Light electric vehicles (LEVs)

SWOV Fact sheet, October 2021

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Summary

As the name implies, a light electric vehicle (LEV) is a light, electrically powered vehicle to travel relatively short distances. Which vehicles are classified as LEVs varies among publications and countries. In the Netherlands, those LEVs that the minister of Infrastructure and Water Management has designated as special mopeds can be used on public roads. Among other things, this implies that most electric scooters cannot be used on public roads in the Netherlands, whereas in many other European countries this is permitted. Not much is known about the safety of LEVs since large-scale, systematic research is hardly available. Studies that have been done mostly concern electric scooters (e-scooters) abroad. That is why this fact sheet also focuses on e-scooters. The studies show that crash risk (number of crashes per billion kilometres) for e-scooters is higher than for bicycles. US research shows that the total number of crashes with e-scooters has decreased since their introduction, probably because of familiarisation with the vehicle. Young men (aged 20-40), first-time and occasional e-scooter users are most frequently involved in crashes. These are mainly crashes not involving other vehicles. In general, injuries are most serious when crashes involve motor vehicles. Injuries to the head or the upper limbs are most common. This fact sheet focuses on the road safety of LEVs.

1 What do we mean by light electric vehicles (LEVs)?

The term LEV refers to a light, electrically powered vehicle used to travel relatively short distances. Which vehicles are covered by this term varies among publications and countries. This fact sheet uses the categorisation proposed by the ministry of Infrastructure and Water Management for the future LEV authorisation framework [1][1]. See *Table 1* for an overview of the proposed LEV categories not covered by a European regulation. (Electric) mopeds/light mopeds and speed pedelecs, for example, are vehicles covered by European regulation EU 168/2013.

1. In the Netherlands, the definition and categorisation of LEVs is part of the future LEV authorisation framework. The framework contents are still under development, which may yet change the categorisation.

Table 1. Proposed LEV categories for the future authorisation framework.

Category	Maximum construction speed	Maximum authorised mass	Maximum power	Maximum dimensions l x w x h (m)	Number of people
1a. e-(cargo)bike with pedal assistance < 55 kg	≤ 25 km/h	200 kg	250 watts	2 wheels: 3 x 0.75 x 2 > 2 wheels: 3 x 1 x 2	1 operator, max. 2 passengers
1b. all LEVs other than 1a. < 55 kg For example: e-scooter, Segway	≤ 25 km/h	140 kg	TBD	2 x 0.75 x 1.5	1 operator
2a. Goods transport >55 kg For example: eCargo bike for goods transport	≤ 25 km/uur	556 kg	TBD	3 x 1 x 2	1 operator
2b. Passenger traffic > 55 kg For example: BSO-bus (electric child carrier)	≤ 25 km/uur	556 kg	TBD	3 x 1 x 2	1 operator, max. 8 passengers

The two main categories proposed are: electrically powered vehicles with a maximum mass in running order (mass of the vehicle including batteries without load) of 55 kilograms (category 1) and electrically powered vehicles with a mass in running order of more than 55 kilograms (category 2). Category 1 is subdivided into 1a and 1b. Category 1a includes vehicles with pedal assistance, such as electric (cargo) bikes. Category 1b includes vehicles without pedal assistance, such as an electric scooter and a Segway. Such vehicles are also called Personal Light Electric Vehicles (PLEVs). Category 2 includes electrically powered vehicles with an authorised maximum mass (total mass of the vehicle in running order, including the operator and possible goods or passengers) of 556 kg, for transporting goods or several passengers, such as the BSO-bus (a Dutch electric child carrier used for out-of-school transport) and large eCargo bikes. All LEVs have a maximum construction speed of 25 km/h. The maximum power of LEVs with pedal assistance (electric (cargo) bikes) is 250 watts. The maximum power of LEVs without pedal assistance (for example e-scooters and BSO-busses) is still to be determined.

Disability vehicles and mobility scooters will not be included in the LEV authorisation framework and are therefore not discussed in this fact sheet. See: fact sheet *Mobility scooters, enclosed disability vehicles and microcars*.

2 Which LEVs are allowed on Dutch public roads?

LEVs that the Netherlands Vehicle Authority has designated as special mopeds can be used on public roads. See *Table 2* for an overview of the vehicles that are presently allowed on Dutch roads [2]. Hoverboards, electric skateboards or monowheels are examples of vehicles not allowed on public roads or pavements. For now, the vast majority of electric scooters (e-scooters)

are banned from Dutch public roads. Some LEVs covered by the 'special moped' rule may be authorised for use on public roads. For January 2023, a new LEV authorisation framework is expected.

Table 2. Overview of vehicles designated as special mopeds and therefore allowed on Dutch public roads (Source: [2]).

Trikke	**Segway**	**Swing**	**Zappy 3**
			
Virto	**Paukool**	**Ninebot type E**	**LEF (previously E-one)**
			
Robin-M1	**Virtos**	**Kickbike Luxury**	**Kickbike Cruise**
			
Ninebot type Urban	**Yedoo Mezec**	**Kickbike Fat Max**	**Qugo runner**
			 Qugo, type Runner
BSO-bus			
			

Current authorisation: special moped rule

A special moped is a light motor-driven vehicle that is not included in the moped category because of its specific characteristics (e.g. no saddle). They are therefore not covered by European moped legislation. The special mopeds are allowed on Dutch roads under the 'special moped' admittance rule [3]. These admittance rules are national rules and they may differ among European countries.

In short, a special moped is a vehicle that:

- is not already covered by a European regulation;
- has a maximum speed of 25 km/h;
- has a combustion engine with a maximum cylinder capacity of 50 cm^3 or an electric motor with a maximum power of 4 kW.

Authorisation from 2023 onwards: LEV authorisation framework

The LEV authorisation framework, expected to take effect in January 2023, will replace the special moped rule (for a summary of the new authorisation framework, see: [1]). This authorisation framework will be introduced in response to an advisory report of the Dutch Safety Board [4] and because, as yet, there is no European framework for LEVs.

3 Which rules will apply to LEVs?

The following rules [5] apply to LEVs that, for now, are admitted onto Dutch roads as special mopeds (see *Table 2* at the question *Which LEVs are allowed on Dutch public roads?*):

The vehicle must be insured (vehicle placard and vehicle identification number are mandatory)

The operator is at least 16 years old

If bicycle tracks are present, they should be used

Maximum speed is 25 km/h

At night and in conditions of poor visibility, the use of lights is mandatory. These should preferably be vehicle lights or, failing these, wearable lights

The vehicle must have red and white/yellow reflectors

Driving licence not mandatory

Registration number not mandatory

Helmets not mandatory

4 What is the procedure for admitting LEVs onto public roads?

Currently, all electric (cargo)bikes (so LEVs with pedal assistance) are allowed to use public roads without any admittance procedure. LEVs without pedal assistance, not covered by European legislation, (see also the question *Which LEVs are allowed on Dutch public roads*), have to comply with the admittance procedure as formulated for the special moped rule [3]. The LEV authorisation framework is expected to replace the current special moped rule from 2023 onwards [1].

Current admittance procedure: Special moped rule

Since January 2011, the special moped rule has applied, which allows the minister of Infrastructure and Water Management to designate motor vehicles as authorised for use on Dutch public roads. In 2019, in response to the tragic crash with a Stint electric child cart, the rule was somewhat tightened. Late June 2021, the rule was adapted once more, in anticipation of the procedures pertaining to the future LEV authorisation framework. A manufacturer, importer or distributor may apply for admittance at the ministry of Infrastructure and Water Management. The applicant has to show that the vehicle has been constructed safely, is safe to use and that each subsequent vehicle that is produced is identical to the vehicle assessed during the admittance procedure. In addition, SWOV will carry out a risk inventory for every vehicle concept, in order to point out the risks that could occur in the interaction between vehicle, operator and traffic environment. A vehicle concept consists of vehicles that are so similar in design and usage that their operational characteristics correspond. The Netherlands Vehicle Authority will carry out a technical inspection and operational tests, will test all the different application components and will present an advice to the minister of Infrastructure and Water Management. On the basis of this advice, the minister will make a decision.

LEV authorisation framework

An authorisation framework for light electric vehicles is currently being worked on [6]. The initiative for this new framework was prompted by a report of the Dutch Safety Board: 'lessons learned from the Stint accident' [4]. One of the recommendations of the report was to review the admittance of new vehicles. The new framework will include small electric (cargo)bikes (category 1a), small electric vehicles without pedal assistance (category 1b: PLEVs) such as electric scooters and the Segway, and heavier electric cargo bikes for the transport of goods (category 2a) or passengers (category 2b) (see the question *What do we mean by light electric vehicles (LEVs)?*). For category 1a, admittance is unlikely to change, and vehicles of this category will be allowed to drive on the road without any admittance procedure. Vehicles in the other categories will probably be subjected to an admittance procedure which will be similar to the present procedure to have a vehicle designated as a special moped. This implies that a technical inspection and a driving test will be carried out, and the road safety risks of the vehicle will be inventoried. After admittance, production of the vehicle will be monitored to evaluate whether the admitted vehicle does not change during production.

5 How many LEVs are there in the Netherlands?

It is unknown how many LEVs there are in the Netherlands. This is partly because LEVs do not (yet) have a registration number and do not need to be registered. In addition, this vehicle category is not separately included in the mobility data (as collected by Statistics Netherlands). Market research by Mulitscope (summer of 2021)[2] showed 3% of Dutch people to own an LEV. Of these LEVs, 47% were electric scooters. This comes down to 167.000 electric scooters. How many of these are actually (illegally) used on public roads is unknown. According to the manufacturer, 3000 Stints (electric child carts) were in use in 2018 (the new version of the Stint is the BSO-bus) [7].

6 What is the status of LEVs in other countries?

There aren't any European regulations for LEVs (yet), allowing each country to follow its own national rules. Also outside Europe, different LEV regulations apply.

Like the Netherlands, several countries have included LEVs in a distinct vehicle category with regulations for admittance and usage; for example Austria, Germany, and Singapore [8]. Only those LEVs meeting the admittance conditions are allowed there. Like the Netherlands, Germany has for example banned hoverboards, e-skateboards and monowheels[8]. In other countries, LEVs are included in existing vehicle categories, such as the bicycle category. Examples are Sweden and Norway. There are also countries in which LEV admittance is authorised by region or city. Thus, in Spain, e-scooters are only admitted in part of the cities [8]. In the United States, admittance and usage rules differ between states. The difference in regulations between countries or locations mostly concerns the wearing of helmets, the position on the road, maximum speed and minimum age. The Netherlands, Greece and Serbia are a few of the remaining countries where most e-scooters are not allowed on public roads. The United Kingdom has not admitted e-scooters on a large scale either, but trials with e-scooters have been started at many locations.

Apart from private LEVs, shared temporary use of LEVs (usually an electric moped scooter, scooter or bicycle) is possible against payment at many locations worldwide: the so-called vehicle sharing systems. Electric scooters are particularly popular and are therefore the most researched shared vehicles. The conditions that apply to the suppliers of these shared vehicles, and the use of the vehicles, differ among countries and cities. Various measure are taken to prevent the prevalence of scooters at undesirable locations. Examples are: restricting the number of suppliers (as in Aalborg, Denmark), using geofencing to restrict the area in which they are allowed to be used (at a certain speed) (as in Stockholm, Sweden), restricting the number of scooters (as in Antwerp, Belgium) and ensuring that the scooters cannot be parked at will [8] [9].

Concerning heavier LEVs for transporting goods and passengers, such as the BSO-bus, no information was found (September 2021) on usage and regulations abroad.

2. http://www.multiscope.nl/persberichten/167-000-elektrische-steps-in-nederland

7 Who uses LEVs, when and to what end?

No Dutch figures are available about who uses (legal) LEVs, when and to what end. Foreign figures mostly concern use of electric scooters. They show that electric scooters are mainly used by young men [10] [11] [12]. Rented electric scooters are also often used for recreational purposes, while privately owned electric scooters are more often used for commuting [10] [13]. Both rented and privately owned scooters mostly replace pedestrian and public transport modes but electric scooters, in particular privately owned ones, are also used instead of cars [10] [13] [14]. Research shows that the number of car/taxi journeys that is replaced by e-scooter rides is between 8% (France) and 50% (Santa Monica, United States) [11]. At which times of day e-scooters are mainly used seems to differ greatly among locations. Research in the United States shows that in the city of Austin, e-scooters are mostly used in the morning and in the weekend, whereas in Minneapolis they are mostly used in the evening/at night [15].

8 What is known about the safety of LEVs?

As yet, little is known about the safety of LEVs. In the Netherlands and most other countries, LEVs that are allowed on public roads have not yet or only recently been included as a distinct vehicle category in crash registrations. In the Netherlands, no LEVs whatsoever have yet been registered as a distinct vehicle category. In Belgium, they have recently been included in the crash registration. The data that we do have, originate from small-scale foreign research and mostly concern hospital treatments after e-scooter crashes; these data do not include information about crashes involving other LEV types. Not much can be said about the crash risk of e-scooters; the safety per distance travelled. Slightly more is known about the type of injury incurred in e-scooter crashes and about other crash characteristics, such as user type and the crash type most prevalent among e-scooter users.

Crash risk

Recent German research shows that the number of e-scooter crashes per billion kilometres is 4.5 times larger than that of bicycle crashes, i.e. 5.5 and 1.2 respectively [16]. The number of serious injury crashes per billion kilometres travelled was almost five times higher (0.18 for bicycles versus 0.88 for e-scooters). On the basis of Norwegian research, the number of e-scooter versus bicycle crashes per billion kilometres is estimated to be 89 and 8 respectively [17]. It should be noted, however, that the number of crashes will probably decrease over time because of increased experience with e-scooters. This is apparent from data from the United States, where e-scooter sharing systems have been operational since 2017 [11]. Previously, US data have also been used to assess crash risk, albeit per journey and not per distance travelled. Comparing the number of fatal bicycle crashes to fatal e-scooter crashes, the US report concludes that the fatality risk per journey is the same. This also goes for the risk of needing ER care. Comparing e-scooters to bicycles, the risk of hospitalisation, however, is greater for e-scooter riders [11]. On the basis of the same research data, a recent report by KiM Netherlands Institute for Transport

Policy Analysis estimates the risk of a fatal crash per distance travelled to be higher for e-scooters than for bicycles [18].

Injuries

Most hospital studies [19] [20] [21] [22] [23] [24] [25] [26] [27] show that the largest number of injuries are to the head (including the face), followed by injuries to the (upper) limbs (hands, wrist, arm, shoulder). They also show that by far most casualties with head injuries did not wear helmets. Only very few casualties of e-scooter crashes die, but a significant number of them need surgery or even end up in intensive care units.

Casualties

Young men (aged 20-40), first-time e-scooter users and occasional users are most often involved in crashes [20] [28] [29]. Research also shows that in a significant number of crashes (about 30%), the e-scooter user was under the influence of alcohol [21] [30] [31] [32] [33].

Crash type

In most e-scooter crashes, no other vehicle is involved. A Norwegian questionnaire survey shows that the road surface quality (slipperiness, tram tracks, potholes) is a common cause of single-vehicle (near miss) crashes [17]. If the crash involves a conflict with other road users, these are most often pedestrians and cyclists. Injuries are usually most severe when a motorised vehicle is involved in the crash. On average, in more than 80% of fatal e-scooter crashes, a heavier motorised vehicle is involved [11].

Time of crash

A number of studies show that the greatest proportion of e-scooter crashes occur in the evening, at night and in weekends [23] [34]. But these results vary among studies and locations [20].

Risk to pedestrians

In some countries, e-scooters can be used on pavements, as for example in Belgium, Finland and Sweden. But e-scooters quite often also ride on pavements where this is not allowed. For pedestrians, e-scooters on pavements are risky 20] [35], particularly because of the difference in speed (sometimes, in combination with a difference in mass, and because of the material the e-scooters are made of). In addition, these vehicles hardly produce any sound and have no readily visible lighting, sometimes even no lighting at all, which makes them harder to see. For older, hearing- or sight-impaired pedestrians this makes it harder to adequately anticipate this kind of vehicle [36]. Moreover, the way the e-scooters are parked causes problems, because most e-scooter sharing systems have no dedicated parking spaces or charging stations. For this reason they often block the pavement, which could lead to unsafe situations (pedestrian stumbles or falls).

9 What do we know about LEV user behaviour?

Information on LEV user behaviour is mostly based on studies of e-scooter users. These studies show that owners of e-scooters behave differently from users of rented e-scooters. The latter take more risks while riding, and more often underestimate hazards. They also wear helmets less often [20] [37] [38].

In general, both observations and studies of casualties (that had to go to hospital) show that helmet use is rare: only 1% to 3% of e-scooter users wear helmets [13] [21]. A number of studies show that relatively many e-scooter users that are hospitalised are under the influence of alcohol. In a Belgian survey [39], 12% of the 99 respondents reply having been under the influence while riding an e-scooter. Austrian research shows that the average speed of e-scooters is 15.1 km/h and the maximum speed 31 m/h [38].

In most European countries, parking e-scooters poses problems [13]. Outside the EU, this is also considered a problem. In the United States, an observational study looking at 600 e-scooters, showed that 16% of them were parked incorrectly and 6% blocked the pavement [40]. In addition, parking on the pavement inevitably leads to (unauthorised) riding on the pavement in order to reach or leave the parking space [9] [11].

10 How do other road users respond to LEVs??

We do not know of any research about behaviour actually displayed by other road users in response to LEVs. However, opinions of non-users have been researched. A study of opinions among LEV users and non-users in Indianapolis (United States) showed, for example, that 72% of non-users thought that riding an e-scooter on the pavement posed a threat to pedestrians, whereas only 47% of e-scooter users shared this opinion [41]. Research in Belgium [39] shows that non-users (158 respondents) consider riding an e-scooter to be much more hazardous to themselves (78%) and others (72%) than e-scooter users (150 respondents) did (16% and 2% respectively).

11 How to integrate LEVs into the traffic system with maximum safety?

Based on available knowledge of, particularly, e-scooters, the OECD International Transport Forum [11] and the European Commission [42] have issued general recommendations for the safe use of and interaction with LEVs. In the Netherlands, several parties, such as ANWB, CROW-

Connekt and SWOV, issued reports containing their ideas about safe use of LEVs. And finally, the government is developing a framework for safe admittance of LEVs.

General recommendations

The main recommendations by OECD/ITF and the European Commission (EC) are:

- Develop a shielded and well-maintained LEV infrastructure. Do not allow LEVs on footpaths and pavements and ensure bicycle tracks are wide enough, so that different kinds of vehicles may use them safely. In addition, designated parking spaces for LEVs should be introduced.
- LEV crashes with motorised vehicles are most serious. Make interaction with these vehicles safer, for instance by improving speed enforcement and alcohol checks (also for LEV users), and introducing urban speed limits of 30km/h everywhere.
- Promote helmet use; wearing a helmet reduces the risk of (severe) head injuries.
- Discourage high speeds and hazardous manoeuvres (such as red light running and not giving right of way to pedestrians where required) by pricing e-scooter rental on the basis of distance, not on duration.
- Improve the design and, thus, the safety of LEVs, by the following measures: direction indicators, sound signal, rear view mirrors, reflecting materials, a minimum brake delay of 4 m/s^2), and two brakes which function independently.
- Introduce clear LEV regulations: are helmets mandatory, where can LEVs be used, at what speed, after what kind of rider training, at what minimum age, and with what alcohol limit.

OECD/ITF and EC recommend improving awareness of (required) LEV rider behaviour among users of other motor vehicles. Moreover, they think it important to collect LEV data (usage, distance travelled and (near miss) crashes), so that more knowledge may be gained.

Visions for safe LEV use in the Netherlands

ANWB, CROW-Connekt and SWOV have issued reports incorporating their vision on (safe) use of LEVs in traffic. Their main road safety issues are listed below.

ANWB: Vision on regulation of micro vehicles [43]

- Page 14: “adapt national policy or introduce new legislation, creating scope for all light vehicles (including self-balancing vehicles), provided that their product safety is guaranteed. Model legislation on bicycle regulations: same road position, helmets not mandatory, no vehicle insurance, no licence needed, maximum construction speed of 25km/h.”

CROW-Connekt: Microbility: disruption of mobility market with major implications? [44]

- Reducing the speed and the number of cars, particularly in 30km/h zones, will contribute to the road safety of LEVs. Even more so than wearing fluorescent clothes and helmets.
- Organising public space in such a way that walking and cycling are encouraged will contribute to road safety. Bicycle tracks and pavements need to be sufficiently wide and well-maintained.
- The vehicle itself should meet specific requirements. Instructing vulnerable road users about vehicle hazards is not enough.
- The road environment should support expected road user behaviour.

SWOV: Safe innovation: authorisation of LEVs and the future of bicycle tracks [45]

- Pag. 4: “The authorisation of LEVs should contribute to realising social goals, and road safety in any case. The guiding principle is that innovative LEVs can be admitted to road traffic if, on balance, the social benefits of admittance exceed the costs and if, at any rate, road traffic becomes safer.”
- Pag. 4: “Bicycle tracks are primarily intended for cyclist safety. Only those vehicle that are similar to regular bicycles in size, weight, speed and function can safely be used on bicycle tracks.

Recommendations for safe admittance onto Dutch roads

Apart from the general recommendations and visions on the safe use of LEVs mentioned above, the Dutch Safety Board [4] has drafted recommendations for safe admittance and monitoring of all LEV types, which were prompted by the tragic Stint crash in 2018. The main recommendations are:

- Carry out an **integral risk assessment** of LEVs. This implies an assessment that gives centre stage to the interaction between operator, technology and road environment. Indicate what safety level is acceptable on the basis of government ambitions. Include both new LEVs and those that have already been admitted onto public roads in the assessment. **Monitor** technology and traffic developments, so that new or altered risks can be identified on time and effective measures can be taken.
- If need be, take **additional measures for LEVs that have already been admitted** onto public roads if the safety level of these vehicles turns out to be insufficient. This safety assessment includes technological requirements, user and usage requirements and infrastructure.
- Ensure that an **independent inspection authority** is responsible for assessing whether or not to admit LEVs (nationally authorised vehicles).

The minister of Infrastructure and Water Management has already promised to ‘be mindful of’ and adopt all recommendations in drafting the LEV authorisation framework [46] that is expected to take effect in January 2023.

As part of the integral risk assessment [47], as has been applied in the ‘special moped rule’ since 2020, SWOV have proposed a method to inventory possible risks in the interaction between LEVs, operators and road environment. Consideration will be given to vehicle ergonomics, visibility, possibly improper use, experience and skills of users, vehicle recognisability, possible distraction of other road users caused by the vehicle, the safety of the intended road position, and the collision protection and crashworthiness of the vehicle.

Publications and sources

Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.

[1]. Minister van IenW (2020). *Maatregelen verkeersveiligheid*. 29398-886. Government document d.d. 14 december 2020. Minister van Infrastructuur en Waterstaat, Den Haag.

[2]. RDW (2021). *Wegwijzer Bijzondere bromfietsen*. RDW. Accessed on 01-03-2021 at https://www.rdw.nl/over-rdw/actueel/dossiers/bijzondere-bromfietsen.

[3]. Minister van IenM (2014). *Beleidsregel aanwijzing bijzondere bromfietsen*. Besluit van de Minister van Infrastructuur en Milieu van 2 december 2014, nr. IENM/BSK-2014/255126. Accessed on 04-06-2021 at https://wetten.overheid.nl/BWBR0035848/2019-05-02.

[4]. OvV (2019). *Veilig toelaten op de weg. Lessen naar aanleiding van het ongeval met de Stint*. Onderzoeksraad voor Veiligheid, OvV, Den Haag.

[5]. Rijksoverheid (2021). *Wanneer mag ik op een bijzondere bromfiets zoals een Segway rijden?* Minister van Infrastructuur en Waterstaat. Accessed on 04-06-2021 at https://www.rijksoverheid.nl/onderwerpen/brommer/vraag-en-antwoord/welke-regels-gelden-er-voor-een-segway.

[6]. Minister van IenW (2021). *Kader Lichte Elektrische Voertuigen*. 29398-954. Government document dd. 13 juli 2021. C. van Nieuwenhuizen Wijbenga, minister van Infrastructuur en Waterstaat, Den Haag.

[7]. Wikipedia (2021). *Stint*. Wikipedia. Accessed on 04-06-2021 at https://nl.wikipedia.org/wiki/Stint.

[8]. Smit, C., Münzel, K., Hair, S. de & Bor, R. van den (2020). *Ervaringen met licht elektrische voertuigen in Europa*. TNO 2020 R10704. TNO, Den Haag.

[9]. Gössling, S. (2020). *Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change*. In: Transportation Research Part D: Transport and Environment, vol. 79.

[10]. Laa, B. & Leth, U. (2020). *Survey of E-scooter users in Vienna: Who they are and how they ride*. In: Journal of Transport Geography, vol. 89.

[11]. OECD/ITF (2020). *Safe micromobility*. Corporate Partnership Board Report. International Transport Forum, Paris.

[12]. Christoforou, Z., Gioldasis, C., de Bortoli, A. & Seidowsky, R. (2021). *Who is using e-scooters and how? Evidence from Paris*. In: Transportation Research Part D: Transport and Environment, vol. 92.

[13]. Kamphuis, K. & Schagen, I. van (2020). *E-scooters in Europe: legal status, usage and safety. Results of a survey in FERSI countries*. FERSI Forum of European Road Safety Research Institutes.

[14]. Tuncer, S. & Brown, B. (2020). *E-scooters on the ground: Lessons for redesigning urban micro-mobility*. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems.

[15]. Bai, S. & Jiao, J. (2020). *Dockless E-scooter usage patterns and urban built environments: A comparison study of Austin, TX, and Minneapolis, MN*. In: Travel Behaviour and Society, vol. 20, p. 264-272.

[16]. Köllner, C. (2020). *Ers-te un-fall-bi-lanz für e-scoo-ter. Was sa-gen die zah-len über ih-re si-cher-heit aus?* DLR. Accessed on 04-06-2021 at https://www.springerprofessional.de/mikromobilitaet/elektrofahrzeuge/unfallrisiko-fuer-e-scooter-ist-hoeher-als-das-fuer-fahrraeder/18144552.

[17]. Fearnley, N., Berge, S.H. & Johnsson, E. (2020). *Shared e-scooters in Oslo*. TØI Report: 1748/2020 [Summary in English]. TØI, Oslo.

[18]. Knoope, M. & Kansen, M. (2021). *Op weg met LEV. De rol van lichte elektrische voertuigen in het mobiliteitssysteem*. Kennisinstituut voor mobilitieitsbeleid, KiM. Ministerie van infrastructuur en waterstaat.

[19]. Faraji, F., Lee, J.H., Faraji, F., MacDonald, B., et al. (2020). *Electric scooter craniofacial trauma*. In: Laryngoscope Investig Otolaryngol, vol. 5, nr. 3, p. 390-395.

[20]. Wrzesinka, D., Kluppels, L., Godart, B. & Gaillet, J.-F. (2019). *E-steps ongevallen. Overzicht België.* VIAS.

[21]. Bauer, F., Riley, J.D., Lewandowski, K., Najafi, K., et al. (2020). *Traumatic injuries associated with standing motorized scooters*. In: JAMA Netw Open, vol. 3, nr. 3, p. e201925.

[22]. Dhillon, N.K., Juillard, C., Barmparas, G., Lin, T.L., et al. (2020). *Electric scooter injury in Southern California trauma centers*. In: J Am Coll Surg, vol. 231, nr. 1, p. 133-138.

[23]. Trivedi, B., Kesterke, M.J., Bhattacharjee, R., Weber, W., et al. (2019). *Craniofacial injuries seen with the introduction of bicycle-share electric scooters in an urban setting*. In: J Oral Maxillofac Surg, vol. 77, nr. 11, p. 2292-2297.

[24]. Aizpuru, M., Farley, K.X., Rojas, J.C., Crawford, R.S., et al. (2019). *Motorized scooter injuries in the era of scooter-shares: A review of the national electronic surveillance system*. In: The American Journal of Emergency Medicine, vol. 37, nr. 6, p. 1133-1138.

[25]. Farley, K.X., Aizpuru, M., Wilson, J.M., Daly, C.A., et al. (2020). *Estimated incidence of electric scooter injuries in the US From 2014 to 2019*. In: JAMA Netw Open, vol. 3, nr. 8, p. e2014500.

[26]. Mair, O., Wurm, M., Müller, M., Greve, F., et al. (2021). *E-scooter accidents and their consequences. First prospective analysis of the injury rate and injury patterns in the urban area of a German city with over 1 million residents*. In: Unfallchirurg, vol. 124, nr. 5, p. 382-390.

[27]. Moftakhar, T., Wanzel, M., Vojcsik, A., Kralinger, F., et al. (2021). *Incidence and severity of electric scooter related injuries after introduction of an urban rental programme in Vienna: a retrospective multicentre study*. In: Archives of Orthopaedic and Trauma Surgery, vol. 141, nr. 7, p. 1207-1213.

[28]. Kobayashi, L.M., Williams, E., Brown, C.V., Emigh, B.J., et al. (2019). *The e-merging e-pidemic of e-scooters*. In: Trauma Surg Acute Care Open, vol. 4, nr. 1, p. e000337.

[29]. Ishmael, C.R., Hsiue, P.P., Zoller, S.D., Wang, P., et al. (2020). *An early look at operative orthopaedic injuries associated with electric scooter accidents: Bringing high-energy trauma to a wider audience*. In: J Bone Joint Surg Am, vol. 102, nr. 5, p. e18.

[30]. Bekhit, M.N.Z., Le Fevre, J. & Bergin, C.J. (2020). *Regional healthcare costs and burden of injury associated with electric scooters*. In: Injury, vol. 51, nr. 2, p. 271-277.

[31]. Blomberg, S.N.F., Rosenkrantz, O.C.M., Lippert, F. & Collatz Christensen, H. (2019). *Injury from electric scooters in Copenhagen: a retrospective cohort study*. In: BMJ Open, vol. 9, nr. 12, p. e033988.

[32]. Puzio, T.J., Murphy, P.B., Gazzetta, J., Dineen, H.A., et al. (2020). *The electric scooter: A surging new mode of transportation that comes with risk to riders*. In: Traffic Injury Prevention, vol. 21, nr. 2, p. 175-178.

[33]. Yarmohammadi, A., Baxter, S.L., Ediriwickrema, L.S., Williams, E.C., et al. (2020). *Characterization of facial trauma associated with standing electric scooter injuries*. In: Ophthalmology, vol. 127, nr. 7, p. 988-990.

[34]. Alwani, M., Jones, A.J., Sandelski, M., Bandali, E., et al. (2020). *Facing facts: Facial injuries from stand-up electric scooters*. In: Cureus, vol. 12, nr. 1, p. e6663.

[35]. Sikka, N., Vila, C., Stratton, M., Ghassemi, M., et al. (2019). *Sharing the sidewalk: A case of E-scooter related pedestrian injury*. In: Am J Emerg Med, vol. 37, nr. 9, p. 1807 e1805-1807 e1807.

[36]. Nisson, P.L., Ley, E. & Chu, R. (2020). *Electric scooters: Case reports indicate a growing public health concern*. In: American Journal of Public Health, vol. 110, nr. 2, p. 177-179.

[37]. Haworth, N., Schramm, A. & Twisk, D. (2020). *E-Scooters in Brisbane – Changes in the first year since introducing a2 shared scheme*. Paper presented at ICSC, Lund, Sweden.

[38]. KfV (2020). *E-Scooter im straßenverkehr. Unfallzahlen, risikoeinschätzung, wissensstand und verhalten von E-scooter-fahrern im straßenverkehr*. Kuratorium für Verkehrssicherheit KfV, Wien.

[39]. Slootmans, F. & Schinckus, L. (in progress). *Risicogedrag van gebruikers van e-steps. Verkenning van de mobiliteit en de veiligheid van gebruikers van elektrische steps via een online enquête*. Brussel.

[40]. James, O., Swiderski, J., Hicks, J., Teoman, D., et al. (2019). *Pedestrians and E-scooters: An initial look at E-scooter parking and perceptions by riders and non-riders*. In: Sustainability, vol. 11, nr. 20.

[41]. Comer, A., Apathy, N., Waite, C., Bestmann, Z., et al. (2020). *Electric scooters (e-scooters): Assessing the threat to public health and safety in setting policies: Assessing e-scooter policies*. In: Chronicles of Health Impact Assessment, vol. 5, nr. 1.

[42]. EC (2021). *Road safety thematic report – Personal mobility devices*. European Road Safety Observatory. European Commission, Directorate General for Transport, Brussels.

[43]. ANWB (2020). *Visie ANWB op de regulering van micro vervoersmiddelen. Met focus op nieuwe kleine lichte voertuigen die in de stad gebruikt worden*. ANWB.

[44]. CROW-Connekt (2020). *Micromobiliteit: disruptie in de mobiliteitsmarkt met grote gevolgen?* K-D07. CROW-KpVV, Ede.

[45]. Knaap, P. van der (2021). *Veilig innoveren: toelating van LEV's en de toekomst van fietspaden. Een perspectief*. R-2021-11. SWOV, Den Haag.

[46]. Minister van IenW (2020). *Beleidsreactie op OvV rapport 'Veilig toelaten tot de weg – Lessen naar aanleiding van het ongeval met een Stint'*. 29398-845. Government document d.d. 16 juli 2020. Minister van Infrastructuur en Waterstaat, Den Haag.

[47]. Goede, M. de, Wijlhuizen, G.J. & Mons, C. (2020). *Voorstel voor een methode van risico-inventarisatie voor lichte elektrische voertuigen [Proposal for a method of risk assessment for light electric vehicles]*. R-2020-13 [Summary in English]. SWOV, Den Haag.

Colophon

URL Source:
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