionally, operators should initiate programs to evaluate the effectiveness and costs of this reporting.

Onboard parking zones in shared micromobility apps and deploy smart docking in high-traffic areas

Shared micromobility apps should onboard designated parking areas and restrictions. Deploying smart docking and charging stations in high pedestrian or vehicular traffic zones can reduce obstruction on sidewalks. This ensures convenient access to charged shared micromobility vehicles. Such hubs could also minimise the use of vans or other vehicles for re-positioning, swapping batteries or otherwise re-charging shared micromobility fleets, which may impose additional risks on all road users. Also, operators can reinforce responsible parking, e.g. by offering rewards for users who comply with parking requirements or in docks if these are available.



Rider-related safety factors associated with bicycles are different to those of e-scooters.

Micromobility crash factors: Riders

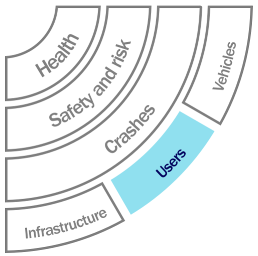
Behaviour, experience and other rider-related factors strongly correlate with micromobility safety. Rider-related safety factors associated with bicycles differ from those of e-scooters, especially concerning nighttime riding, alcohol consumption and helmet use.

Nighttime and reduced lighting conditions are positively correlated with both injury and fatal crashes and are responsible for 30-44% of e-scooter-related casualties.

A prominent cause of e-scooter riders' injuries is alcohol impairment. Riders under the influence of alcohol are more likely to be involved in injury collisions. Alcohol impairment reduces reaction times and crash bracing behaviour, thus contributing to more severe injuries.

In contrast with conventional and electric bicycle riders in many countries, injured e-scooter riders display low levels of helmet-wearing – even when required by law. International evidence indicates that up to 11% of observed shared e-scooter riders wear helmets. Helmets contribute to reducing the severity of head injuries, which are common in e-scooter crashes. Evidence suggests that while current bicycle helmet standards are generally well-adapted to bicycle crashes, they may not provide sufficient protection from face and jaw injuries common in e-scooter crashes. Type C and D micromobility (travelling up to 45 km/h) call for enhanced helmet protection that may go beyond current bicycle helmets.

Some e-scooter users occasionally ride with an additional passenger (tandem riding). Evidence indicates that 2% to 5% of all observed trips involve two riders on a single e-scooter. Tandem riding contributes to 17% of all e-scooter-related casualties.



Rider-related safety factors (continued)

More experienced riders are safer.

Excessive speeding contributes to 30% of e-scooter injury crashes. When e-scooter riders travel on bicycle infrastructure, their speed is comparable to, but slightly higher than, conventional cyclists (~15 km/hour). E-bike average speeds are even higher than average conventional or e-scooter speeds, potentially leading to higher-severity crash injuries. Crash data is sparse on the use of fast e-scooters capable of speeds up to 45 km/h (where these are legal). This suggests the need to capture these types of vehicles separately from mopeds (where they are often grouped) and lower-speed e-scooters.

E-scooter riders are mostly younger males. With driving and cycling, younger males are associated with higher incidences of risky behaviour, crash rates and severe crash outcomes. However, evidence indicates that male and female e-scooter riders display similar injury and crash probabilities.

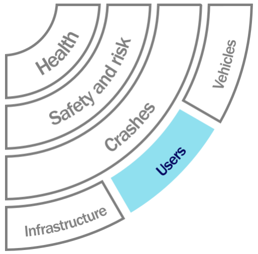
Inexperienced riders are linked to high crash risk, whether due to a limited number of rides or unfamiliarity with the local context. Unfamiliarity with the local context is particularly relevant to shared e-scooter use, considering that in many cities, e-scooters are used by a high share of non-residents. Up to 78% of e-scooter crashes involve infrequent users, while first-time riders face three times the crash risk of more experienced riders. Experience levels differ between riders who own their e-scooters and those using shared services, with the former displaying significantly better riding skills and greater experience.

Risk factor	Vehicle type	Effect
Nighttime (% of fatal crashes)	es	82%
	eb	48%
	cb	57%
	es	43%
Nighttime & Reduced lighting (% of casualties)	es	30-44%
	cb	14-28%
	eb	18%
Nighttime crash risk	es	4.8 crashes per 100 000 trips vs 2.2 for daytime crashes
Helmet use (% of casualties)	es	0-3%
	cb	16-64%
	eb	53%
Alcohol	es	Fatalities: 41%
	es	Casualties: 7-53%
	cb	Casualties: 6-13%
Double riding (% of casualties)	es	14-17%: >one rider/ vehicle
Experience	es	24-37% of injuries occurred during the 1st ride
	es	78% of crashes involved riders with low riding rates

es = electric scooter, eb = electric bike, cb = conventional bike

Casualties: persons injured and fatalities

All sources are detailed in the accompanying technical report.



Safe riders: Recommendations for authorities

Implement a 30km/h (or lower) speed limit in areas with high micromobility use

Authorities should default to a 30 km/h (or 20 km/h) speed limit for car and truck traffic in areas with high micromobility traffic. Lowering the speed limit to 30 km/h or lower provides a crucial safety buffer, allowing motorists to react more effectively to unexpected situations and reducing the severity of potential micromobility vehicle-motor vehicle collisions.

Establish low-speed limits for micromobility vehicles in pedestrian or shared zones

In areas where micromobility riders legally can or must share pedestrian spaces, authorities should default to establishing a safe (~6-10 km/h) speed limit for micromobility modes to enhance pedestrian safety. Implementation involves clear signage, providing access to geospatially-referenced speed control zones. It also involves educating road users on speed limitation rules and enforcement to reduce the risk of crashes and conflicts. This ensures a safe co-existence between micromobility riders and pedestrians.

Take enforcement action against risky micromobility riding

Authorities should impose penalties for illegal micromobility riding, including:

- speeding for micromobility vehicles in speed-restricted zones,
- riding under the influence of drugs and alcohol,
- riding under the age limit,
- riding with two or more people,
- riding on sidewalks when it is forbidden,
- riding outside designated infrastructure where its use is obligatory,
- illegal parking.

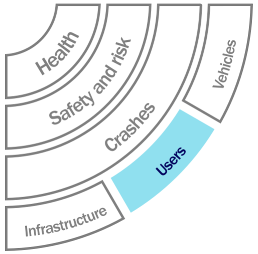
Authorities should define a common limit for alcohol and drug levels and establish minimum age requirements for micromobility.

Promote the use of appropriate helmets

Authorities should encourage helmet use for private and shared micromobility in a way that does not discourage using active micromobility, which would diminish overall health benefits. Further research is needed regarding closed-face helmets or equivalent protection to protect against maxillofacial injuries common in e-scooter crashes. Authorities should require adapted helmets for riders of high-speed e-scooters and e-bikes (e.g. with a maximum speed between 25 km/h and 45 km/h and above).

Introduce rider education in secondary schools

Micromobility training should be integrated into the curriculum of secondary schools. Introducing micromobility training at this level equips students with the knowledge and skills necessary for safe and sustainable urban mobility. Implementation should involve developing age-appropriate micromobility training modules, training qualified instructors, and integrating these lessons into the school curriculum to ensure students are well-prepared for micromobility usage.



Safe riders: Recommendations for shared micromobility operators

Provide safety feedback via telematics data

Operators can use telematics data on speeding, acceleration/deceleration or distracted riding to provide riders with post-trip feedback. This feedback gives riders insights into their habits and opportunities for operators or insurers to incentivise safe behaviour. Real-time safety alerts to riders could also be considered where these do not contribute to rider distraction. These alerts detect risky riding behaviours and notify riders of speed limits, especially in high-risk areas like sidewalks and junctions. Operators should explore how real-time safety alerts impact micromobility safety.

Provide economic incentives for safe riding

Shared micromobility operators may encourage helmet use with economic incentives such as providing free helmets or discounts to encourage safety-conscious ridership. They can also discourage inappropriate parking and alcohol- or drug-impaired riding with incentives or automatic vehicle locking, pending a better understanding of the necessary costs and potential public and private funding schemes.

Implement mandatory initial rider training

To enhance rider safety, shared micromobility operators can require new riders to pass through safe riding screens for the first few rides they make to help ensure that riders are familiar with local rules and guidelines before embarking on their e-scooter trips.

Verify age to start riding

Operators should implement age verification procedures to ensure riders meet the minimum age requirements defined in each city, ensuring compliance with local regulations and safety standards.

Micromobility crash factors: Vehicles

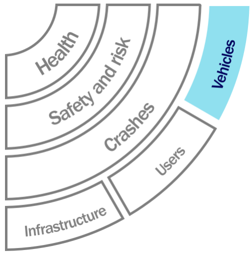
E-scooters differ greatly in their design and stability from both electric and conventional bicycles.

The rapid uptake of micromobility vehicles, specifically e-scooters, brings a range of safety concerns linked to vehicle design. E-scooters, e-bikes and conventional bicycles differ greatly in their design and stability.

A key distinction between e-scooters and bicycles lies in the rider's position. Unlike bicycles, e-scooter users stand on the vehicle while riding and can fall freely from the vehicle, absorbing the full impact of the fall. The standing posture on e-scooters has been identified as risky, particularly during braking to manoeuvre around or away from obstacles. Conversely, the seated posture offers improved braking and handling performance for both seated e-scooters and bicycles.

The maximum design speed of powered micromobility vehicles remains a core determinant of safety. Evidence shows that the reduction of e-scooter riding speed can lead to a significant reduction in the mean head-ground impact speed during crashes.

The differences in vehicle handling profiles affect safety outcomes. Bicycles are the most stable vehicles – especially at low speeds – followed by seated e-scooters and finally by standing e-scooters whose stability increases with speed. As with bicycles, changing the fork-steerer column or headtube angle of e-scooters impacts front wheel handling characteristics and shifts the rider's/vehicle's centre of mass. In some cases, this brings it nearer to the self-stability range of a larger-wheeled bicycle.



Various e-scooter and bicycle characteristics and safety

E-scooters

Head height
Higher head height and distance to the ground due to standing position may increase head acceleration in crashes

Centre of gravity
Higher and more forward centre of gravity reduces stability and makes the rider more prone to vaulting over the handlebar in forward crashes.

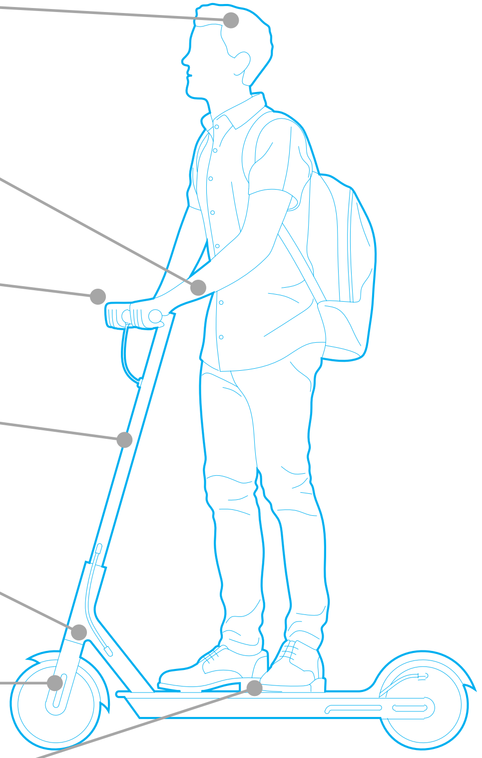
Braking
Single front braking reduces stability and contributes to loss of rear wheel ground contact in emergency braking

Steering column
Steering column serves as a fulcrum, increasing the risk of the rider vaulting over the handlebar in forward crashes if the rider places weight on it

Wheel size
Smaller wheel sizes are more agile but more prone to deflection and stoppage by obstacles. Less gyroscopic stability

Acceleration
Throttle-initiated acceleration can be more sudden

Platform
A narrow or insufficiently large platform reduces rider stability



Newer shared e-scooter models address these design issues with larger wheels, wider tyres, lower and more anterior frame/battery weight distribution, dual front and back braking and wider foot platforms.

Bicycles

E-bikes are generally heavier and operated at higher speeds than traditional bikes, increasing kinetic energy in self-crashes and crashes with pedestrians and other users.

Head height
Lower head height means less free-fall distance and lower acceleration to the ground in a crash

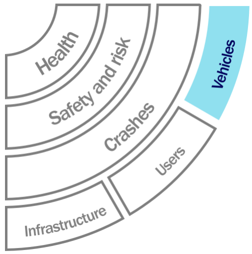
Centre of gravity
Lower and less forward centre of gravity contributes to more stability, better emergency braking and less risk of vaulting over the handlebar in crashes

Braking
Standard dual mechanical or hydraulic brakes and a low centre of gravity provide improved emergency braking

Steering column
Steering column near centre of gravity, high frame attachment point and large wheel size reduce handlebar vaulting risk

Wheel size
Larger wheels prevent deflection, improve obstacle clearing and provide gyroscopic stability, but are less agile

Acceleration
Pedalling-initiated acceleration can be less sudden



Micromobility vehicle design and safety

Compared to bicycles, the slightly higher and more forward-facing centre of mass of e-scooters leads to forward obstacle crashes. In these instances, e-scooter riders exerting weight on the steering bar and column can induce a fulcrum effect, potentially leading to over-the-handlebar vaulting. Many recent-generation shared scooters place weight lower and to the rear of the e-scooter, thus improving stability.

Head-ground impact velocities during e-scooter falls align with those observed in bicycle falls. However, the difference in injury characteristics discussed earlier suggests dissimilar head-ground impact configurations.

The foot platform's width determines the e-scooter rider's stability, with crash injury rates significantly higher in narrow “foot-behind-foot” riding stances than in a “side-by-side“ stance.

Wheel size is linked to safety; larger wheels prevent deflection, improve obstacle clearing and provide gyroscopic stability.

E-scooters have much smaller wheels and more solid and less forgiving tyres compared to bicycles. Bicycle wheels also have a shallower angle of attack than smaller e-scooter wheels and are thus more stable when encountering obstacles of the same height. E-scooters with smaller wheels have been linked to a higher likelihood of falls, elevating the risk of head injuries for riders. Recent generations of shared e-scooters adopt larger front wheel sizes and air-chambered tyres, thus improving stability and shock absorption.

Braking systems are critical to micromobility vehicle design, and their diversity warrants attention. Effective braking systems employ separate hand-lever operated front and rear brakes. E-scooters display lesser efficacy in braking than bicycles – especially in emergency stops – whereas e-scooters exhibit superior performance in steering avoidance manoeuvres. This suggests that crash avoidance techniques may differ between e-scooters and bicycles.

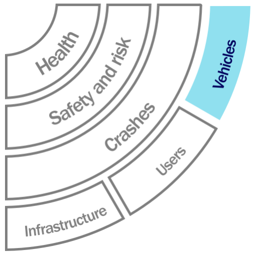
E-scooters and bicycles display different acceleration profiles. E-scooter throttled acceleration is more rapid and responsive than pedal-powered or motor-assisted pedal acceleration. In most cases of the latter, most implementations of pedal torque-input-linked acceleration are smoother and less sudden than torqueless motor engagement.

Ensuring visibility and audibility on the road is paramount for the safety of both micromobility riders and pedestrians. Bikes often come equipped with front and rear lights, offering visibility in various lighting conditions, while pedal and wheel reflectors offer extra visibility. In contrast, e-scooters often feature just a single headlight, and due to their small wheel size, side reflectors show small movement. Without turn indicators on most e-scooters, riders risk instability when resorting to hand signals, unlike bike riders who maintain stability during such manoeuvres due to the gyroscopic effect of the larger wheels.

In addition to the above design features, combined vehicle-rider weight matters from a handling and safety perspective. Considering the standing riding position of e-scooter riders and the fact that the overall average weight of the scooter is less than the average weight of the rider, the rider’s position drastically impacts the centre of gravity.

Standing e-scooters may pose physical accessibility challenges for those with mobility-related disabilities as compared to seated e-scooters, bicycles and tricycles. But, for some people, standing e-scooters may be more easily accessible.

Shared e-scooter fleets are generally comprised of vehicles with safer design characteristics compared to private e-scooters (larger wheels, wider tyres, lower and more anterior frame/battery weight distribution, dual front and back braking and wider foot platforms). They undergo regular technical inspections to ensure their roadworthiness. Shared e-scooters are also designed to conform to dynamic geofenced speed controls, unlike privately-owned e-scooters.



Safe vehicles and management recommendations for authorities

Set universal technical requirements for e-scooter design

Establishing and joining technical standards for e-scooters is essential. E-scooter standards should account for the following:

- maximum speed (e.g. <20/25 km/h. Vehicles operating at higher speeds would be regulated differently and more stringently)
- maximum power (e.g. <250-500 W. Vehicles with higher power should be regulated differently and more stringently)
- minimum wheel size (the larger, the better)
- foot platform area (e.g. at least 150 cm2)
- dual, separate and hand-initiated braking systems
- independent front and rear lights
- indicator lights (due to the difficulties of using hand signals)
- reflective markings
- phone attachment feature.

Further investigation into the impact of weight on e-scooter safety is needed due to the limited current data and potential implications on collision energy.

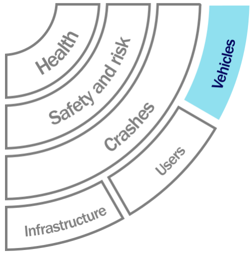
Adopt riding support systems in micromobility vehicles

Authorities should foster the adoption of riding support systems in micromobility vehicles, including automatic emergency braking assistance, audible warning devices providing alerts when speeding, detection technology capable of assessing factors like unsteady movement, occupancy detection sensors and alerts when inappropriately parking.

Safe management

Establish and collect data on distinct micromobility categories in safety statistics

Creating distinct categories for each micromobility mode (i.e., conventional bikes, e-bikes, e-scooters, speed e-scooters/e-bikes, monowheels/e-unicycles) in road traffic casualty records, including police records and medical records, improves safety assessment. Micromobility-related incidents are often grouped under broad categories, making it challenging to track and understand the specific risks and injuries associated with these modes. Additionally, collecting exposure data for each category is essential to calculate casualty risk accurately.



Safe Vehicles and Management Recommendations for Shared Micromobility Operators

Ensure systematic maintenance of micromobility fleets

Operators should maintain their fleets in good repair and follow state-of-the-art maintenance protocols, emphasising regular checks and upkeep of essential components, including brakes, lights and batteries. This approach ensures the vehicles' continued safety and optimal performance, enhancing the micromobility service's overall reliability.

Enable context-dependent maximum speed control using geofencing

Shared micromobility operators can employ geofencing technology to smoothly and dynamically lower maximum speeds to designated speed limits in high-risk zones, such as pedestrian areas or during risky hours like nighttime, prioritising safety for all road users.

Restrict e-scooter access if tandem riding and/or alcohol use is detected

Shared micromobility operators should be encouraged to incorporate in-vehicle sensors to detect tandem riding and introduce in-app tests to identify users under the influence of alcohol and drugs. If violations are detected, e-scooter access can be disabled, ensuring responsible and sober usage.

Implement riding support systems in shared e-scooters

Operators should be encouraged to implement safe riding support systems in e-scooters, including automatic emergency braking assistance and detection technology capable of assessing factors like unsteady movement, tandem riding and inappropriate parking.

Safe management

Enable in-vehicle or in-app crash detection technology

Shared micromobility operators can enhance the safety and user experience of their services and address the low availability of micromobility crash data by integrating crash detection technology into their vehicles or mobile applications. In cases where the technology detects a potential crash, and the user does not respond within a specified timeframe, the app can automatically notify emergency services (e-call). Micromobility operators can establish partnerships with local emergency services, medical facilities or roadside assistance providers to ensure a swift response to detected crashes and improve the effectiveness of this app feature. However, it is crucial to conduct research and pilots to prevent the overexposure of false calls to emergency services.

Summary of key micromobility risk factors

A holistic approach that combines improved infrastructure, safe riding behaviour, vehicle design standards, and safety and exposure data collection is essential to improve micromobility safety.

Poorly maintained or unpaved surfaces are linked to a heightened crash risk. What is particularly concerning is that these infrastructure-related issues often result in falls, further emphasising the need for infrastructure improvements to bolster rider safety. Riding location can also influence crash probability, with intersections and sidewalks the least safe locations due to high conflict rates. The risk for other road users is heightened by vehicles being parked inappropriately.

Speeding is a significant concern, as excessive speed of micromobility and other vehicles (in particular cars, vans and trucks) is a key risk factor for e-scooter and e-bike injuries. Riders who exceed safe speed limits are more susceptible to crashes. At the same time, large motor vehicles speeding is the main source of serious injuries to users of micromobility.

The use of helmets, particularly those adapted to crash injury profiles of e-scooter riders and vehicles travelling above 25 km/h, is another critical factor. .

The influence of alcohol and drugs, mainly among e-scooter riders, is a significant concern, as riders under the influence are more likely to be involved in injury collisions and are more likely to suffer serious injuries.

Visibility is an essential safety factor, with nighttime and reduced lighting conditions positively correlated with injury and fatal crashes. Low rider experience is a recurrent factor in e-scooter collisions, contributing to most crashes and falls. Furthermore, mobile phone use while riding is a distraction that can impair a rider's focus and reaction time.

Rider stability is a key contributor to crashes and falls and is linked to parameters such as the rider's position, vehicle dimensions and riding experience.

Larger wheels contribute to stability and vehicle control, as does centring weight lower and further back. Optimised braking systems enhance riders' ability to slow down or stop safely.

Setting appropriate maximum speeds for e-scooters and e-bikes helps prevent excessive travel speed, a significant risk factor for e-scooter, e-bike and pedestrian injuries. Efforts to manage micromobility travel speed (e.g. via geofencing) should be fair and proportionate to risk. This means addressing active speed management for privately owned micromobility vehicles as well as for larger motor vehicles.

Effective lighting and auditory signalling mechanisms ensure visibility and communication with other road users, reducing the risk of crashes in low-light conditions or situations where awareness is critical. Increasing the e-scooter foot platform width improves stability.

The availability of micromobility safety data and exposure data (preferably distance or time travelled) is crucial for informed decision-making and effective policymaking. Consistently gathering and analysing data on micromobility crashes, injuries and near-miss incidents can provide valuable insights into these events' root causes and patterns and address the under-reporting.

Summary of micromobility safety recommendations

Safe infrastructure

Proactively maintain micromobility infrastructure (Authorities)

Establish a dedicated and well-connected micromobility network (Authorities)

Establish micromobility parking policy and designate parking areas where needed (Authorities)

Establish collaborative partnerships with authorities for infrastructure condition reporting (Operators)

Onboard parking zones in shared micromobility apps and deploy smart docking in high-traffic areas (Operators)

Safe riders

Implement a 30km/h (or lower) speed limit in areas with high micromobility use (Authorities)

Establish low-speed limits for micromobility vehicles in pedestrian or shared zones (Authorities)

Take enforcement action against risky micromobility (Authorities)

Promote the use of appropriate helmets (Authorities)

Introduce rider education in secondary schools (Authorities)

Enable real-time safety interventions via telematics (Operators)

Provide post-trip feedback via telematics data (Operators)

Provide economic incentives for safe riding (Operators)

Implement mandatory initial rider training (Operators)

Verify age to start riding (Operators)

Safe vehicles

Set universal technical requirements for e-scooter design (Authorities)

Adopt riding support systems in micromobility vehicles (Authorities)

Ensure systematic maintenance of micromobility fleets (Operators)

Enable context-dependent maximum speed control using geofencing (Operators)

Restrict e-scooter access if tandem riding and/or alcohol use is detected (Operators)

Implement riding support systems in shared e-scooters (Operators)

Safe management

Establish and collect data on distinct micromobility categories in safety statistics (Authorities)

Enable in-vehicle or in-app crash detection technology (Operators)

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About this report

In 2020, the ITF published Safe Micromobility, a report assessing the safety of micromobility and new mobility services. In the four years since publication, much has changed in terms of the evidence base regarding the safety of micromobility.

This publication summarises an analysis of the current evidence on recent micromobility safety trends and risks. It provides safety recommendations for authorities and micromobility operators in line with the Safe System approach. It does not address safety issues related to fire risk from defective or damaged battery packs which is typically addressed via battery-specific standards and policies.

It is based on a comprehensive technical report written by the same authors. The technical report contains more detailed information and a full list of references for all of the data and findings of this publication.

Link to the technical report and references

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