TRAFFIC SAFETY OF ELECTRIC SCOOTER USERS: ANALYSIS OF OFFENCES AND CRASHES IN CROATIA AND SLOVENIA

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eSCURB: Electric scooters in urban environments: A study of safety, infrastructure, and mobility dynamics

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Contents

Ethical Declaration and Authorship Statement

We declare that this report is the result of the collective authorship of the project team. We declare that the report and its research was carried out in accordance with the principles of research, professional, and academic ethics, as well as with the requirements of the project, its funders, and the funding scheme. The project activities and its results were implemented within the framework of, and in compliance with, the project objectives, conditions, and the applicable rules of the funding agencies.

In preparing the project, we ensured the accuracy, traceability, and credibility of the presented data, consistently cited the sources used, and observed applicable legal and ethical standards. Appropriate scientific and professional sources were used in preparing the project report, and these are listed in the respective bibliographies or source lists. In doing so, we consistently respected copyright and the principles of proper source citation.

Generative artificial intelligence was also used as a support tool, exclusively for the following purposes:

- searching for and reviewing general information, especially for comparing information throughout sources and searching for statistical sources (tools: ChatGPT and Copilot);
- translating sources and texts from foreign languages and into foreign languages (primarily DeepL and Copilot);
- translating reports between Slovenian, Croatian, and English for reporting and inter-project communication purposes (primarily DeepL and Copilot);
- grammatical and stylistic proofreading of original texts created by the project team (tools: Grammarly and Copilot).

Generative artificial intelligence was not used for independently creating the substantive parts of the research or the project results, but solely as support in processing, understanding, and linguistically optimizing content, as well as for translation between the project languages.

ABSTRACT

This report presents a comparative analysis of electric scooter (e-scooter) safety, offences, and crash characteristics in Slovenia and Croatia. It focuses on understanding behavioural patterns, environmental conditions, and the role of infrastructure in shaping user safety. Data from Slovenian police records (2021–April 2025) and Croatian national crash statistics (2023–2024) were examined, complemented by hospital data from Slovenian emergency canters. The findings show a rapid increase in e-scooter use and related incidents in both countries, especially in urban areas and during warmer months. Most crashes occur on dry roads and in daylight, indicating that human behaviour, such as excessive speed, low helmet use, and occasional alcohol influence, is the predominant risk factor. Males dominate both offence and crash statistics, while younger riders are most frequently involved. Older riders, however, experience more severe injuries. Although Croatia records a higher proportion of severe and fatal injuries (27%) than Slovenia (about 16%), direct statistical comparison is not possible due to differences in data coverage, legal classifications, and reporting systems. The study highlights the urgent need for harmonized definitions, standardized data collection, and targeted safety measures, including stricter enforcement, mandatory helmet use, and infrastructure improvements to ensure safer and more sustainable e-scooter integration into urban transport systems.

1. INTRODUCTION

In recent years, the use of forms of micromobility has become widespread in cities around the world, with electric scooters being particularly prominent. They represent a fast, convenient and more environmentally friendly way of travelling short distances, especially in urban environments. E-scooters complement public transport, reduce dependence on private cars and offer an alternative to walking or cycling.

E-scooters represent a significant advance in urban mobility and have attracted attention primarily because of their potentially positive impact. Their key advantage is increased mobility and convenience for short-distance travel, which contributes significantly to reducing dependence on private cars. According to Kim and McCarthy, e-scooters also have a positive impact on the local economy, as they facilitate access to various establishments, including restaurants (Kim & McCarthy, 2023), which means that the use of e-scooters not only meets users' mobility needs but also stimulates economic activity in urban environments. This economic perspective is also confirmed by the findings of Yang and his colleagues, who, based on data from several American cities, showed that the use of e-scooters indicates consistent trends towards alternative forms of transport, which can help reduce traffic congestion (Yang, et al., 2023). Their study emphasizes that e-scooters often serve as a complement to other forms of transport and encourage users to choose e-scooters over private cars for shorter journeys. This shift in modes of transport contributes to a more sustainable urban environment by reducing the number of car journeys and the associated emissions.

In addition, the integration of e-scooter services has a positive impact on urban transport infrastructure. Speak and colleagues argue that greater access to e-scooters could improve the combination of transport options, especially in areas with poor public transport coverage (Speak, Taratula-Lyons, Clayton, & Shergold, 2023). E-scooters effectively address the "first and last mile" problem by making it easier for users to get from public transport stations to their final destinations. According to Castiglione et al. (Castiglione, Comi, Vincentis, Dumitru, & Nigro, 2022), electric micro-mobility vehicles, including e-scooters, can make a significant contribution to more sustainable urban logistics, particularly in parcel delivery systems with growing demand in e-commerce. This is also confirmed by the findings of Roig-Costa and colleagues, who describe changes in mobility strategies with the introduction of micro-mobility options and emphasise their role in complementing traditional means of transport (Roig-Costa, Marquet, Arranz-López, Miralles-Guasch, & Acker, 2024).

In the environmental field, e-scooters are recognised as a more sustainable alternative to conventional motor vehicles. Al-Habaibeh and colleagues conclude that electric scooters can make an important contribution to achieving sustainable urban goals by reducing air and noise pollution (Al-Habaibeh, Watkins, Shakmak, Javareshk, & Allison, 2024). Especially when used as a complement to public transport, they can make a significant contribution to reducing greenhouse gas emissions.

Statista shows the impact of carbon dioxide equivalent emissions from the use of e-scooters in 2022 compared to the mode of transport they replace. E-scooter users can reduce their carbon footprint (CO2e[1]) the most by replacing car travel with e-scooter travel. This substitution results in a reduction of CO2e emissions of 17.7 grams per passenger kilometre. However, replacing walking or cycling with e-scooter travel results in an increase in emissions of 16.1 and 1.7 grams, respectively (Statista, 2025).

E-scooters also have an impact on public health. Although there are safety concerns, their use encourages outdoor exercise, which can lead to increased physical activity among users and thus have positive health effects (Huang, 2021).

However, the introduction of e-scooters as a micro-mobility solution has also had several negative effects that require careful consideration. One of the most pressing challenges is the safety of both users and other road users, especially pedestrians. Research shows that a large proportion e-scooter users are unaware of local regulations regarding their use, including riding under the influence of alcohol or riding on pavements, which increases the risk of crashes and injuries for both users and other road users (Comer, et al., 2020). In addition, Krier and colleagues point out that e-scooters often replace journeys that individuals would otherwise make on foot or by public transport, which means that the environmental burden may even increase, as more sustainable modes of transport are being replaced by less efficient ones (Krier, Chrétien, Lagadic, & Louvet, 2021).

In addition to safety risks, traffic infrastructure is often inadequate, preventing the safe use of e-scooters. Glavić and his colleagues emphasise that poor infrastructure and low levels of perceived safety among users reduce their willingness to use e-scooters regularly as a normal mode of transport (Glavić, Trpković, Milenković, & Jevremović, 2021). Tuncer and his colleagues note that initial enthusiasm for e-scooters is often followed by public complaints and calls for regulation, reflecting friction between their introduction and existing urban transport systems (Tuncer, Laurier, Brown, & Licoppe, 2020). This indicates that while e-scooters offer greater flexibility in mobility, the lack of separate lanes and an appropriate regulatory framework often leads to conflicts with pedestrians and other road users, posing a safety threat.

The negative effects on public health are also significant. Emergency departments have recorded a marked increase in injuries related to the use of e-scooters, including serious trauma, which places a burden on the healthcare system (Sheikh, et al., 2022). Common injuries include head injuries, fractures and other serious medical complications, raising further questions about the safety of this form of transport (Shichman, Shaked, Factor, Weiss-Meilik, & Khoury, 2022).

From the perspective of safety and user behavior, the introduction of e-scooters into urban environments therefore raises important questions. Research emphasizes that

[1] Carbon dioxide equivalent.

although e-scooters enable affordable mobility and better community accessibility, safety behaviors related to their use remain under-researched, necessitating the development of policies tailored to these vehicles rather than simply transferring existing rules for bicycles (Neshagaran, Cherry, & Sanders, 2024).

In addition, Mura and co-authors believe that improving infrastructure and developing a robust regulatory framework are key to improving safety (Mura, Failla, Gori, Micucci, & Paganelli, 2022).

2. TRAFFIC SAFETY AND THE CONSEQUENCES OF TRAFFIC CRASHES INVOLVING E-SCOOTERS

Electric scooters, both shared and private, are becoming increasingly popular around the world, and their use continues to grow. Especially during the COVID-19 pandemic, e-scooters have become a key alternative to public transport for many people. Various benefits of these micromobility systems can be observed, such as social, health and environmental effects, improved connections between different modes of transport, and economic impacts (e.g. delivery services, new jobs). However, these benefits are accompanied by safety challenges, such as incorrectly parked scooters that endanger pedestrians (especially the elderly, blind people and wheelchair users), inexperienced drivers, feelings of insecurity due to crime, and an increased number of crashes and injuries (e.g. head injuries). As technology and user needs are changing rapidly, many organisations have begun to develop guidelines for managing micromobility. However, the available data and research tools are not keeping pace with the rapid growth in e-scooter use, and legislation is often inconsistent or lacking.

The growing popularity of electric scooters has led to an increase in injuries related to their use. Evidence shows that a large proportion of injuries related to electric scooters involve users who are predominantly male and younger. For example, research has shown that most injured users are younger than 40 years of age, with males accounting for a higher proportion of injuries than females (Cittadini, Aulino, Petrucci, Valentini, & Covino, 2022), (Farley, et al., 2020).

In terms of the nature of injuries, head injuries are particularly common among electric scooter users, with approximately 33% to 40% of those injured suffering this type of injury (Namiri, Lee, Amend, Vargo, & Breyer, 2021), (Farley, et al., 2020). This is also contributed to by low helmet use; reports indicate that only 2% to 4.8% of users were wearing a helmet at the time of the crash (Namiri, Lee, Amend, Vargo, & Breyer, 2021) and (Liew, Wee, & Pek, 2020)). Findings indicate that in falls or collisions involving electric scooters, in addition to the head, the upper and lower extremities are also exposed, while chest and abdominal injuries are less common (Toofany, Mohsenian, Shum, Chan, & Brubacher, 2021).

In addition, there is a significant association between alcohol consumption and injury severity, as younger users under the influence of alcohol are associated with a higher incidence of serious injuries compared to sober users (Namiri, Lee, Amend, Vargo, & Breyer, 2021), (Suominen, et al., 2022).

Another important group affected by injuries related to electric scooters are pedestrians. Research shows that a significant proportion of crashes involve collisions with pedestrians, who are at risk both from collisions and from improperly parked scooters obstructing crossings (Kleinertz, et al., 2023; Uluk, et al., 2021).

Regardless of the method and database used, traffic crashes involving e-scooters result in significant economic and social costs, in addition to injuries, trauma and other negative social impacts. From a health perspective, the financial burden of crashes involving e-scooters is increasingly reflected in the strain on health systems. A study in New Zealand showed that the total cost attributed to injuries caused by e-scooters in the Auckland area amounted to NZD 1,303,155[2], with an estimated average cost per injury of NZD 1,693 and an average cost per shared e-scooter of NZD 1,300 (Bekhit, Le Fevre, & Bergin, 2020). Similarly, a study involving 21 injured individuals (e-scooter falls) who required a total of 23 surgeries showed that the costs for anaesthesia, operating rooms, and personnel amounted to USD 162,901. The cost of implants needed to fix the fractures was $39,898. Treatment required 93 hospital nights and 61 follow-up visits, resulting in additional costs of $141,639 and $16,119, respectively. The total cost of these 23 cases was $360,557. The extrapolated loss of income due to these injuries was $44,368. The total economic cost was thus $404,925 or 19,282 USD per person (Campbell, Wong, Monk, Munro, & Bahho, 2019). The results of a study by Vasara et al. conducted for the Helsinki area showed that, including hospital treatment costs and lost work time, the total cost of electric scooter injuries is €1.7 million, with the median cost of a single crash being €1,148 (interquartile range €399–4,263) (Vasara, et al., 2022). A study by Lavoie-Gagne and colleagues showed that the average total billed cost for clinical treatment related to e-scooter crashess was US$95,710. The average cost billed to insurance companies was $86,376 for hospital costs and $9,334 for healthcare professional services (Lavoie-Gagne, et al., 2021).

Researchers use different methodological approaches to determine injuries related to e-scooters. The main sources of data are (National Academies of Sciences, Engineering, and Medicine, 2023):

- Hospital records;
- Databases on injuries and crashess;
- Emergency medical services;
- Self-reported surveys;
- Police records and insurance data.

The most common method is to search for injury codes in various databases, but many countries do not yet have specific codes for e-scooter riders, which means that researchers often search for keywords such as "e-scooter" within medical records.

This leads to various challenges in terms of accuracy (National Academies of Sciences, Engineering, and Medicine, 2023):

- Some records include other modes of transport (e.g., motor scooters) and are not specific to micromobility.
- Due to different local regulations, the same type of injury may be classified differently.

[2] 1 NZD = 0.52 € (22 June 2025)

The same applies to Slovenia, where emergency centres often treat people injured while riding e-scooters as part of a broader group, such as scooters. Even the Slovenian police, which keeps statistics on traffic crashes, does not identify e-scooter riders as a specific ID, but classifies them in the group of light motor vehicle drivers.

3. OVERVIEW OF E-SCOOTER SAFETY STATISTICS ACROSS EUROPE

3.1 Introduction

The expansion of urban micro-mobility has given cities new ways to ease congestion on the road network and to promote increased engagement in active transport [1, 2]. E-scooters have become a common mode of urban micro-mobility, used for both private trips and shared rental services. Their popularity is linked to their efficient electric motors, their ability to move easily through different types of urban infrastructure [3, 4], and their flexibility for parking without relying on designated parking areas. The growing popularity of this mode of travel necessitates a closer examination of rider behaviour to address emerging safety challenges. E-scooter use has increased rapidly across the European Union (European Transport Safety Council, 2024). This growth in usage has been accompanied by a clear rise in reported crashes, serious injuries, and fatalities involving e-scooters across EU countries (European Transport Safety Council, 2024). Evidence from European Union studies consistently shows that most e-scooter crashes are single-user incidents, rather than collisions with other road users (Stormann et al., 2020; Suominen et al., 2022; Benhamed et al., 2022; Cittadini et al., 2022; Vasara et al., 2022). In Germany, single-user crashes accounted for 92.1% of cases (Stormann et al., 2020), while similar proportions were reported in Finland (92.3%) (Suominen et al., 2022), France (83.2%) (Benhamed et al., 2022), and Italy (94.6%) (Cittadini et al., 2022). Across these studies, collisions with vehicles or other road users were generally below 20%, indicating that interactions with traffic are not the dominant crash mechanism in EU contexts (Stormann et al., 2020; Benhamed et al., 2022; Kleinertz et al., 2023).

Injury distribution data from European Union countries indicate a high prevalence of head injuries among e-scooter riders (Kleinertz et al., 2021; Stigson et al., 2021; Suominen et al., 2022; Gan-El et al., 2022). In several studies conducted in Germany, Sweden, Belgium, and Finland, head injury proportions exceeded 40%, demonstrating a consistent injury pattern across these regions (Stigson et al., 2021; Gan-El et al., 2022; Vasara et al., 2022). Data from Finnish trauma centres further indicate that head injuries are frequently associated with alcohol intoxication, underscoring the critical influence of rider condition on crash severity (Suominen et al., 2022). Upper-limb injuries are also commonly reported and, in some studies, represent the most frequent injury type, likely due to riders' instinctive attempts to break falls with their arms (Graef et al., 2021; Uluk et al., 2022; Benhamed et al., 2022). For instance, upper-limb injury rates exceeded 50% in studies from Germany, Belgium, and France (Graef et al., 2021; Gan-El et al., 2022; Benhamed et al., 2022). These findings indicate that loss of balance and sudden falls are central mechanisms underlying many e-scooter crashes in EU countries (Uluk et al., 2022; Kleinertz et al., 2023). Lower-limb injuries display greater variability across EU studies, with proportions ranging from moderate to very high depending on study focus and sample characteristics (Oksanen et al., 2020; Suominen et al., 2022; Lentzen et al., 2021). In Finland, some studies reported lower-limb involvement in up to 65–100% of cases, highlighting differences in injury classification and crash scenarios (Oksanen et al., 2020; Suominen et al., 2022). Facial and craniofacial injuries are also notable in several EU countries, particularly Germany and France, which raises additional concerns regarding low helmet use (Graef et al., 2021; Benhamed et al., 2022; Leyendecker et al., 2023).

To place the findings of this report in a broader international context, Table 1 provides an overview of selected studies from different European countries, summarising injury mechanisms in e-scooter crashes and highlighting the predominance of single-user incidents compared to collisions with other road users.

Table 1. Injury type and mechanism of e-scooter riders

Author(s)	Country	Data source	Sample size	Single-user (%)	Collision (%)
Stormann et al. (2020)	Germany	2 trauma centres	76	92.1	7.9
Kleinertz et al. (2021)	Germany	1 trauma centre	89	79	2
Coelho et al. (2021)	Spain	1 trauma centre	397	95.5	4.5
Stigson et al. (2021)	Sweden	Insurance data	321	83	17
Graef et al. (2021)	Germany	1 trauma centre	43	41.9	2.3
Uluk et al. (2022)	Germany	4 trauma centres	248	90	10
Hennocq et al. (2020)	France	2 trauma centres	125	–	–
Nielsen et al. (2021)	Denmark	1 trauma centre	49	94	6
Blomberg et al. (2019)	Denmark	emergency medical service	130	91.1	8.9
Oksanen et al. (2020)	Finland	1 trauma centre	23	–	–
Gan-El et al. (2022)	Belgium	1 trauma centre	170	84.5	5.3
Moftakhar et al. (2021)	Austria	Multicentre	175	–	–
Benhamed et al. (2022)	France	Multicentre	825	83.2	16.8
Vasara et al. (2022)	Finland	3 trauma centres	446	83.9	9
Kowalczewska et al. (2023)	Poland	1 trauma centre	31	–	–
James et al. (2023)	France	26 trauma centres	229	–	–
Cittadini et al. (2022)	Italy	1 trauma centre	92	94.6	3.2

Leyendecker et al. (2023)	Germany	1 trauma centre	97	–	–
Kleinertz et al. (2023)	Germany	1 trauma centre	268	80	10
Murros et al. (2023)	Finland	1 trauma centre	45	97.8	2.2

3.2 Analysis of collision data

This section gives an overview of collisions and casualties involving e scooter in various EU countries, where the data are available.

3.2.1 Germany

Table 2 indicates that e-scooter users accounted for a minor share of total road traffic casualties in Germany during 2021 and 2022. Fatalities among e-scooter riders totaled 15 cases, representing 0.3% of all road user deaths. In contrast, e-scooter users accounted for a greater proportion of non-fatal injuries, comprising 1.7% of serious injuries and 1.8% of slight injuries.

Table 2. Number of people injured by severity, Germany 2021 and 2022 (Statistisches Bundesamt (Destatis), 2024)

Road user type	Killed		Serious		Slight		Total	
E-scooters	15	0.3%	1,886	1.7%	10,413	1.8%	12,314	1.8%
All road users (100%)	5,350	100.0%	112,864	100.0%	571,399	100.0%	689,613	100.0%

Table 3 shows that most e-scooter fatalities occurred within built-up areas, representing 60% of deaths, while 40% occurred outside these areas. No fatalities were reported on motorways or freeways. Non-fatal injuries exhibited a similar distribution. Serious injuries were predominantly concentrated within built-up areas (94%), with only 6% occurring elsewhere. Slight injuries followed the same trend, with 97% recorded inside built-up areas and a minimal proportion occurring outside built-up areas or on motorways.

Table 3. Number of people injured by severity, and road user type, Germany 2021 and 2022

–		Inside built-up areas		Outside built-up areas		On motorways/ freeways		Total (100%)
E-scooters	Killed	9	60%	6	40%	-	0%	51,074
	Seriously injured	1,767	94%	119	6%	-	0%	15
	Slightly injured	10,085	97%	325	3%	3	0%	1,886
	Total	11,861	96%	450	4%	3	0%	10,413

3.2.2. Italy

National statistics indicate that Italy recorded 3,159 road traffic fatalities in 2022, with e-scooter users comprising only 0.5% of this total (Istat, 2023). The majority of injuries resulting from e-scooter collisions involved riders or passengers, who accounted for 97% of all injured individuals. Pedestrian involvement in e-scooter collisions remained limited; in 2022, pedestrians accounted for 4.5% of injuries in e-scooter-related crashes, compared to 3.1% for e-bikes and 2.4% for pedal cycles (Istat, 2022; Istat, 2023).

3.2.3 Great Britain

Police-recorded collision statistics demonstrate a significant increase in e-scooter-related casualties in Great Britain from 2020 to 2022. Table 4 reports 3,410 casualties resulting from e-scooter collisions during this period. The number of casualties increased from 484 in 2020 to 1,434 in 2021, and further to 1,492 in 2022, reflecting a consistent upward trend in reported e-scooter involvement in road traffic collisions.

Table 4. Reported casualties in collisions involving an e-scooter, GB 2020-2022 by year (DfT, 2023)

Year	Number of reported casualties in e-scooter collisions
2020	484
2021	1,434
2022	1,492
Total	3,410

Further disaggregation by road user type and injury severity (Table 5) shows that e-scooter users accounted for the majority of casualties associated with these collisions. Specifically, e-scooter users comprised 2,635 casualties, including 22 fatalities, 792 serious injuries (adjusted), and 1,821 slight injuries (adjusted). In comparison, the total number of casualties recorded across all road users in e-scooter-related collisions was 3,410.

Table 5. Reported e-scooter casualties, GB 2020-2022 by road user type and severity

Road user type	Killed	Serious (Adjusted)	Slight (Adjusted)	Total
E-Scooter users	22	792	1,821	2,635
Total	23	989	2,398	3,410

Factsheets provided by the Department for Transport (DfT) for 2020 (DfT, 2021), 2021 (DfT, 2022) and 2022 (DfT, 2023) breakdown the number of casualties by road user group (Table 32). Factsheets provided by the Department for Transport (DfT) for 2020 (DfT, 2021), 2021 (DfT, 2022) and 2022 (DfT, 2023) broke down the number of casualties by road user group (Table 5). Supplementary information from the 2022 factsheet provides additional insight into collision characteristics. Of the 1,401 recorded e-scooter collisions in 2022, 341 involved no other vehicles or pedestrians, indicating a substantial proportion of single-vehicle incidents. The majority of casualties were male (77%), with most individuals aged between 10 and 39 years. The most frequently reported serious injuries included head injuries, fractures of the upper extremities (arm, collarbone, and hand), and fractures of the lower extremities (lower leg, ankle, and foot). Evidence suggests that official police statistics substantially underestimate the true burden of e-scooter-related injuries. A comparative analysis conducted by the Parliamentary Advisory Council for Transport Safety (PACTS, 2023), which examined police-recorded collision data (STATS19) alongside hospital records, found that fewer than 10% of casualties presenting to emergency departments following e-scooter collisions were captured in official statistics. Moreover, only approximately one quarter of the most seriously injured individuals were recorded in both police and hospital datasets, highlighting significant limitations in the completeness of reported e-scooter casualty data.

3.3 Relative risks

An analysis based on emergency department attendance data and travel survey information from Oslo, Norway, assessed the injury risk associated with e-scooter use in traffic-related incidents (Bjerkan, Engebretsen, & Steinbakk, 2021). The analysis excluded collisions occurring on paths or off-road locations and expressed risk estimates per million person-kilometres travelled. As presented in Table 6, the overall risk of injury for e-scooter users was estimated at 112.969 injuries per million person-kilometres. When examined by injury severity, the estimated risks were 76.754 for slight injuries, 27.161 for moderate injuries, and 9.054 for severe injuries per million person-kilometres. These estimates indicate a substantial injury burden associated with e-scooter use when exposure is taken into account.

Table 6. Risk of injury to bicycle, e-scooter and EPAC users, Oslo, 2019 (Bjerkan, Engebretsen, & Steinbakk, 2021)

-	E-scooter injuries per million-person km
Risk of injury (all severities)	112.969
Risk of slight injury	76.754
Risk of moderate injury	27.161
Risk of severely injured	9.054

The International Transport Forum (ITF) report on safer micromobility provides estimates of the number of shared e-scooter casualties requiring medical treatment per million trips for selected European countries (ITF, 2024). These data, presented in Table 7, cover 2021 and 2022 and pertain exclusively to shared e-scooter schemes. The findings indicate considerable variation in casualty rates between countries and reveal differing temporal trends. For example, Austria, Finland, Italy, and Norway experienced declines in casualty rates between 2021 and 2022, while the Czech Republic, Denmark, France, Portugal, and

Switzerland reported increases. In the United Kingdom, the casualty rate decreased from 31.9 to 20.6 per million trips, yet remained higher than in most other countries. The ITF advises caution in interpreting these differences, as the data reflect only shared e-scooter use and exclude private e-scooter travel. Differences in national regulations, reporting practices, usage levels, and exposure likely contribute to the observed disparities. The report suggests that reductions in some countries may be partially attributable to enhanced safety measures implemented by operators and users. Specifically, the decline in Italy has been associated with recent mandatory technical upgrades to shared e-scooters, such as the addition of front and rear brakes and direction indicators. The ITF further notes that limited data on e-scooter casualties and exposure outside shared schemes restricts the ability to draw comprehensive conclusions regarding overall e-scooter safety risk across countries.

Table 7. Shared e-scooter casualties requiring medical treatment per Mio trips (ITF, 2024)

Country	2021	2022
Austria	4.1	1.5
Belgium	7.1	7.0
Czech Republic	9.2	15.6
Denmark	8.6	14.8
Finland	5.0	2.9
France	9.0	12.1
Germany	4.3	4.0
Italy	12.1	4.4
Norway	3.2	2.7
Poland	4.9	4.5
Portugal	22.3	25.0
Spain	22.4	14.8
Sweden	5.2	5.3
Switzerland	2.2	4.4
UK	31.9	20.6

3.4 Discussion

Road conditions significantly influence the occurrence of e-scooter crashes. Poor road surfaces, including potholes and uneven pavement, are associated with approximately 30–40% of reported e-scooter crashes (ITF, 2024). This finding indicates that e-scooters are particularly sensitive to surface quality. A review of media reports on fatal e-scooter incidents determined that pedestrian fatalities are rare (ITF, 2020). Most fatal cases involved e-scooter riders, most often in collisions with larger vehicles. Numerous studies further indicate that most e-scooter crashes are single-vehicle incidents. A meta-analysis found that approximately 93% of e-scooter injuries resulted from single-vehicle crashes, primarily due to falls or loss of control (Toofany et al., 2021; ITF, 2024). However, official police data, such as the UK STATS19 database, report fewer single-vehicle crashes. This discrepancy is likely attributable to under-reporting, as crashes not involving other vehicles are less frequently documented.

An evaluation of e-scooter trials in Great Britain found that most e-scooter users were male (71%) and under 35 years of age (74%) (Dillon, 2022). Men and younger individuals were also more likely to frequently rent e-scooters. The primary motivations for e-scooter use included time and cost savings, convenience, and enjoyment. Despite these factors, surveys of residents in trial areas indicated limited public acceptance. Approximately 63% of respondents reported no interest in using e-scooters, and 46% expressed safety concerns. A narrative review of the literature identified common behaviours among e-scooter riders, including riding with more than one person, low helmet use, alcohol or drug use, mobile phone use while riding, riding on footpaths, and travelling against the flow of traffic (Laverdet, 2023). Most of these findings were derived from small observational studies. Evidence regarding crash mechanisms was inconsistent: some studies reported frequent collisions with other vehicles, while others identified falls as the primary cause of injury. In both scenarios, injuries most commonly affected the head and the upper or lower limbs.

A retrospective study at three hospitals in Brisbane examined injuries among emergency department patients (Vallmuur, 2023). Of the 1,048 cases reviewed, 91% involved e-scooter riders. Data on helmet use, alcohol involvement, and speed were not consistently recorded. Among cases with available information, 28% of riders wore a helmet, while 16% did not. Alcohol involvement was identified in 27% of cases, and over one-third of riders traveled at speeds of 20 km/h or higher. Fractures represented 37% of injuries, and cuts or open wounds accounted for 23%. The most frequently injured body regions were the head and face (27%) and the upper limbs, including arms and hands. The consistency of these findings across multiple EU countries indicates a shared safety profile, despite variations in national regulations and infrastructure (Stigson et al., 2021; Vasara et al., 2022; Benhamed et al., 2022). These crash statistics highlight the need for safety measures targeting helmet use, intoxication prevention, speed control, and fall-risk reduction, rather than focusing solely on vehicle separation strategies (Suominen et al., 2022; Leyendecker et al., 2023).

4. METHODOLOGY AND DATA SOURCES

The research methodology is based on data obtained from the police in Slovenia and Croatia and emergency centres of Slovenian hospitals. In contrast to data from Slovenia, which included information on traffic offences, road crashes involving e-scooter riders and medical records, the Croatian dataset used in this chapter is exclusively limited to recorded road crashes.

4.1 Data from the police

In Slovenian legislation, e-scooters are defined as light motor vehicles. This is stipulated in Article 3(1)(15a) of the Road Traffic Rules Act (ZPrCP), which classifies light motor vehicles as "motor-driven vehicles with a maximum design speed not exceeding 25 km/h, are no wider than 80 cm and are exempt from the scope of Regulation (EU) No 168/2013" (Road Traffic Act, 2011). Consequently, traffic crashes involving e-scooter users are classified in statistics and treated as crashes involving light motor vehicles. This classification affects both the way offences are dealt with and the analysis of road safety. The provisions on the technical characteristics and classification of such vehicles are supplemented by the provisions of the Motor Vehicles Act (ZMV-1).

Based on a request for research by the police, we received data on offences and traffic crashes from the General Police Administration. Both sets of data cover the period from 2021 to April 2025 (status at the time of receipt of the data).

The data on offences includes:

- The offence code;
- Reference to the law related to the offence and the type of violation (link to the article of the law)
- Year, date and time of the offence;
- Type of road/settlement;
- Location and street/house number, and description of the location;
- Gender and age;
- Nationality;
- Number of offences.

Offences are therefore linked to laws and the type of violation within the law. The laws to which the offences detected refer to are:

- Road Traffic Act;
- Criminal Code;
- Motor Vehicles Act;
- The Identity Card Act;
- Drivers Act;
- Aliens Act;

- State Border Control Act;
- Public Order and Peace Protection Act;
- Act on the Production and Trafficking of Illicit Drugs;
- Compulsory Insurance Act;
- Roads Act;
- Nature Conservation Act;
- Personal Name Act.

Within these acts, individual offences are divided into so-called violations (example ZPC1/45/6//1, representing the Road Traffic Rules Act and referring to a violation of the first paragraph of Article 45 of the ZPrCP, which in this case carries a fine of €40): ZPC1/97/6//2, ZPC1/97/7//5, ZPC1/45/6/1/, ZPC1/105/3/2/1B, ZPC1/42/3//2, ZPC1/37/4//2, ZPC1/35/4//1, ZPC1/97/6//1, KZ12/323/1//, ZPC1/83/9//3, ZPCF/37/4//2, ZPC1/37/4//3, ZPCF/105/4/3/2, ZPCF/45/6/1/, ZPCF/97A/9//1, ZPCF/42/3//1, ZMV1/41/5//1, ZPCF/105/4/4/2, ZPCF/34/5//1, ZPC1/107/12/B/10, ZPCF/42/3//2, ZPCF/110/6/5/2, ZPCF/105/4/2/2, ZPCF/107/12/A/10, ZPCF/37/4//3, ZPCF/106/3//1A, ZPCF/37/5//2, ZPCF/97A/9//5, ZPCF/97/5//1, ZPCF/97A/9//6, ZPCF/35/4//1, ZPCF/56/2//, ZPCF/37/4//1, ZPCF/45/10//1, ZPCF/107/12//3A, ZPCF/97A/10//8, ZPCF/110/6/10/2, ZPCF/99/10/1/1, PCF/98/2//1, ZPCF/99/8//1, ZPCF/56/3//, ZPCF/97A/9//4, ZPCF/45/6/2/, ZPCF/44/4//2, ZPCF/105/3/4/1A, ZPCF/110/6/6/2, ZPCF/34/5//, ZPCF/58/6//1, ZMV1/18/5/C/4, ZPC1/56/2//, ZPCF/42/4//1, ZMV1/25/6//1A, ZOI1/24/1/1/, ZPCF/65/5//3, ZMV1/25/6//3, ZPCF/44/4//1, ZPCF/52/3/1/1, ZPCF/93/11//4, ZPCF/50/4//1, ZPCF/93/11//7, ZPCF/93/11//9, ZPCF/93/11//1, ZPCF/37/5//3, ZPCF/58/6//2, ZPCF/95/10//1, ZPCF/53/6//, ZPCF/37/5//1, KZ08/323/1//, ZPCF/71/9//2, ZPCF/105/3/3/1A, ZPCF/53/7//1, ZVZ1/56/8//1C, ZVOD/56/8//1C, ZPCF/83/9//7, ZPCF/107/12//3C, ZPCF/107/12/C/10, ZPCF/31A/4//2, ZPCF/45/10//2, ZPCF/92/13//2, ZPCG/105/4/4/2, ZPCG/37/4//3, ZPCF/33/5//1A, ZT21/144//5/,ZPCF/88/17//1,ZND2/45//11/, ZPCF/65/6/18/4, ZMV1/35/6//5, ZT11/147/3//1, ZPCF/16/5//1, ZT21/143//5/, ZT21/143//4/, ZPCF/35/5//1, ZPCF/97/5//2, ZPCF/71/8//4, ZPCF/46/7/2/, ZPCF/99/9/3/1, ZPCF/99/9/5/1, ZPCF/71/8//6, ZPCF/92/13//3, ZPCG/45/6/1/, ZPC1/35/5//1, ZVJR/22/1//, ZPC1/99/8//1, ZPC1/46/6/4/, ZPC1/27/9//, ZPCF/27/9//, ZPCF/30/24//1, ZVJR/7/2//, ZPCF/105/3/2/1A, ZPCF/107/12/B/10, ZPCF/32/3//1, ZMV1/25/6//1C, ZPCF/101/10/3/3, ZPDR/33/2//, ZPCF/97A/9//7, ZMV1/25/7//1C, ZPCF/46/8/2/, ZPCF/46/6/2/, ZPCF/46/8/4/, ZPCF/44/5//1, ZOZ2/46///, ZPCF/88/17//14, ZPCF/99/10/6/1, ZPCF/46/6/1/, ZPCF/74/8//1, ZPCF/46/8/3/, ZPCF/46/6/3/, ZMV1/25/10//2, ZPCF/95/10//8, ZPCF/27/8//, ZPCF/74/7//, ZMV1/18/6/C/1, ZPCF/46/7/1/, ZPCF/52/5/3/1, ZCE2/35/3A/2/1, ZPCF/93/11//3, ZPCF/99/9//5, ZPCF/42/4//2, ZPCF/46/7/4/, ZPCF/40/3//2, ZPCF/46/6/4/, ZVJR/6/1//, ZMV1/49/7//, ZPCF/38/7//2, ZOI1/23/1/1/, ZPCF/35/4//2, ZMV1/41/4//2, ZPCF/30/25//5, ZPCF/38/7//1, ZPCF/50/5//3, ZVJR/7/1//, ZPCF/45/9/1/, ZPCF/65/5/8/4, ZONC/161/4//, ZOSN/24/1//, ZPCF/46/5/2/, ZPCF/7/3//, ZMV1/25/6//1D, ZMV1/41/4//1, ZPCF/46/7/6/, ZPCG/37/5//1, ZPCG/97A/9//1, ZPCG/37/4//2, ZPCG/105/4/3/2, ZPCG/34/5//1, ZPCG/107/12/A/10.

During the aforementioned period (2021 - April 2025), the police recorded a total of 3,345 offences committed by drivers of light motor vehicles. These data will be included in the analysis with the restriction that this group includes not only e-scooter drivers but also drivers of light motor vehicles with a maximum design speed not exceeding 25 km/h and a width not exceeding 80 cm.

Traffic crash data includes:

- Date and time of the crash;
- Location of the crash: in a settlement, type of road/settlement, location, stc/hš, hd and description of the location the crash;
- Cause of the traffic crash;
- Type of traffic crash;
- Information about the weather, traffic, condition and type of road surface;
- Information about the perpetrator/participant: gender, age, nationality, injury, breathalyser test result, medical examination result. Overview.

During the period (2021-April 2025), the police recorded a total of 905 traffic crashes involving drivers of light motor vehicles3. These data will be included in the analysis with the caveat that this group includes not only e-scooter drivers but also drivers of motorised vehicles with a maximum design speed of 25 km/h and a width of no more than 80 cm.

Croatian data are based on officially available national road crash data (collected by the Ministry of the Interior). The analysis focuses on the period 2023–2024, which represents the most recent years for which harmonised and sufficiently detailed data on micromobility users are available at the time of report preparation. The used data were obtained from official Croatian police crash databases, collected and processed in accordance with national reporting procedures. These databases include information on crashes involving so-called personal mobility devices, which are legally defined as a vehicle category under Croatian road traffic legislation.

According to the Road Traffic Safety Act ("*Zakon o sigurnosti prometa na cestama*"), Article 2, paragraph 1, item 104, a personal mobility device is defined as a vehicle that is not classified into any other vehicle category under specific regulations, has no seating position, has an engine displacement not exceeding 25 cm^3 or a continuous electric motor power not exceeding 0.6 kW, and is not capable of exceeding a speed of 25 km/h on a flat road, i.e. whose maximum design speed does not exceed 25 km/h. This category includes self-balancing vehicles, motor- or electric-powered unicycles, and motor- or electric-powered scooters, among others.

Although this legal category encompasses several types of vehicles, electric scooters are the most prevalent form of personal mobility device in real-world traffic. In the statistical tables, it is not possible to disaggregate electric scooters as a standalone vehicle type, except when the vehicle model was specified. For this report, all relevant crashes are recorded under the broader category of personal mobility devices (code 58).

Consequently, the analyses presented in this chapter rely on this aggregated category, while acknowledging that electric scooters account for most cases. By focusing on the 2023–

2024 period and using the legally defined category of personal mobility devices, this chapter aims to provide a realistic and data-driven overview of e-scooter rider safety in Croatia, while clearly outlining the legal and statistical framework that shaped the final analytical sample.

4.2 Data from emergency centres in Slovenian hospitals

Data on injured e-scooter riders collected in emergency centres of Slovenian hospitals are an important source of information for a more comprehensive understanding of the consequences of using e-scooters in traffic. E-scooter riders often travel on surfaces that are not defined as public traffic areas, which means that any crashes are not treated as traffic crashes and are therefore not included in official police records. In addition, in many cases, injured e-scooter riders seek treatment on their own without reporting the incident to the police. As a result, such crashes remain outside official databases, which reduces the reliability and completeness of statistical analyses based solely on police sources.

To supplement the data on the safety of e-scooters, we therefore asked the emergency centres of Slovenian hospitals to provide anonymised data on injured persons who sought medical assistance due to injuries related to a fall or crash involving an e-scooter. This database includes all persons involved in crashes with light motor vehicles. This means that sometimes an individual appears in the database as a Participant and not as a Causer. We will discuss the basic analyses on the basis of the person, and the additional analyses from the perspective of the causers, providing insight into the extent and type of injuries that are not covered by official police traffic statistic and contribute to a better understanding of the risks associated with the use of e-scooters.

We sent requests to the following hospitals with emergency departments:

- Celje General Hospital;
- Izola General Hospital;
- Jesenice General Hospital;
- Brežice General Hospital;
- Ljubljana Clinical Centre;
- Trbovlje General Hospital;
- Dr. Jože Potrč Ptuj General Hospital;
- University Medical Centre Maribor;
- Murska Sobota General Hospital;
- Dr. Franc Derganc General Hospital;
- Novo Mesto General Hospital;
- Slovenj Gradec General Hospital.

We also requested data from the University Rehabilitation Institute of the Republic of Slovenia Slovenia Soča.

We received responses only from:

- Celje General Hospital, which provided us with data on the number of cases since 2014 onwards.
- Jesenice General Hospital responded with a message stating that they cannot provide the requested data, as they only record the cause of injury as a fall from a scooter and do not keep records of whether the scooter was regular or electric. Unfortunately, we did not receive a response after requesting that the combined data be provided.
- The Dr. Jože Potrč Ptuj General Hospital stated that only the time of injury is recorded for injured persons, while all other data is kept in medical records and cannot be accessed.
- Brežice General Hospital, which provided general information on the number of injured persons.

The Ljubljana Clinical Centre, which kindly shared a database containing:

- Description of diagnosis;
- Diagnosis (code);
- Description of diagnosis;
- Method of arrival (1 Helicopter, 2 - Ambulance, 3- Other, 9-Unknown);
- Time of injury;
- Place of occurrence;
- Amount of treatment.

5. ANALYSES OF VIOLATIONS AND TRAFFIC CRASHES INVOLVING LIGHT MOTOR VEHICLES AND E-SCOOTERS

In this chapter, we will examine the state of traffic safety in relation to the use of electric scooters in Slovenia and Croatia. We will pay particular attention to the analysis of offences, traffic crashes and injuries resulting from the use of e-scooters. Based on police data, we will analyse offences and crashes in the period from 2021 to April 2025 in Slovenia and 2023 do 2024 in Croatia, while data obtained from the emergency centres of Slovenian hospitals will shed light on the health consequences of crashes that are not covered by official traffic statistics.

5.1 Offences involving light motor vehicles and e-scooters in Slovenia (2021–April 2025): Analysis of police data

During the period analysed (2021–April 2025), 3,345 offences were recorded in police records (in some cases, the same person committed multiple offences; however, this analysis will focus on offences rather than individuals) committed by drivers of light motor vehicles. When interpreting these data, a methodological limitation must be taken into account, as the category "light motor vehicles" includes a wider range of means of transport, which, in addition to electric scooters, also includes other motorised vehicles with a design speed not exceeding 25 km/h and a width not exceeding 80 cm. As a result, the data does not allow for a precise distinction between different types of vehicles, which poses a challenge when focusing exclusively on e-scooters. Nevertheless, the range of offences provides an insight into the typical types of violations associated with the use of such means of transport on public traffic areas.

It is also important to note that, in accordance with the law, e-scooters (as motor vehicles in road traffic) may be driven by persons over the age of 14, or children between the ages of 12 and 14, only if they have a valid bicycle licence.

5.1.1 Descriptive analysis of data on offences

A total of 3,345 individual records of violations were examined in the analysis. Individual offences are linked to the law to which the offence relates. Of the 3,345 valid cases, as many as 94.5% (3,161 cases) were dealt with based on the Road Traffic Act, which clearly shows that this Act is by far the most frequently violated in the cases examined. It is followed by the Motor Vehicles Act with 2.4% (79 cases) and the Identity Card Act with 1.1% (36 cases). Other laws appear much less frequently. For example: the Criminal Code was applied in 0.3% of cases (9 cases), the Public Order and Peace Act in 0.7% of cases (24 cases), while laws such as the Aliens Act, the Drivers Act, the Compulsory Insurance in Transport Act and others are represented by less than 0.5%.

Below is a list of offences related to the law (mentioned above) and more detailed information about the type of violation. The analysis covered 3,281 valid cases, with 64 values missing. The most common offence was ZPCF/97A/9//1 (Road Traffic Act, conditions for the participation of light motor vehicles in road traffic, (9) A fine of EUR 40 shall be imposed on a driver of a light motor vehicle who acts contrary to the provisions of the first, fourth, fifth, sixth or seventh paragraph of this Article), which accounted for 17.8% of all valid offences, followed by ZPCF/37/4//2 (Road Traffic Act, driving a vehicle on the road; (4) A fine of EUR 40 shall be imposed on a driver who does not require a driving licence and who acts contrary to the provisions of this Article) (11.9%) and ZPCF/34/5//1 (Road Traffic Rules Act, protective helmet, (5) A fine of EUR 120 shall be imposed for an offence committed by: 1. a driver or passenger on a bicycle, light motor vehicle, moped, light quadricycle, motorcycle, tricycle or quadricycle without an enclosed cabin who acts contrary to the provisions of the first or third paragraph of this Article) (10.0%). These three together account for almost 40% of all offences considered, which indicates a marked concentration of certain types of offences.

The number of offences is increasing year on year (Figure 1).

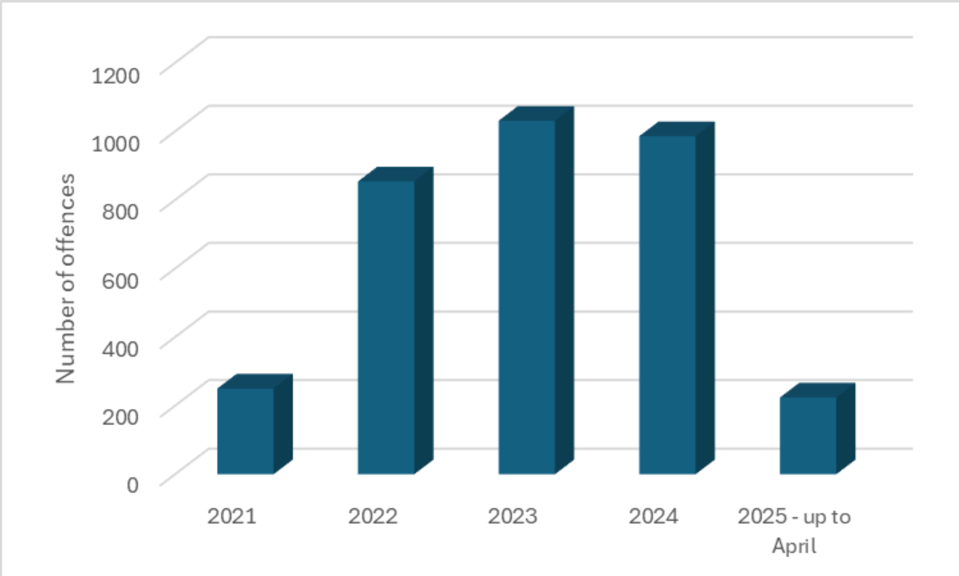

Figure 1. Number of offences in each year (2025 only includes data up to 13 April) (N = 3345)

The data includes a total of 3,345 recorded cases of offences in the period 2021–April 2025 (Figure 1). The highest number of cases was recorded in 2023, namely 1,031 (30.8%), followed by 2024 with 986 cases (29.5%). Together, these two years account for more than 60% of all cases considered, indicating increased reporting or an actual increase in the number of incidents in recent years. The year 2022 accounts for 25.5% of cases, while relatively few events were recorded in the initial year of 2021 (7.5%), which may be related to the start of monitoring or reporting. For 2025, the share is lower (6.7%), but it should be noted that the data only covers the period up to 13 April 2025, when the database was received, and is therefore not comparable with other years, which cover the whole year.

Offences involving light motor vehicles, including e-scooters, occur throughout the year, but there is a slight decrease in the colder months, as the use of these vehicles is also lower at that time (Figure 2).

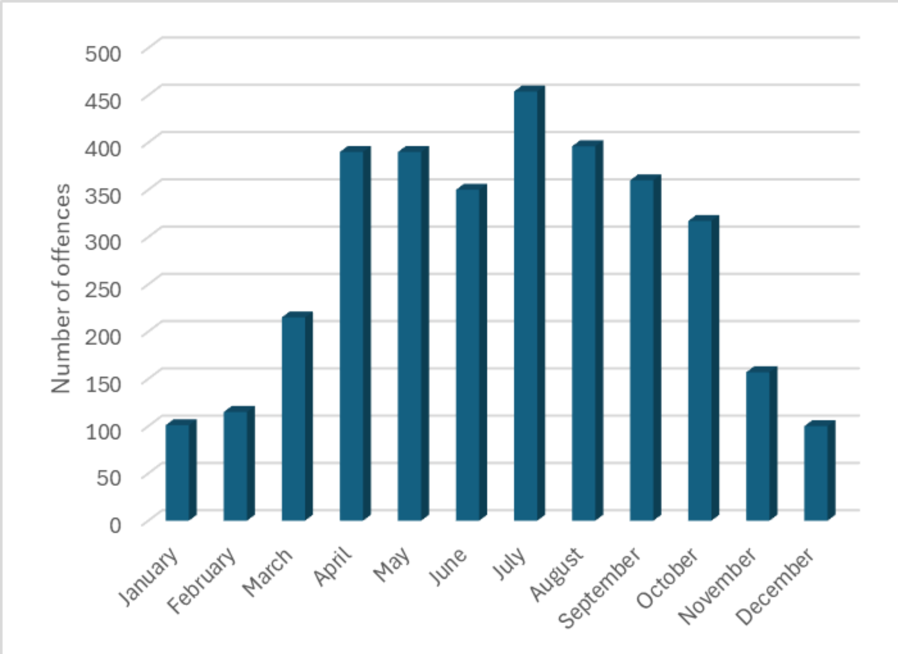

Figure 2. Number of offences by month (2021-April 2025) (N = 3345)

An analysis of the data by month shows that the highest number of offences involving light motor vehicles was recorded in the summer months (Figure 2). July stands out with the highest number of cases (454 or 13.6%), followed by August (396 or 11.8%) and April and May, each with 390 cases (11.7%). June and September also have relatively high shares (10.5% and 10.8%). The winter months (January, February and December) have the lowest shares: January and December each with 3.0%, and February with 3.4%. This distribution may reflect several factors, such as greater exposure in warmer months (more traffic, more outdoor activity) or seasonal influences on the behaviour of road users.

For each recorded offence, we roughly determined whether it occurred during the light or dark part of the day. This classification was made based on the time and month of the event, taking into account the general natural light conditions in Slovenia. For example, if an offence occurred at 4 p.m. in December, we classified it as occurring during the dark part of the day, whereas the same time in May would be classified as occurring during the light part of the day. This gave us a rough estimate of the actual illumination, as precise data on sunrise/sunset for each day and location was not available (Figure 3).

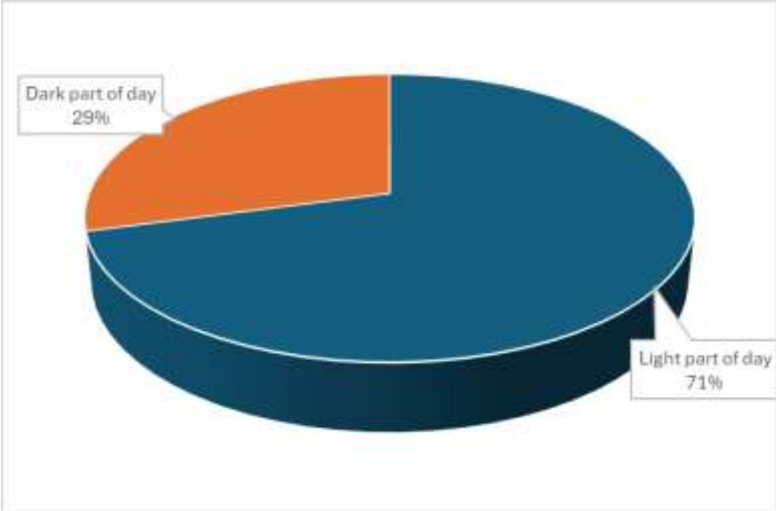

Figure 3. Time of offence – light/dark part of the day (N = 3345)

The analysis shows (Figure 3) that as many as 70.8% of all offences occurred during the day, i.e. when it was light outside (N = 2369). The remaining 29.2% of offences (N = 976) occurred during the dark part of the day.

For each individual offence, we also analysed the type of area or road category where the offence was recorded (Figure 4). The aim was to gain insight into where offences occur most frequently – whether in orderly urban environments, on rural roads, on main roads or on motorways.

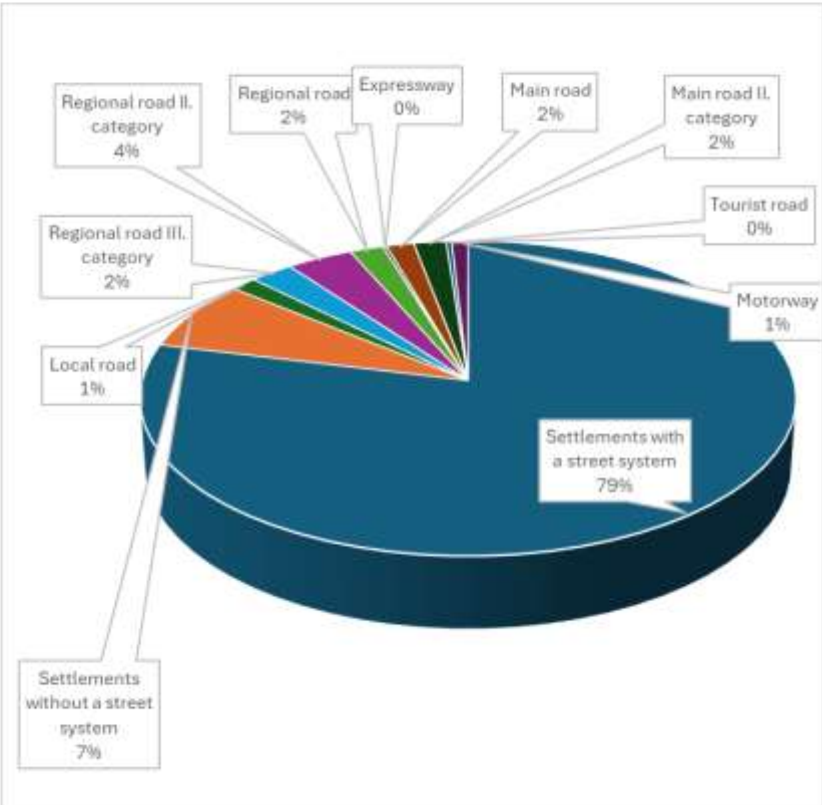

Figure 4. Offences by type of area or road category (N = 3323)

The analysis (Figure 4) shows that the vast majority of offences (78.8%) occur in settlements with a street system, which indicates a distinctly urban context for most events. This is followed by settlements without a street system, where 7.2% of offences were committed. Among road categories outside settlements, regional roads of the second order (3.7%) and regional roads of the third order (2.4%) stand out. Smaller proportions of offences were also recorded on local roads (1.4%), main roads (1.5%) and motorways (0.9%). On tourist roads, expressways and other special categories of roads, the proportions of offences are negligible (all below 1%). The type of road was not specified in 22 cases, representing 0.7% of the total sample.

Below we show (Figure 5) the distribution of traffic offences according to the location where they occurred. The data are classified according to the type of location where the offence was recorded, which allows for a better understanding of the circumstances and spatial characteristics of traffic offences.

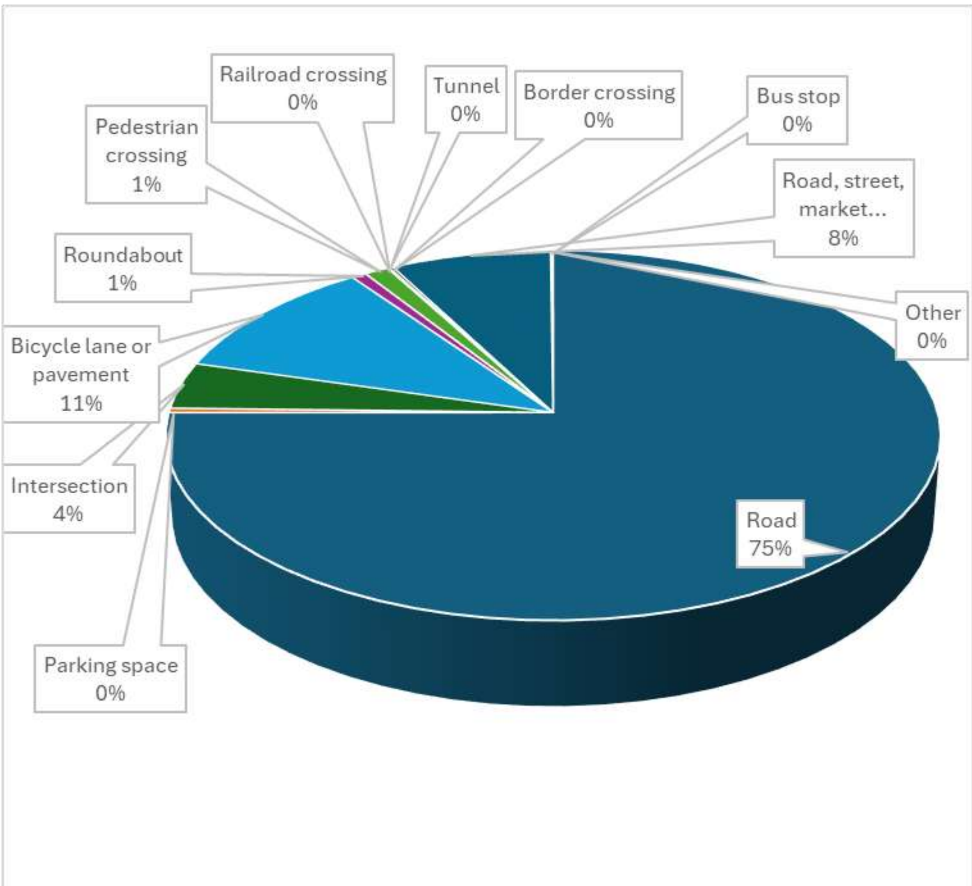

Figure 5. Location of the offence (N = 3323)

A significant proportion of all offences considered occurred on the road (Figure 5 bookmark12), as this category accounts for as much as 75% of all cases (N = 2492). This is followed by cycle paths or pavements with a good 10.8%, roads, streets, squares, etc. (7.5%) and intersections (4.1%). Less common locations for offences include pedestrian crossings (1.1%), roundabouts (0.7%) and parking areas (0%). Violations were very rarely recorded at border or railway crossings, in tunnels, at bus stations or under the category "other", with no individual category exceeding 0.2% of all cases. In total, the location of the offence was recorded in 3,323 cases (99.3%), while in 22 cases (0.7%) the information was missing.

An analysis of the gender variable shows that the vast majority of offenders were male. Of a total of 3,064 valid records on gender, 2,569 offenders were male, representing 83.8% of valid cases, while 495 offenders were female, representing 16.2%.

Data Gender is missing in 281 cases (8.4% of all records). An analysis of the age[3] of offenders (Figure 6) shows that most offences were committed in the 26 to 40 age group, which accounts for 27.1% of all cases. This is followed by the 18 to 25 age group (20.1%) and the 14 to 17 age group (19.0%). A significant proportion are also people aged 41 to 50 (15.1%) and over 51 (10.3%). Offenders under the age of 12 represent 8.4% of the total, while only one offence was recorded for a person aged between 12 and 13, which is less than 0.1%. The results show that the most frequent offenders are persons of working age and younger adults, which is consistent with periods of greater mobility and more frequent participation in traffic.

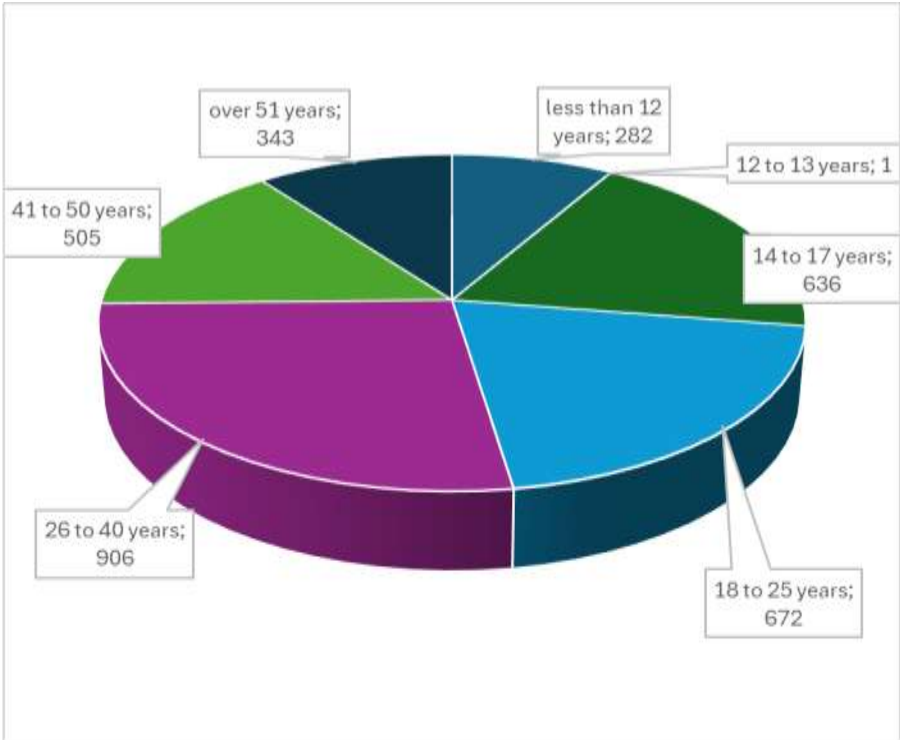

Figure 6. Number of offences by age group (N = 3345)

Among the traffic offenders included in the analysis, persons with Slovenian citizenship predominate, accounting for 82.7% of all cases with valid citizenship data. They are followed

[3] For the purposes of this report, age has been divided into the following categories: under 12 years of age – too young – riding an e-scooter is prohibited; 12 to 13 years old – riding an e-scooter is only permitted with a cycling license; 14 to 17 years old – minors – riding an e-scooter permitted (helmet mandatory); 18 to 25 years old – young adults; 26 to 40 years old - adults of working age; 41-50 years old – middle age; over 51 years old – older users.

by citizens of Bosnia and Herzegovina (4.6%), Kosovo (3.6%) and North Macedonia (2.2%). Smaller proportions of violators also come from Serbia (1.5%), Croatia (0.8%), Ukraine, Germany, the Philippines, Austria and other countries. The data also show several individual cases from very diverse countries (e.g., Eritrea, Mexico, China, Afghanistan, Palestine, etc.), indicating the presence of offenders from different backgrounds, although these proportions are low (individual cases). Citizenship data is missing in 48 cases (1.4%). This means that the variable was recorded for 3,297 individuals, representing 98.6% of all analysed units.

5.1.2 Links between the characteristics of offenders and the circumstances of offences

Below, we present only those links between the characteristics of offenders and the circumstances of offences that proved to be statistically significant ($p < 0.05$) and meaningful from the point of view of content interpretation. The emphasis is on the differences between groups where significant links were found, with analyses performed using appropriate statistical tests.

In order to determine whether the types of violations of the law differ according to the age of the offenders, we examined the relationship between the variables Age and Law Violated. The results showed a statistically significant correlation (Pearson $\chi^2 = 111.264$; $p = 0.002$), which means that the types of violations differ significantly between age groups. The largest share of all offences relates to the Road Traffic Act, which is predominant in all age groups (e.g. 95.4% for children up to 12 years of age, 95.6% for 14-17 year olds, 94.9% for 18-25 year olds). In addition, other categories of legislation also stand out in individual age groups. For example, in addition to road traffic violations, those under the age of 18 also violate the Motor Vehicles Act, the Identity Card Act and the Aliens Act to a lesser extent. The group of offenders under the age of 12 stands out in particular, as they also commit violations of the Aliens Act, which is probably not related to driving, but to other procedures in which children are recorded. In the 18-25 age group, violations of laws such as the Identity Card Act, the Public Order and Peace Act, and the Compulsory Insurance in Transport Act are more pronounced. This indicates greater diversity of behaviour and perhaps greater exposure to proceedings. The largest group of offenders, aged between 26 and 40, is represented not only in traffic offences but also in violations of the Criminal Code, the Personal Identification Card Act and the Motor Vehicles Act. This group also includes the largest proportion of violators of the Public Order and Peace Protection Act. Those over 41 years of age mainly violate traffic laws, and to a lesser extent the Criminal Code, the Identity Card Act and the Compulsory Traffic Insurance Act. A special feature of the over-51 age group is that they are the only violators of the Road Traffic Act. It is important to note that Slovenian legislation stipulates that motor vehicles (e.g., e-scooters) may only be driven in road traffic by persons over the age of 14 or children between the ages of 12 and 14 if they have a cycling licence. This analysis recorded as many as 283 persons younger than 13 years of age.

The purpose of the further analysis was to investigate the possible connection between the nationality of individuals and the law on the basis of which proceedings were initiated against them or a violation was recorded. Such an analysis is important in terms of identifying possible patterns, systemic differences or discriminatory tendencies in the treatment of individuals of different nationalities or countries of origin. In doing so, we analysed the intersection of two variables – citizenship and the law that was applied in each individual case. The results of the chi-square test ($\chi^2 = 186.470$, df = 540, p = 1.000) and the likelihood ratio, also with a p-value of 1.000, show that there is no statistically significant correlation between nationality and the law that was violated. The p-value significantly exceeds the usual significance threshold (e.g. 0.05), which means that based on this data, we cannot claim that there is a statistically significant correlation between the analysed variables. In addition, in the vast majority of cells (96.5%), the expected number is less than 5, which means that the test results are unreliable or unsuitable for classical interpretation.

To determine whether offences occur more frequently during the day or at night depending on the season, we created a cross-tabulation between the variables Month and Part of the day (light or dark part of the day). The results (Figure 7) show clear seasonal differences in the distribution of offences depending on whether they occurred during daylight or darkness.

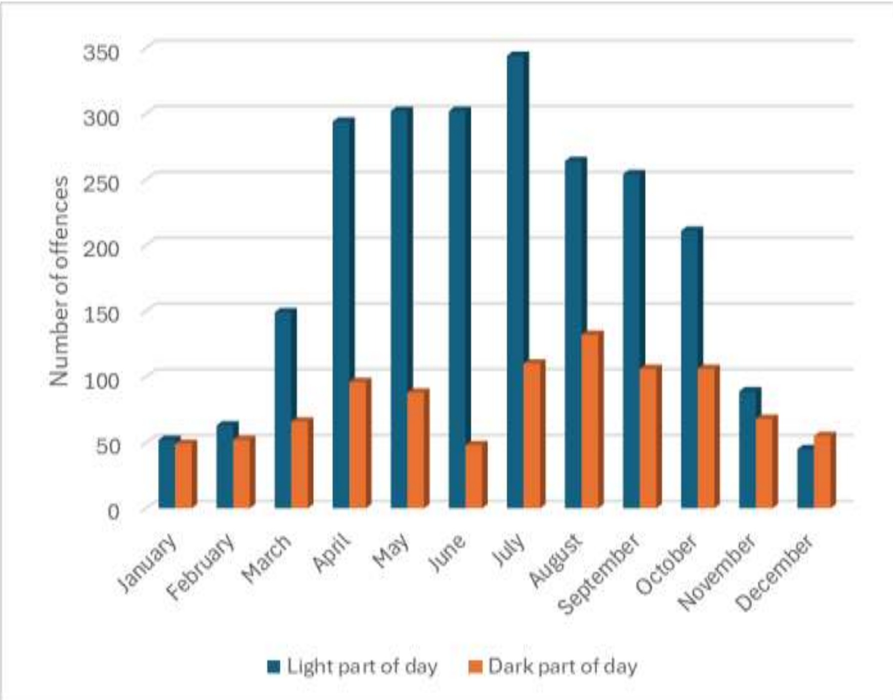

Figure 7. Correlation between the month and time of day when the offence was committed (N = 3345)

Statistical tests confirm that the correlation between the month and the time of day is statistically significant (Pearson Chi-Square = 144.451, $p < 0.001$). This means that the probability of offences occurring during the day or at night is statistically significantly dependent on the month of the year – in line with the natural length of the day. In the winter months (December, January, February), the proportion of offences (Figure 7) that occurred during the dark part of the day is highest – in December, it even exceeds the proportion of offences during the light part of the day (55% versus 45%). In January, this difference is almost equal (51.5% during daylight hours, 48.5% during darkness), which indicates shorter days and a greater possibility of offences occurring in the dark. Conversely, in summer (June, July), most offences occur during daylight hours. In June, as many as 86.3% of offences occur during daylight hours, which is the highest percentage among all months. A high percentage of offences during daylight hours is also present in April (75.4%) and May (77.4%).

To determine possible differences between age groups and whether offences occur more frequently during the day or at night, we performed a cross-analysis between the variables of age and time of day (light/dark) (Figure 8).

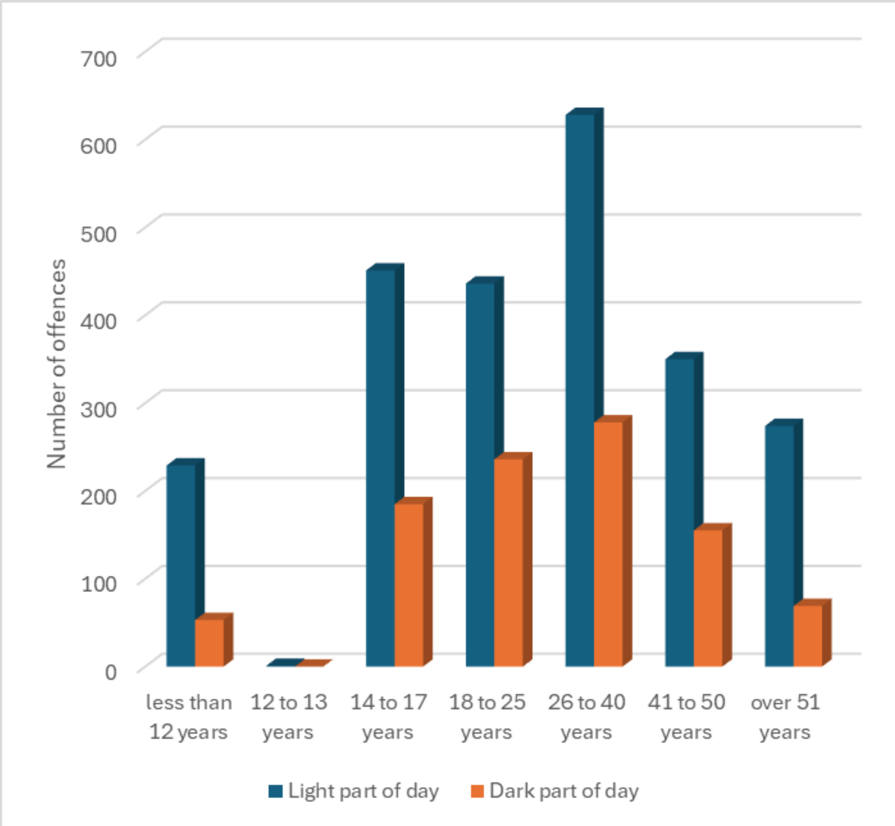

Figure 8. Offences by age group according to time of day (N = 3345)

Pearson's chi-square test ($p<0.001$) confirms that there is a statistically significant correlation between age and the part of the day in which the offence occurred. This means that age groups differ in terms of whether they violate regulations more often during the day or at night. The results show (Figure 8) that most offences in all age groups occur during daylight hours (a total of 70.8% of all offences), but the proportion of offences during the dark hours of the day is highest in the 18 to 25 age group (35.1%) and the 26 to 40 age group (30.7%). In comparison, the proportion of night-time offences is lower among the youngest (under 12 years of age: 18.8%) and the oldest (over 51 years of age: 20.1%). This indicates a slightly higher risk of night-time offences among younger adults.

In order to identify possible differences in the behaviour of road users according to their age, we analysed the relationship between the age groups of offenders and the types of roads or areas (settlements) where the offences were committed (Figure 9). We were particularly interested in the distribution of offences according to whether they occurred in urban areas, on local or regional roads, or on major traffic routes such as expressways and motorways.

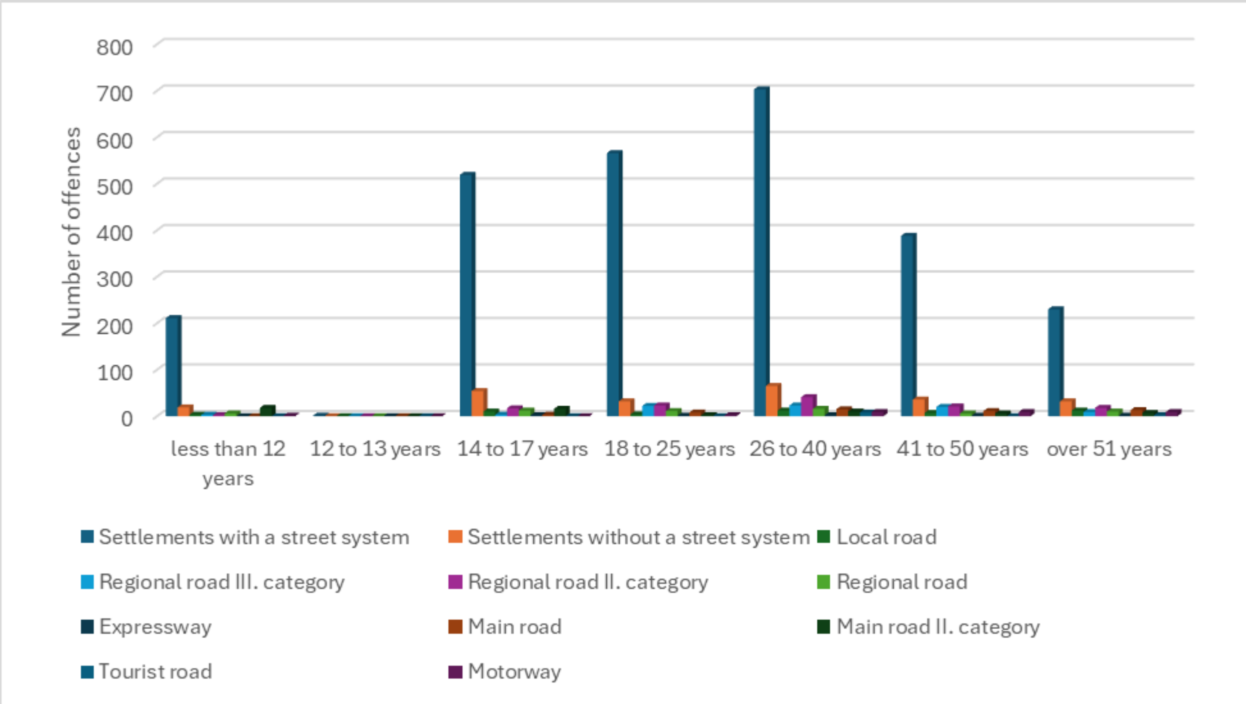

Figure 9. Distribution of traffic offences by road type and age group (N = 3323)

The differences between age groups and road types are statistically significant ($\chi^2(60) = 185.58$; $p < 0.001$), which means that there is a correlation between the age of offenders and the types of roads on which offences occur. The results (Figure 9) show that the majority of offences (78.8%), regardless of age group, occur in settlements with a street system. However, younger offenders (up to 17 years of age) also commit offences slightly more frequently in areas without a street system and on local roads. Young people (14–17 years of age) also stand out with a slightly higher proportion of offences on regional roads III. and II. order roads. Meanwhile, older age groups (over 50) account for a relatively higher proportion of offences on main roads and motorways.

5.2 Traffic crashes involving light motor vehicles and e-scooters in Slovenia (2021–April 2025): Analysis of police data

During the period analysed (2021–April 2025), 905 traffic crashes caused by (or involving) drivers of light motor vehicles were recorded in police records. The results show that the majority of individuals (66%) in the cases examined were the cause of the traffic crashes. The remaining third (34%) were involved in crashes but did not cause them. When interpreting the results, methodological limitations must be taken into account, as the category of light motor vehicles covers a wider range of means of transport. In addition to electric scooters, it also includes other motorised vehicles with a design speed not exceeding 25 km/h and a width not exceeding 80 cm. As a result, the data do not allow for a precise distinction between individual types of vehicles, which poses a challenge when focusing solely on electric scooters.

5.2.1 Descriptive analysis of traffic crash data

The distribution of traffic crashes by year shows a gradual increase in their number throughout the analysed period (Figure 10).

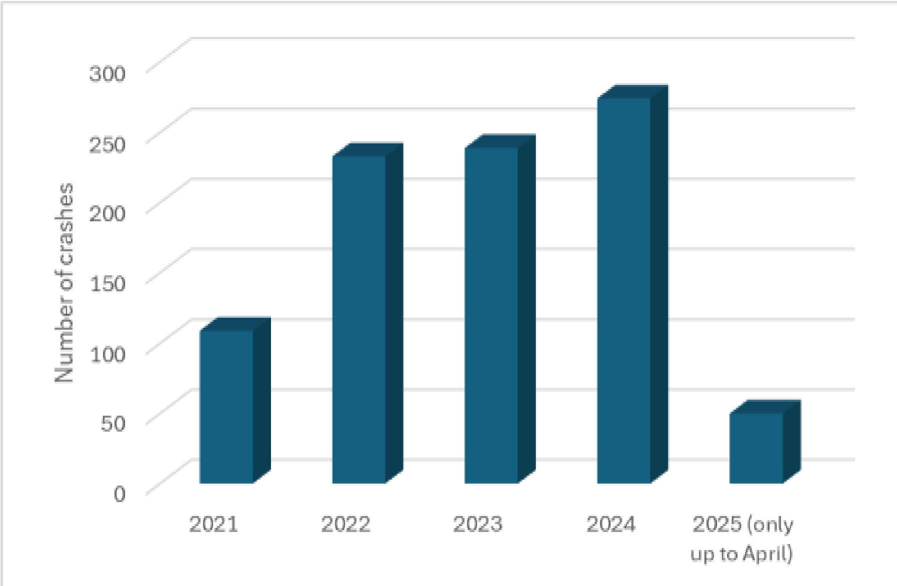

Figure 10. Number of traffic crashes by year (N = 905)

In 2021, 109 crashes (12.0%) were recorded, which is the lowest number among the years considered. In 2022, the number rose to 233 (25.7%), and then remained at a similar level in 2023 with 239 incidents (26.4%). The highest number of crashes was recorded in 2024, namely 274, representing 30.3% of all cases. The year 2025, for which only data up to April was available, logically shows a lower frequency (50 crashes or 5.5%). This distribution may indicate an increase in the use of such vehicles or greater awareness and recording of crashes by the competent authorities. Most crashes occurred in the summer months (Figure 11) – July (14.6 %), August (12.9%) and June (11.7%). This is followed by September with 12.3%. These months coincide with a period of increased traffic due to holidays, tourist travel and a greater presence of vulnerable road users (cyclists, pedestrians). The fewest crashes occurred in January (3.1%), February (3.5%) and December (3.5%), which can be attributed to reduced mobility in the winter months and the possible influence of weather conditions.

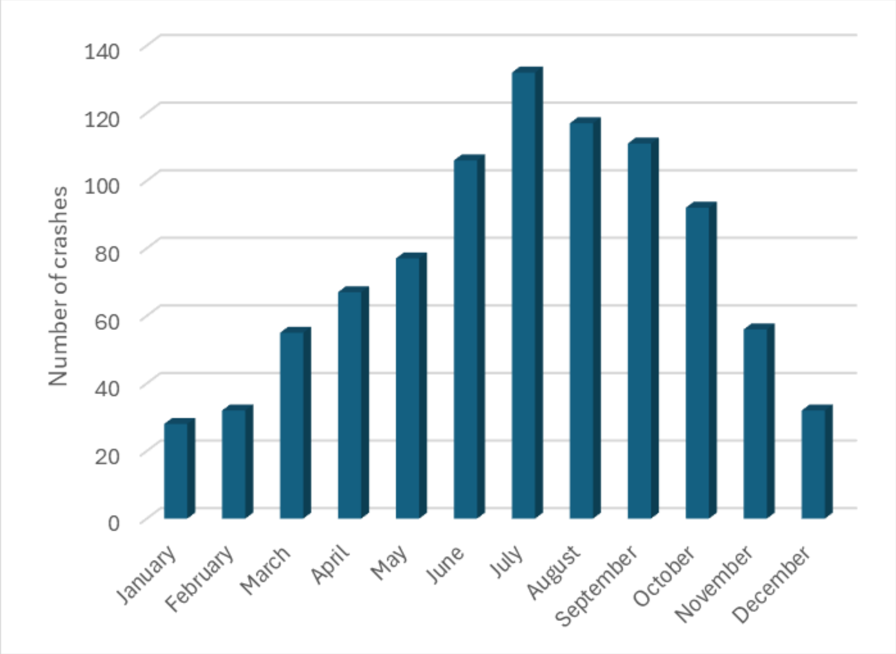

Figure 11. Number of traffic crashes by month (N = 905)

An analysis of traffic crashes by time of day shows that as many as three quarters of all crashes (75.2%) occur during daylight hours, while significantly fewer – 24.8% – occur during the dark hours of the day (Figure 12). This difference may be due to higher traffic density during the day, when road users are more active and more frequently on the road. Although traffic is less frequent at night, night-time crashes are often associated with greater risks (e.g., poorer visibility, fatigue, driving under the influence of alcohol).

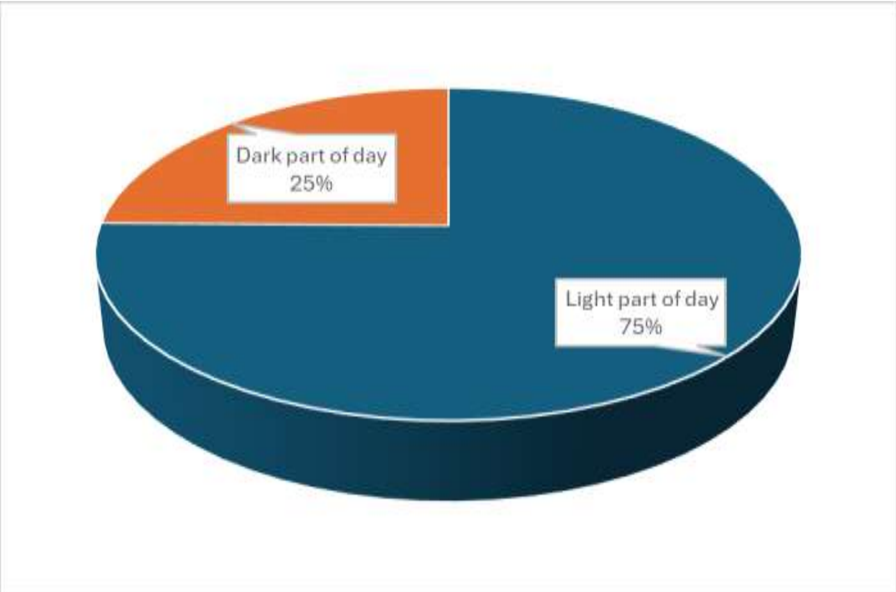

Figure 12. Proportion of crashes during daylight and darkness (N = 905)

As part of the analysis of traffic crashes involving drivers of light motor vehicles, we also examined the gender structure of the persons involved. Gender data provides insight into possible differences in representation between men and women and contributes to understanding behavioural patterns in traffic. The results show that in as many as 71.8% of cases, the participants were men (650 cases), while women accounted for 28.2% of all cases (255 cases). This means that men are much more frequently involved in such traffic incidents, which may indicate a greater presence of men in driving these vehicles or different patterns of risky behaviour between the sexes.

In the following analysis, we examined the age distribution of perpetrators and participants in traffic crashes (Figure 13), as age is often an important factor in traffic safety and risky behaviour in traffic. The data are divided into age groups, which provides a clearer insight into which age group was most exposed during the period under review.

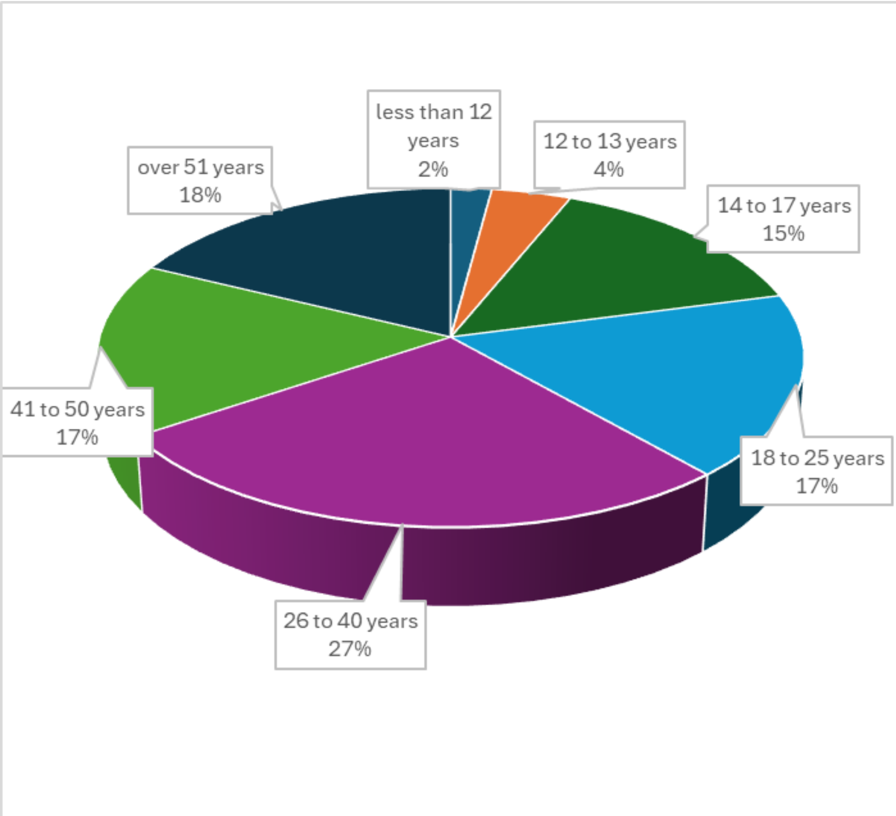

Figure 13. Distribution of traffic crashes by age (N = 905)

The results show that most of the people were between 26 and 40 years old, with this group making up 27.2% of the total (246 cases). This was followed by the group aged 51 and over with 17.8% (161 cases), and then young adults aged 18 to 25 (17.6%, 159 cases). Young people aged 14–17 represent 14.7%, while children and teenagers up to 13 years of age represent a total of 6.2% (19 + 37 cases). It is also important to note that people aged 41 to 50 accounted for 16.6% of all cases.

Next, we looked at the breathalyser results for people who caused traffic crashes where alcohol was involved. Out of a total of 905 cases, there were 135 where a breathalyser test showed a measurable alcohol concentration. The results show that the measured alcohol values in exhaled air ranged from 0.01 mg/l of exhaled air to 1.77 mg/l. The average value was approximately 0.63 mg/l, which exceeds the legal limit for drivers in many cases. The median, i.e. the middle value of all results, was 0.63 mg/l, indicating a relatively symmetrical distribution of results. A quarter of all detected values were lower than 0.37 mg/l, while the upper quarter (75th percentile) was higher than 0.85 mg/l.

An analysis of the nationality of perpetrators and participants in traffic crashes provides insight into the ethnic and international composition of persons involved in such events. The results show that Slovenian citizens strongly predominated among participants, representing as much as 81.0% of all those with valid data (727 persons). They are followed by citizens of Bosnia and Herzegovina (5.9%) and Kosovo (3.1%). Citizens of Serbia represent 2.1%, and those of North Macedonia 1.9%. Citizens of other countries represent a very small proportion (each individual country less than 1%), which also includes countries outside Europe, such as Mexico, Egypt, Iran, Nepal, Vietnam, Cuba, etc.

An analysis of the classification of traffic crashes according to their consequences reveals the severity of the crashes included in the database (Figure 14). Such classification is crucial for understanding the extent of traffic safety and for planning appropriate measures to reduce injuries and fatalities.

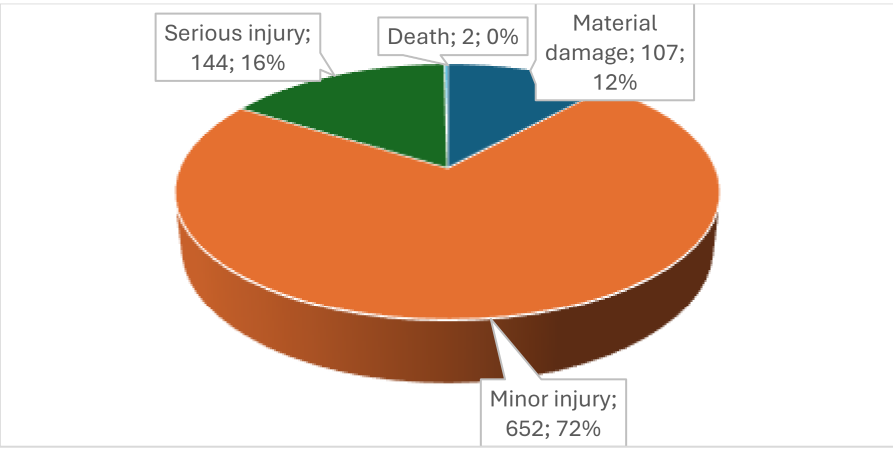

Figure 14. Number (and percentage) of traffic crashes by consequences (N = 905)

The data show (Figure 14) that the vast majority of traffic crashes (72.0%) resulted in minor injuries. This is followed by crashes with serious injuries, which account for 15.9% of all cases, and crashes with only material damage (11.8%). A smaller proportion of crashes – 0.2% – resulted in fatalities (2 cases).

An analysis of traffic crash data by type of road or area where they occurred shows a clear predominance of urban environments with a developed street system (Figure 15).

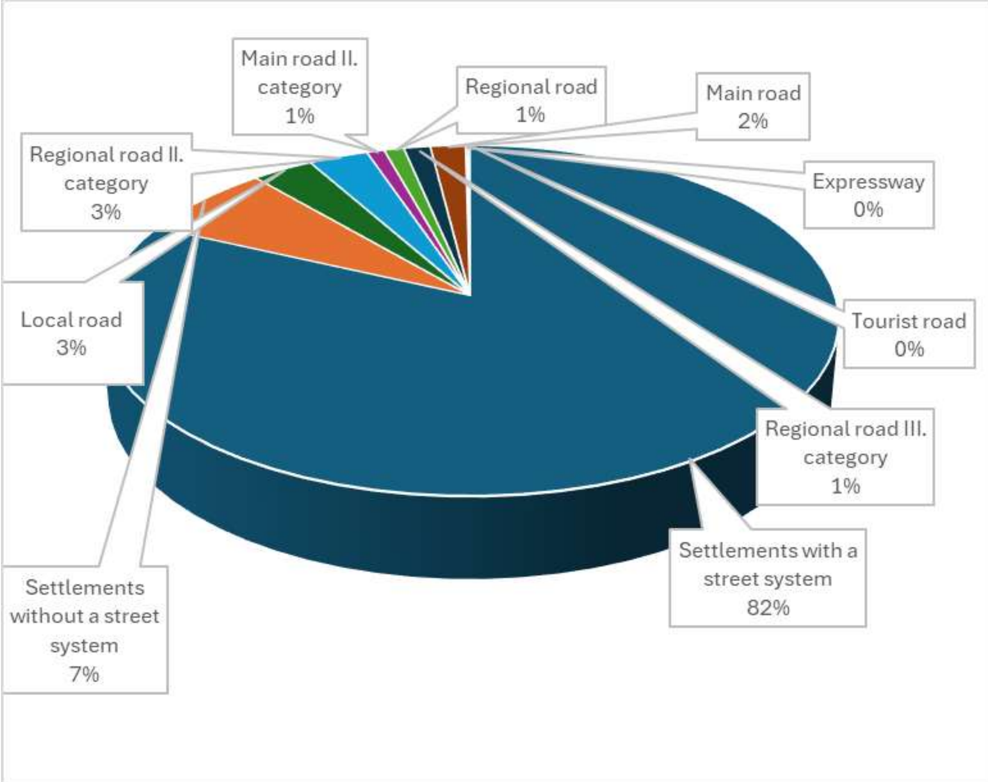

Figure 15. Relationship between road environment and traffic crashes (N = 905)

As many as 81.9% of all crashes occurred in settlements with a street system (Figure 15), which is to be expected, as these areas are more congested due to higher traffic density, a greater presence of vulnerable road users and numerous intersections. Settlements without a street system accounted for 6.9% of crashes. Among road types outside urban areas, local and regional roads of lower order are the most common (each with around 3%), while the proportion of crashes on main and express roads is negligible. This distribution reflects the greater exposure of urban traffic areas, where there are more contacts between road users and more complex traffic situations.

An analysis of the distribution of traffic crashes (Figure 16) according to the type of location where they occurred reveals that most of them happen on the road (50.8%) – i.e. outside specific infrastructure points such as intersections or pedestrian crossings. This indicates that even long and clear sections of road are often the scene of crashes, which may be due to excessive speed, inattention or other violations of traffic rules. Crashes on areas intended for vulnerable road users also account for a significant proportion – as many as 22.7% of crashes occur on cycle paths or pavements, which highlights the lack of separation between vehicles and pedestrians or cyclists. This is followed by intersections with 16.2%, which are classic points with a higher risk of crashes due to conflicts in driving directions. Interestingly, 5% of crashes occur at pedestrian crossings, which also indicates the vulnerability of pedestrians and the need for greater protection. Other locations, such as car parks, roundabouts, railway crossings, tunnels or bus stops, account for only a small proportion of all incidents, but nevertheless indicate that dangers also exist in otherwise less busy or special locations.

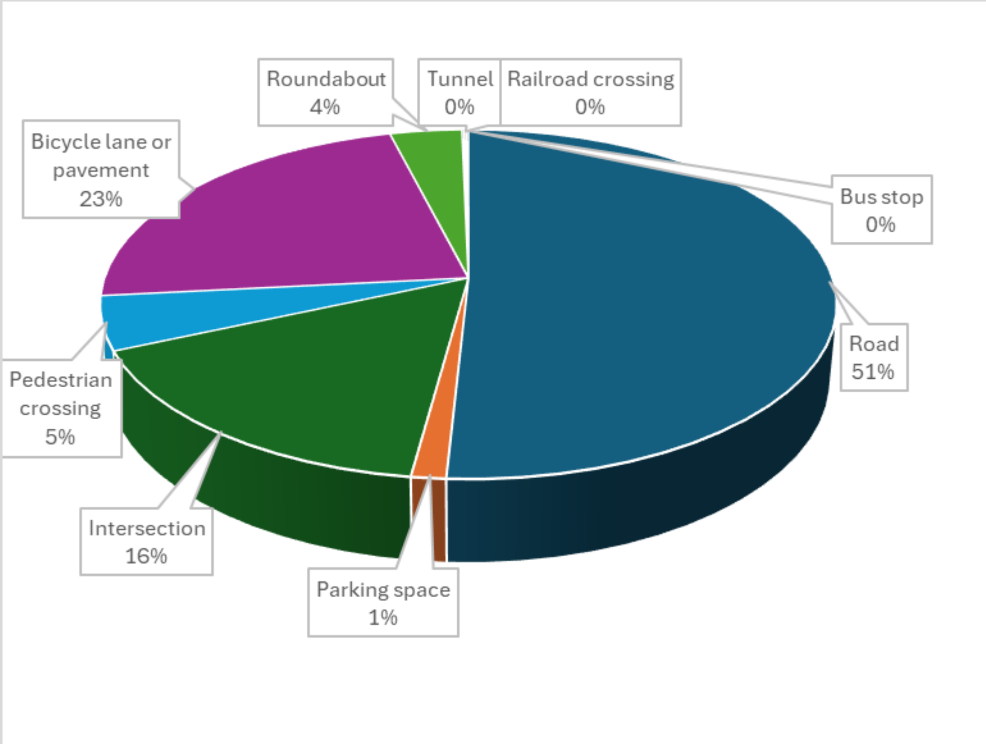

Figure 16. Traffic crashes by type of location of the incident (N = 905)

We then analysed the main causes of traffic crashes in order to better understand the factors contributing to their occurrence and thus highlight areas where additional preventive measures or improvements in traffic safety would be necessary (Figure 17).

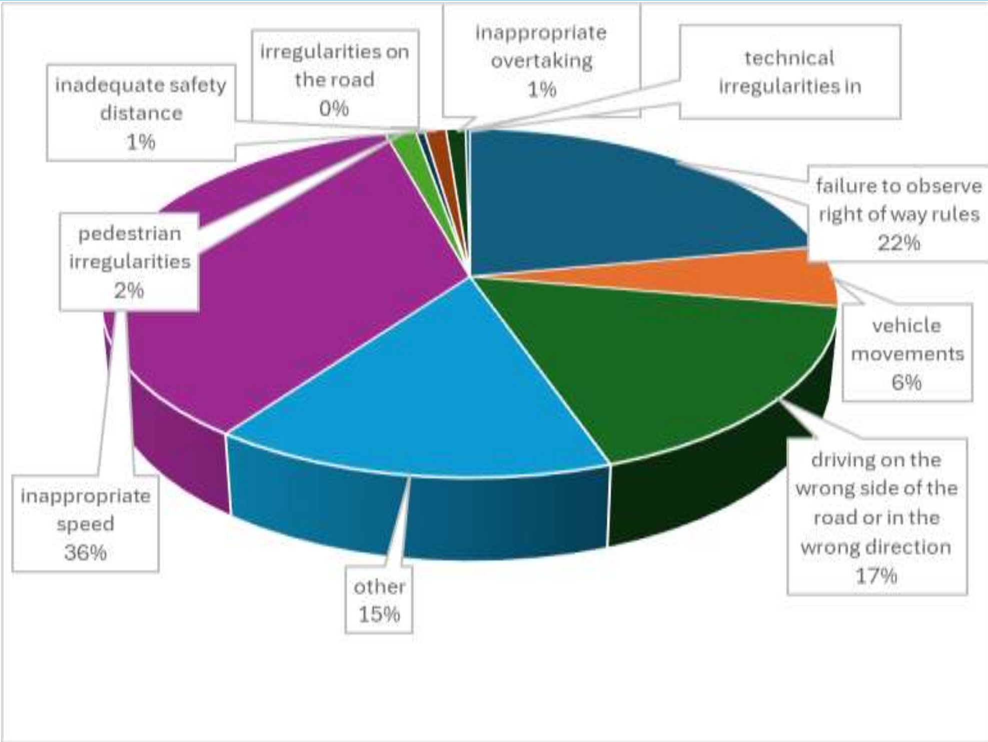

Figure 17. Main causes of traffic crashes (N = 905)

The results (Figure 17) show that by far the most common cause of traffic crashes is inappropriate speed, which is present in as many as 35.7% of all cases. This confirms that speed remains a key safety challenge in traffic. This is followed by failure to observe right of way rules (22.1%), which indicates a lack of respect for basic traffic rules and a possible lack of attention or experience on the part of drivers. The third most common cause is driving on the wrong side of the road or in the wrong direction (16.9%), which often leads to head-on collisions. A significant proportion (15.4%) are also cases classified as "other", which may include combinations of circumstances or less common causes. Smaller proportions are attributed to specific violations, such as vehicle movements (5.6%), pedestrian irregularities (1.5%) and inadequate safety distance (1.1%). A negligible but still present proportion of crashes are also caused by technical irregularities in vehicles (0.2%) and on the road (0.4%).

We then analysed the weather conditions at the time of the traffic crashes covered by data set (Figure 18).

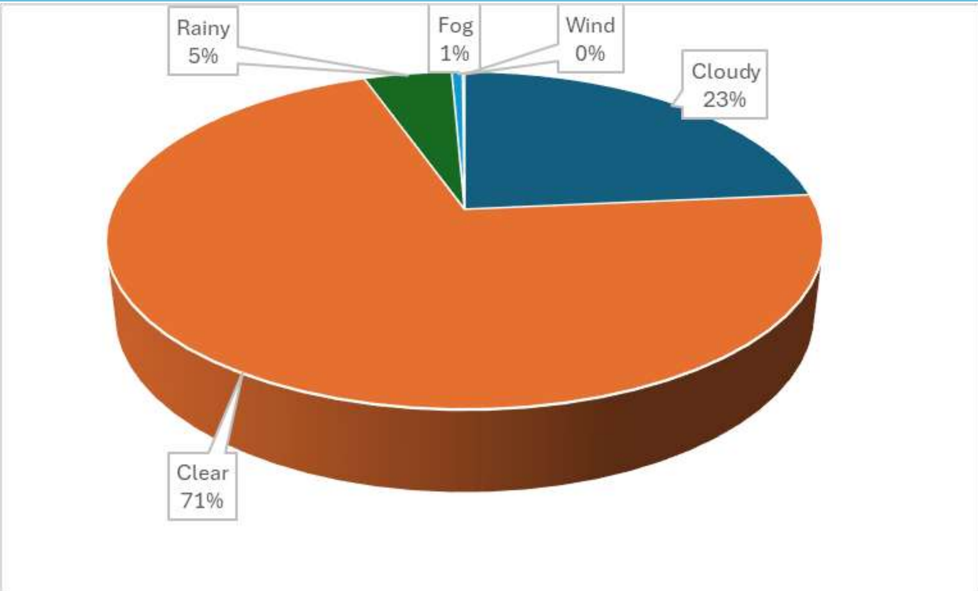

Figure 18. Weather at the time of the traffic crash (N = 866)

The data show (Figure 18) that most crashes occurred in clear weather, accounting for 71% of all cases with valid data. This is followed by crashes in cloudy weather with 23.6%, while crashes in rainy (4.7%), foggy (0.6%) and windy weather (0.1%) are rare. From this, we can conclude that most traffic crashes do not coincide with bad weather conditions, but mostly occur in favourable driving conditions.

We then analysed traffic density at the time of traffic crashes, focusing on four categories: light traffic, flowing (normal) traffic, heavy traffic and traffic jams (Figure 19).

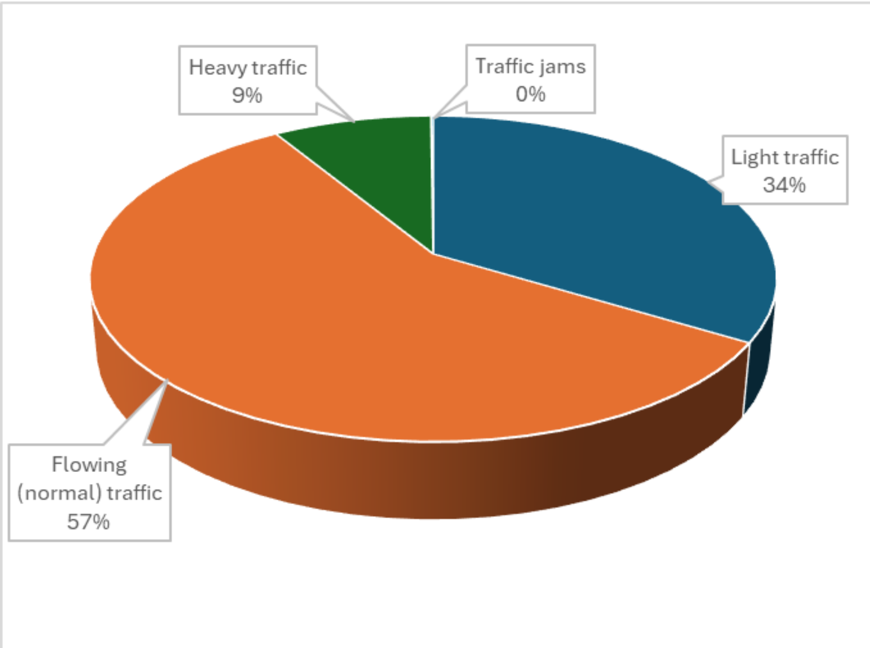

Figure 19. Traffic density at the time of the traffic crash (N = 788)

The results show (Figure 19) that most crashes occurred in flowing (normal) traffic, accounting for 57.6% of all cases with valid data. This is followed by light traffic with 33.6%, while 8.6% of crashes occurred in heavy traffic. Crashes in traffic jams are extremely rare (0.1%).

As part of the analysis of traffic crashes, we also focused on the condition of the road surface at the time of the crash, as road surface conditions can have a significant impact on traffic safety (Figure 20).

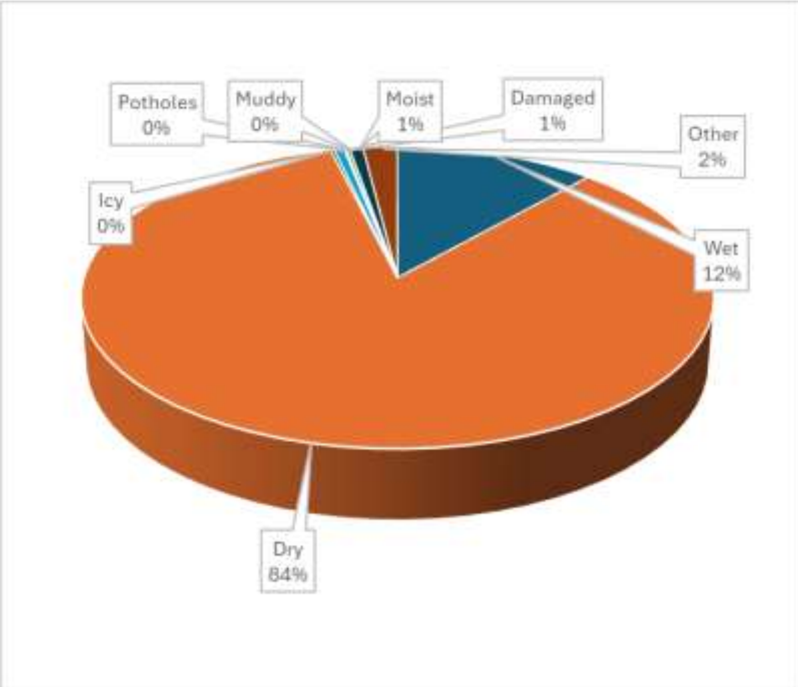

Figure 20. Road surface conditions at the time of traffic crashes (N = 905)

Most crashes occurred on dry road surfaces (84.5%), which means that most crashes occur in normal and predictable conditions, not necessarily in bad weather or on dangerous surfaces. Wet road surfaces were present in 11% of cases, indicating a slightly increased risk in the event of rainfall. All other conditions (icy, damaged, potholes, muddy, etc.) account for only a small proportion and together do not exceed a few percent.

In this phase of the analysis, we also focused on the type of road surface (Figure 21) on which traffic crashes occurred. The type of surface can affect tyre grip, braking distance and the overall behaviour of vehicles, making it an important aspect of traffic safety.

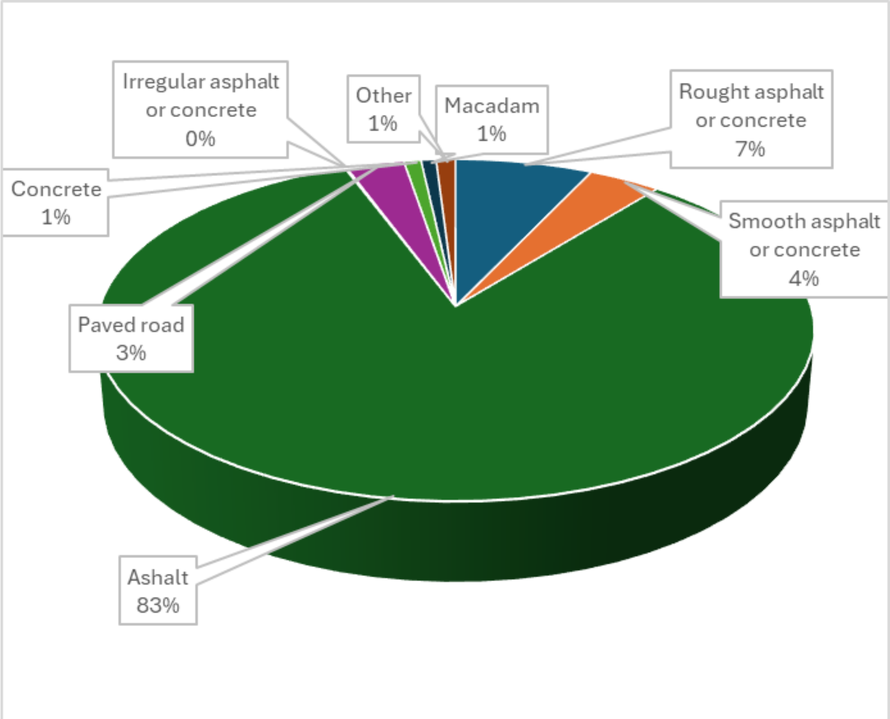

Figure 21. Traffic crashes by road surface (N = 905)

The data (Figure 21) show that the vast majority of crashes occurred on asphalt, accounting for 83.4% of all cases. This is followed by rough asphalt or concrete (7.1%), smooth asphalt or concrete (3.8%) and paved roads (3.0%). Other types of surfaces, such as macadam, concrete or other forms, occur only rarely.

5.2.2 Links between perpetrator characteristics and crash circumstances

Below, we present only those links between the characteristics of perpetrators/participants (e.g., age, gender, driving status, etc.) and the circumstances of traffic crashes (e.g., type of violation, time of event, location) that proved to be statistically significant ($p < 0.05$). The emphasis is on results where significant differences were found between individual groups, which allows for a meaningful and well-founded interpretation of the content.

First, we present an analysis of the relationship between the month in which the traffic crash occurred and the part of the day (daylight or darkness) in which the crash occurred (Figure 22). We were particularly interested in the distribution of crashes according to the time of year and lighting conditions. We used the chi-square test of independence to check the statistical correlation between the variables.

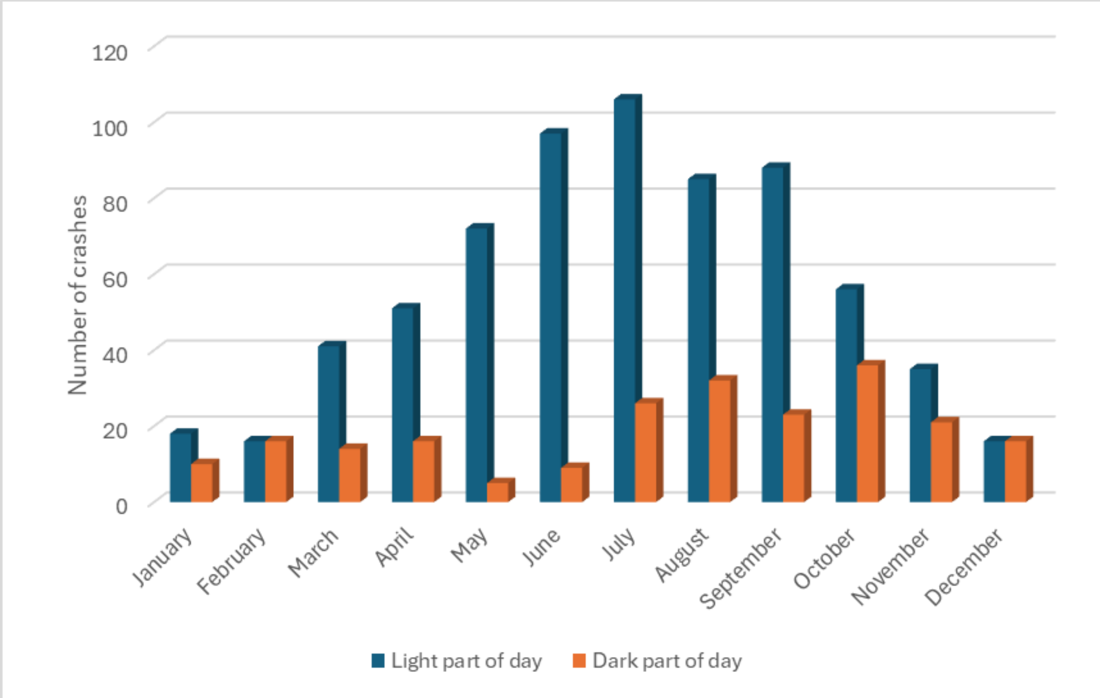

Figure 22. Distribution of traffic crashes by month and time of day (N = 905)

The results (Figure 22) show that most crashes occurred during the summer months (July, August), with the proportion of crashes during daylight hours exceeding 70% in these months. A very high proportion of crashes during daylight hours was also observed in May and June (93.5% and 91.5% respectively). In contrast, in the winter months, such as February and December, crashes were more evenly distributed between daylight and darkness (50% – 50%). The chi-square test performed is statistically significant ($\chi^2(11) = 70.887$, $p < 0.001$), which means that there is a statistically significant correlation between the month and the time of day when the crash occurred.

To determine the possible correlation between the cause of the traffic crash and the age groups of the perpetrators/participants (Figure 23), a cross-tabulation and a chi-square test were performed. All 905 valid cases were included in the analysis.

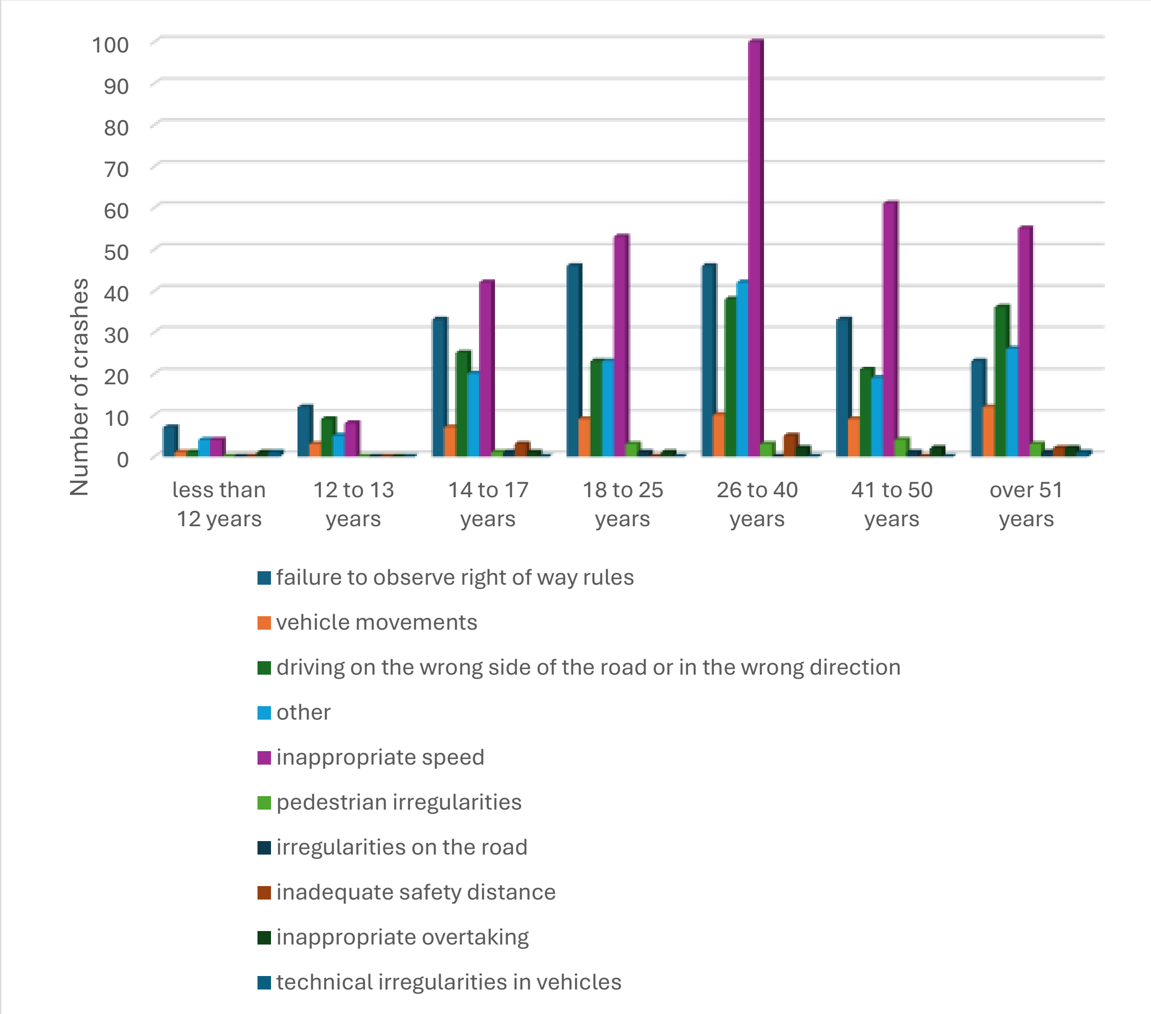

Figure 23. Causes of traffic crashes by age of perpetrators (N = 905)

The most common cause of traffic crashes in all age groups (Figure 23) was inappropriate speed, which was most pronounced in the 18-50 age group, where it accounted for over 40% of all crashes. In addition to inappropriate speed, the youngest age groups (up to 17 years) often caused crashes due to failure to observe the rules of right of way, while in the oldest group (over 51 years), incorrect driving direction and pedestrian irregularities were also more common. The results of the chi-square test show that there is a statistically significant correlation between the cause of the traffic crash and the age of the person who caused it ($\chi^2 = 73.63$; $p = 0.039$). However, it appears that more than half of the cells (57.1%) have an expected value of less than 5, which may affect the reliability of the result. Nevertheless, the results show certain differences in the causes of crashes depending on the age of the perpetrators.

Next, we examined the relationship between the age of the perpetrators/participants and the classification of traffic crashes (Figure 24). We were interested in whether the severity of traffic crashes (property damage, physical injury, fatality) differs statistically significantly according to the age groups of the participants.

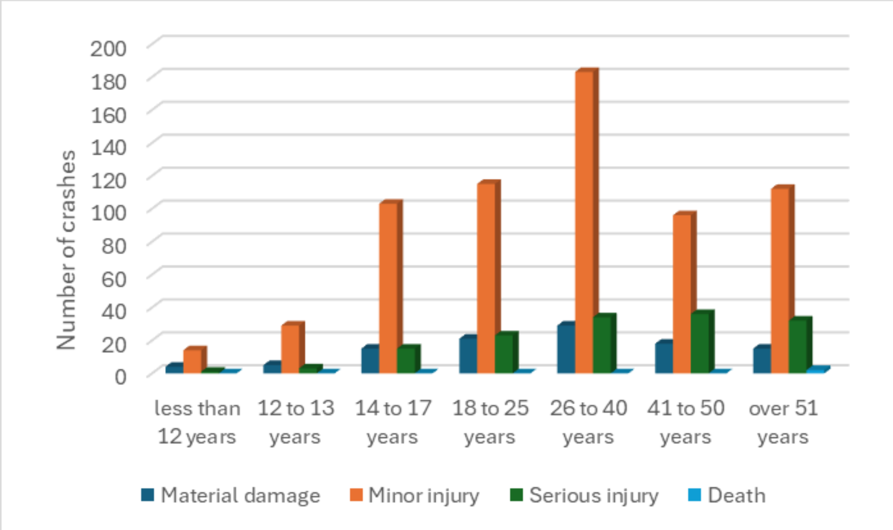

Figure 24. Distribution of traffic crash classifications by age group (N = 905)

The results show that minor injuries are the most common consequence of traffic crashes in all age groups (a total of 72% of all crashes). However, there is a difference between younger and older participants: among minors (up to 17 years of age), the proportion of crashes with minor injuries is even higher than 75%, while among those older than 51 years of age it is slightly lower (69.6%), but they stand out with a higher proportion of serious injuries (19.9%) and fatalities (1.2%). Younger children (up to 12 years of age) have a significantly high proportion of crashes with injuries (e.g., 73.7% for the age group up to 12 years). The chi-square test shows that the difference between age groups in terms of crash classification is not statistically significant ($\chi^2(18) = 27.484$, $p = 0.070$). Nevertheless, the value only slightly exceeds the significance threshold, which may indicate a certain trend that could become significant with a larger sample size. The linear trend shows a significant correlation ($p < 0.001$), which means that the severity of the consequences can be partially predicted with age.

Below, we show the relationship between the age groups of participants and the time of day (daylight or darkness) when traffic crashes occurred (Figure 25). We wanted to check whether the frequency of crashes at a certain time of day differs statistically depending on the age group. For this purpose, we used a cross-tabulation table and a chi-square test of independence.

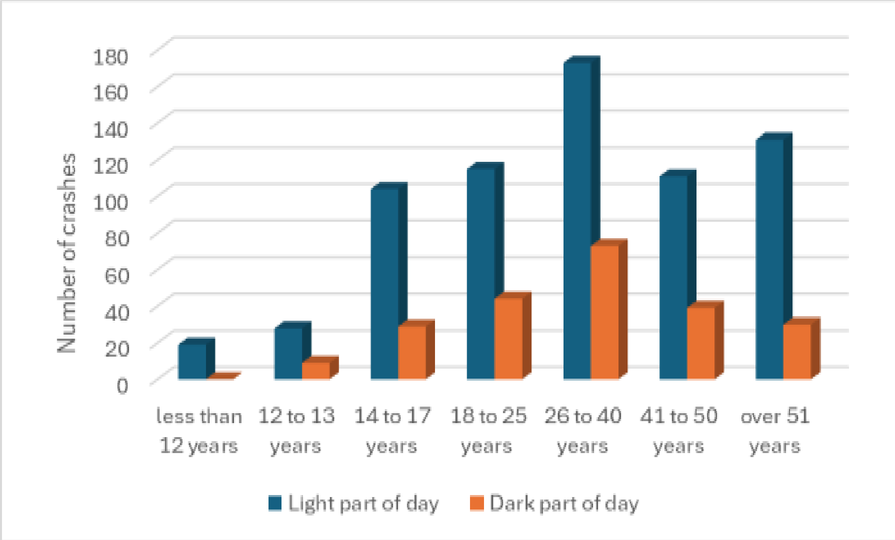

Figure 25. Age and incidence of traffic crashes during daylight or darkness (N = 905)

The analysis (Figure 25) shows that the proportions of traffic crashes that occurred during daylight and darkness differ according to age group. The youngest participants (under 12 years of age) were involved exclusively in crashes during daylight hours (100%). Adolescents (aged 14–17) and young adults (aged 18–25) had a slightly higher proportion of crashes during the dark part of the day (21.8% and 27.7 %), which may indicate greater exposure in the evening hours. The oldest group (over 51 years) had the highest proportion of crashes during the day (81.4%), which is to be expected, as their mobility in the evening is generally lower. The chi-square test shows that the difference is statistically significant ($\chi^2(6) = 14.165$; $p = 0.028$), which means that there is a correlation between age and the time of day when a traffic crash occurs.

This was followed by an analysis of the relationship between the age of the participants and the measured alcohol content in their exhaled air. Alcohol measurements were classified into six categories in accordance with the legally prescribed limits and penalties. Of the total 905 cases, only 135 had valid data on alcohol concentration (Figure 26), which means that as much as 85.1% of the values were missing – either because the test was not performed or because the data was unavailable.

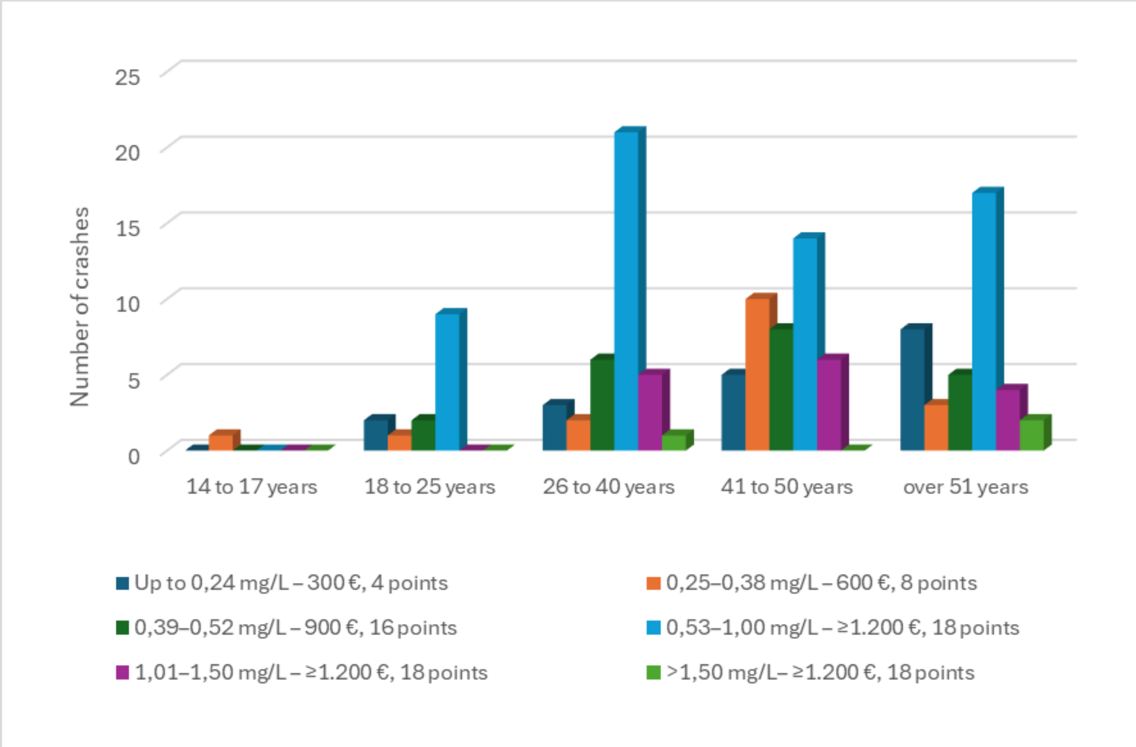

Figure 26. Distribution of alcohol values by age group (N = 135)

The results show (Figure 26_bookmark37) that higher alcohol levels occur more frequently in older age groups. The highest proportion of individuals with levels above 0.52 mg/L (which means loss of driving licence) occurs in the 26 to 50 age group. The "over 51" group has the highest proportion of values above 1.50 mg/L. Among younger participants (e.g., 14-17 years), the number of cases is negligible, which may indicate lower involvement in events where breathalyser tests were performed. The chi-square test ($\chi^2 = 24.77$; $p = 0.210$) did not show a statistically significant correlation between age and alcohol class, which is to be expected given the small number of valid cases and scattered values.

When analysing the relationship between the gender of the person who caused the traffic crash and the cause of the crash (Figure 27), we performed a cross-tabulation and a chi-square test.

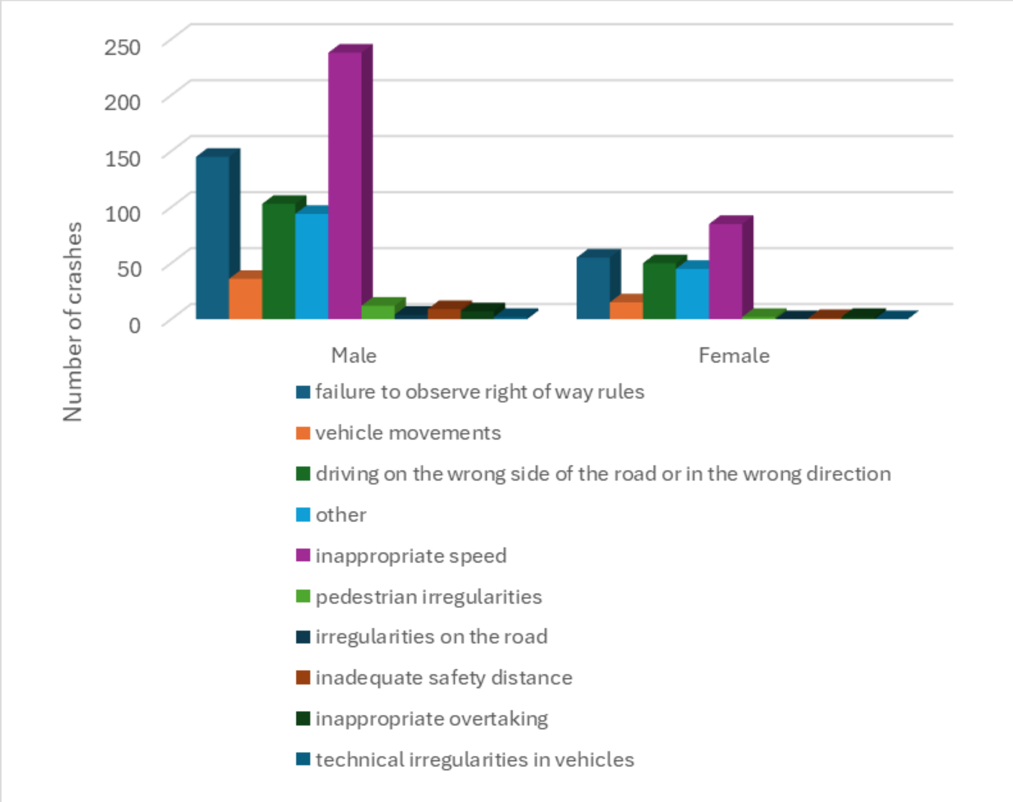

Figure 27. Correlation between the gender of the perpetrator and the cause of the traffic crash (N = 905)

The analysis considered data for 905 cases (Figure 27). Among male perpetrators, the most common causes of crashes were inappropriate speed (36.6%), failure to observe the rules of right of way (22.3%) and incorrect side or direction of travel (15.8%). Among female drivers, the most common causes were the same, but with slightly different percentages: inappropriate speed (33.3%), incorrect side/direction of travel (19.6%) and failure to observe the rules of right of way (21.6%). Despite noticeable differences between the sexes in individual causes of crashes, statistical analysis (Pearson's chi-square test) did not show a statistically significant correlation between gender and the cause of a traffic crash ($\chi^2(9) = 8.86$; $p = 0.450$).

We also checked whether the frequency of different classifications of traffic crashes (e.g., material damage, bodily injury, etc.) differed statistically according to the gender of the person who caused the crash (Figure 28).

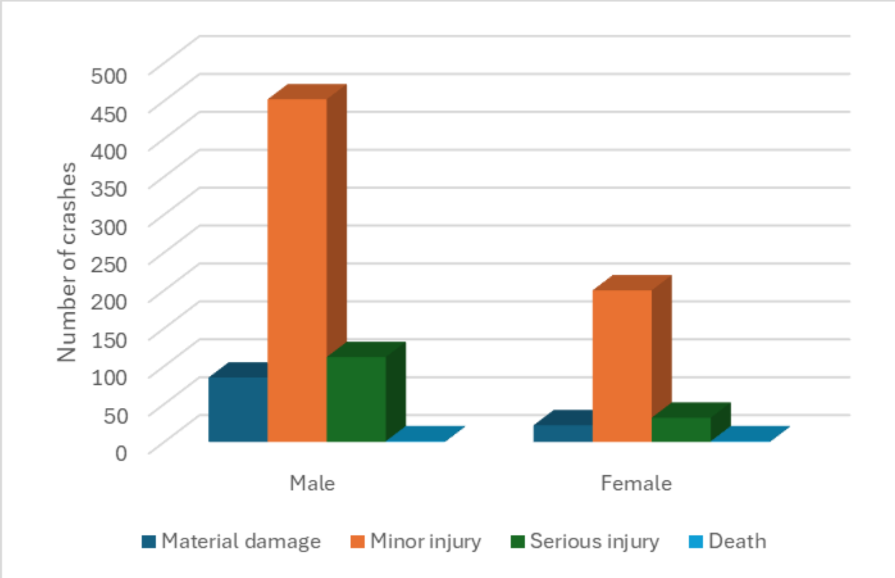

Figure 28. Gender of the perpetrator according to PN classification (N = 905)

The analysis shows (Figure 28) that traffic crashes were more frequently caused by men, regardless of their classification. However, the results of the chi-square test show that there is no statistically significant correlation between the gender of the perpetrator and the classification of the traffic crash ($p > 0.05$). This means that the type of consequences of a traffic crash does not differ significantly depending on the gender of the perpetrator – men and women cause similar types of crashes in similar proportions.

The purpose of the further analysis was to examine the relationship between the gender of traffic crash participants and the measured value of alcohol in exhaled air (Figure 29), classified into six content-defined classes according to legally defined limits and penalties. The data used includes 135 cases with a valid alcohol value, representing 14.9% of the total sample.

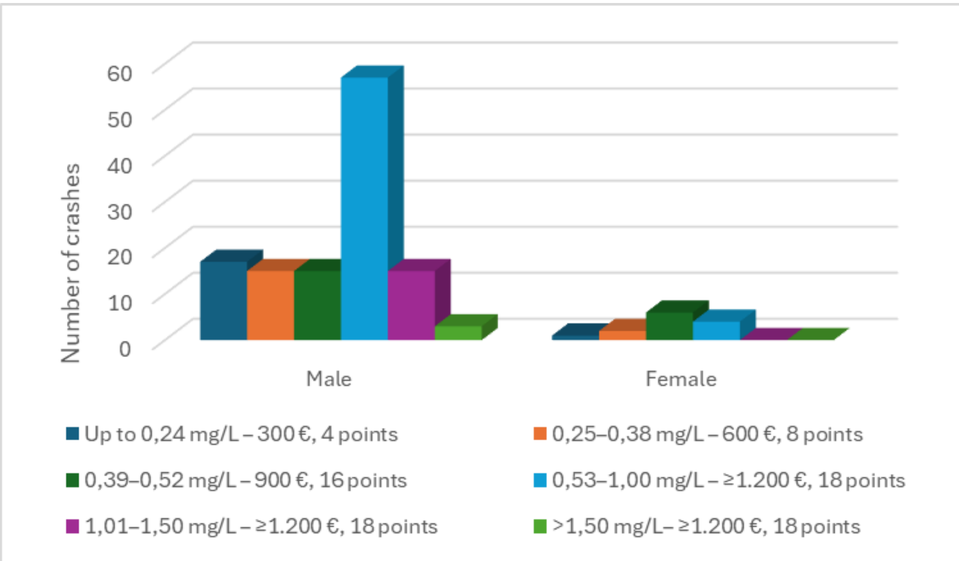

Figure 29. Distribution of alcohol levels by gender of traffic crash participants (N = 135)

An analysis of the relationship between gender and breath alcohol concentration in participants involved in traffic crashes showed statistically significant differences ($\chi^2 = 11.670$; $p = 0.040$). Among the 135 cases with valid alcohol values, the participants were mostly men (90.4%), while women accounted for only a small proportion (9.6%). The most common alcohol level among men was between 0.53 and 1.00 mg/L (46.7%), which is a high level of intoxication leading to the withdrawal of a driving licence. Among women, the highest number of cases was recorded in the 0.39–0.52 mg/L range (46.2%), which corresponds to a fine of €900 and 16 penalty points.

5.3 Description of e-scooter riders' safety indicators in Croatia

During the 2023–2024 period, a total of 613 e-scooter crashes were recorded. Of these, 225 crashes occurred in 2023, accounting for 36.7% of all recorded cases, while 388 occurred in 2024, representing 63.3% of the total. Overall, 616 e-scooters (e-scooter riders) were involved in these crashes, indicating that in some cases more than one scooter was involved in a single crash event.

In this report, injury severity in e-scooter crashes is classified into three categories: death or severe injury, mild injury, and no injury. For 19 cases, the injury consequence was not recorded and therefore could not be classified. Among the cases with available data, death or severe injury was reported in 162 cases (27.1%), mild injury in 301 cases (50.4%), and no injury in 134 cases (22.4%), indicating that more than half of the recorded crashes resulted in some level of injury, most commonly mild injuries.

The following subsections, based on the consequences of crash participants on e-scooters, show the distribution of consequence severity across various environmental, temporal, and participant-related variables.[4]

5.3.1 Time, season and weather conditions

This section explores how the distribution of crash severity varies with time-related factors, such as day of the week and seasonality.

Table 8 presents the distribution of crash outcomes by year. In 2023, death or severe injuries accounted for 25.9% of cases, mild injuries for 52.3%, and no injury for 21.8%. A similar pattern was observed in 2024: 27.8% of crashes resulted in death or severe injury, 49.3% in mild injury, and 22.8% in no injury. Overall, mild injuries remained the most common outcome in both years. In contrast, the proportion of severe outcomes increased slightly in 2024 compared to 2023.

[4] Note: the sum of the cases in the tables corresponds to the available (recorded) data for each variable.

Table 8. Distribution of crash outcomes by year

Year	Death or severe injury	Mild injury	No injury
2023	56 (25.9%)	113 (52.3%)	47 (21.8%)
2024	106 (27.8%)	188 (49.3%)	87 (22.8%)
Overall	162 (27.1%)	301 (50.5%)	134 (22.4%)

Table 9 presents the distribution of crash outcomes by month. Death or severe injuries were proportionally more frequent during the winter months, particularly in January (50.0%) and March (41.7%). In contrast, mild injuries predominated throughout most of the year. The highest number of crashes occurred during the warmer months, with June and July recording the largest shares of mild injuries (56.0% and 47.3%, respectively). No-injury crashes were relatively more common in transitional months such as April, September, and October, accounting for around one-quarter to one-third of cases. Overall, the results suggest a clear seasonal pattern: higher e-scooter crash frequency in warmer months and a relatively higher proportion of severe outcomes during the winter.

Table 9. Distribution of crash outcomes by month

Month	Death or severe injury	Mild injury	No injury
January	10 (50.0%)	7 (35.0%)	3 (15.0%)
February	5 (29.4%)	9 (52.9%)	3 (17.6%)
March	10 (41.7%)	9 (37.5%)	5 (20.8%)
April	7 (23.3%)	13 (43.3%)	10 (33.3%)
May	16 (31.4%)	22 (43.1%)	13 (25.5%)
June	25 (27.5%)	51 (56.0%)	15 (16.5%)
July	39 (34.8%)	53 (47.3%)	20 (17.9%)
August	13 (17.8%)	43 (58.9%)	17 (23.3%)
September	14 (18.2%)	41 (53.2%)	22 (28.6%)
October	13 (22.4%)	27 (46.6%)	18 (31.0%)
November	5 (18.5%)	16 (59.3%)	6 (22.2%)
December	5 (29.4%)	10 (58.8%)	2 (11.8%)

Table 10 presents the distribution of crash outcomes by day of the week. Mild injuries were the most common outcome on all days, accounting for approximately half of the crashes throughout the week. The proportion of death or severe injury was relatively stable from Monday to Saturday, ranging between 22.0% and 27.7%, but increased notably on Sunday, when severe outcomes accounted for 40.9% of cases. No-injury crashes were more frequent on weekdays, particularly on Tuesday and Wednesday (26.8% and 26.4%, respectively), and least common on Sunday (9.1%). Overall, the results indicate a higher relative severity of e-scooter crashes during weekends, especially on Sundays, compared to weekdays.

Table 10. Distribution of crash outcomes by day of the week

Day	Death or severe injury	Mild injury	No injury
Monday	20 (22.0%)	48 (52.7%)	23 (25.3%)
Tuesday	19 (23.2%)	41 (50.0%)	22 (26.8%)
Wednesday	19 (26.4%)	34 (47.2%)	19 (26.4%)
Thursday	28 (27.7%)	51 (50.5%)	22 (21.8%)
Friday	28 (25.9%)	52 (48.1%)	28 (25.9%)
Saturday	21 (27.3%)	42 (54.5%)	14 (18.2%)
Sunday	27 (40.9%)	33 (50.0%)	6 (9.1%)

Table 11 shows the distribution of crash outcomes by visibility condition, reflecting differences by time of day. Night-time crashes accounted for the largest number of cases, with death or severe injuries reported in 26.6% of crashes, mild injuries in 48.6%, and no injury in 24.8%. During daytime conditions, a slightly higher proportion of death or severe injuries was observed (31.1%), along with a higher share of mild injuries (53.8%) and a lower proportion of no-injury crashes (15.2%). Crashes occurring at dusk and dawn were less frequent overall and were predominantly associated with mild injuries; however, these results should be interpreted with caution due to the small number of cases in these categories.

Table 11. Distribution of crash outcomes by visibility conditions

Visibility conditions	Death or severe injury	Mild injury	No injury
Night	117 (26.6%)	214 (48.6%)	109 (24.8%)
Day	41 (31.1%)	71 (53.8%)	20 (15.2%)
Dusk	3 (15.8%)	11 (57.9%)	5 (26.3%)
Dawn	1 (16.7%)	5 (83.3%)	0 (0.0%)

Table 12 presents the distribution of crash outcomes by weather conditions. In bright weather, crashes most frequently resulted in mild injuries (48.0%), followed by death or severe injuries (32.9%) and no injury (19.1%). In cloudy conditions, mild injuries were even more prevalent, accounting for 57.0% of cases, while death or severe injuries represented 21.1%. Crashes occurring during rain showed a higher proportion of death or severe injuries (44.4%). However, the total number of cases in rainy conditions was relatively small. Fog-related crashes were rare and resulted exclusively in mild injuries. In contrast, crashes classified under other weather conditions showed a relatively high share of severe outcomes (50.0%). These findings suggest that adverse weather conditions may be associated with a higher relative severity of e-scooter crashes. However, the results for less frequent conditions should be interpreted with caution due to small sample sizes.

Table 12. Distribution of crash outcomes by weather circumstances

Atmospheric conditions	Death or severe injury	Mild injury	No injury
Brightly	50 (32.9%)	73 (48.0%)	29 (19.1%)
Cloudy	24 (21.1%)	65 (57.0%)	25 (21.9%)
Rain	8 (44.4%)	5 (27.8%)	5 (27.8%)
Fog	0 (0.0%)	2 (100.0%)	0 (0.0%)
Other	5 (50.0%)	4 (40.0%)	1 (10.0%)

5.3.2 E-scooter riders' demographics and rider-related variables

Table 13 delivers the distribution of crash outcomes by rider gender. Among male riders, crashes most commonly resulted in mild injuries (46.6%), followed by death or severe injuries (29.7%) and no-injury outcomes (23.8%). In contrast, female riders experienced a higher proportion of mild injuries (62.7%) and a lower share of death or severe injuries (23.2%) compared to males. Overall, the results indicate gender-related differences in injury severity, with male riders more often involved in crashes with severe outcomes. On the other hand, female riders were more likely to sustain mild injuries.

Table 13. Distribution of crash outcomes based on rider gender

Gender	Death or severe injury	Mild injury	No injury
Male	121 (29.7%)	190 (46.6%)	97 (23.8%)
Female	41 (23.2%)	111 (62.7%)	25 (14.1%)

Based on the available data, the mean age of riders was 28.7 years (SD = 16.9), with a median age of 22.0 years (IQR = 16.0–39.0), indicating that crashes predominantly involved younger riders, while a wide age range was also present. Information on vehicle age was available for 472 cases, showing that e-scooters involved in crashes were relatively new, with a mean age of 2.1 years (SD = 2.5) and a median of 2.0 years (IQR = 1.0–3.0).

Table 14 presents the distribution of crash outcomes across rider age groups. Death or severe injuries were most prevalent among riders older than 35 years, accounting for 33.1% of crashes in this age group, followed by riders aged 18–24 years (29.9%). Riders aged 25–35 years showed the lowest proportion of severe outcomes (23.7%) and the highest share of mild injuries (62.9%). Among riders younger than 18 years, mild injuries were the most common outcome (51.4%), while the proportions of severe injuries (24.1%) and no-injury crashes (24.5%) were similar.

Additional descriptive statistics of rider age by crash outcome further support these findings. Riders involved in crashes resulting in death or severe injury had the highest mean age (31.1 years, SD = 18.3) and median age (24.5 years, IQR = 16.0–45.0). In comparison, crashes resulting in mild injury involved slightly younger riders (mean = 28.5 years, SD = 16.1; median = 24.0 years, IQR = 16.0–38.0), while no-injury crashes were associated with the youngest riders on average (mean = 26.4 years, SD = 16.6; median = 18.0 years, IQR = 16.0–30.8). Overall, the results indicate a tendency toward more severe outcomes among older riders.

In addition to the distribution of outcomes, the total number of crash participants differed across age groups. Riders younger than 18 accounted for the largest number of crash participants, with 216 cases. This was followed by riders aged 35 or older, who were involved in 175 crashes. The age groups 18–24 years and 25–35 years each accounted for 97 crash participants. Overall, the results indicate that although younger riders were more frequently involved in crashes, older riders experienced a higher proportion of severe outcomes.

Table 14. Distribution of crash outcomes based on rider age

Age groups (years)	Death or severe injury	Mild injury	No injury
<18	52 (24.1%)	111 (51.4%)	53 (24.5%)
18–24	29 (29.9%)	41 (42.3%)	27 (27.8%)
25–35	23 (23.7%)	61 (62.9%)	13 (13.4%)
>35	58 (33.1%)	88 (50.3%)	29 (16.6%)

Table 15 presents the distribution of crash outcomes by rider nationality. Among Croatian riders (80.6% of cases), crash participants most frequently suffered mild injuries (49.9%), followed by death or severe injuries (28.7%) and no-injury outcomes (21.4%). Riders of other nationalities showed a higher proportion of mild injuries (58.7%) and a lower share of death or severe injuries (23.1%) compared to Croatian riders, while no-injury crashes accounted for 18.3% of cases.

Table 15. Distribution of crash outcomes based on rider nationality

Nationality	Death or severe injury	Mild injury	No injury
Croatian	138 (28.7%)	240 (49.9%)	103 (21.4%)
Other	24 (23.1%)	61 (58.7%)	19 (18.3%)

More than 80% of riders were not wearing helmets. Table 16 shows the distribution of crash outcomes by helmet use. Among riders who were wearing a helmet at the time of the crash, mild injuries were the most common outcome (51.7%), followed by death or severe injuries (28.8%) and no-injury crashes (19.5%). A similar pattern was observed among riders not using a helmet, with mild injuries accounting for 50.1% of cases, death or severe injuries for 26.7%, and no-injury outcomes for 23.2%.

Table 16. Distribution of crash outcomes based on helmet usage

Helmet used	Death or severe injury	Mild injury	No injury
Yes	34 (28.8%)	61 (51.7%)	23 (19.5%)
No	128 (26.7%)	240 (50.1%)	111 (23.2%)

The distribution of crash outcomes according to alcohol use is shown in Table 17. Among riders who tested positive for alcohol, mild injuries were the most frequent outcome (63.0%), followed by death or severe injuries (26.0%), while no-injury crashes accounted for 11.0% of cases. For riders who did not use alcohol, mild injuries remained the most common outcome (48.6%), with death or severe injuries reported in 27.3% of crashes and no-injury outcomes in 24.1%. Only one crash involved a rider who refused alcohol testing, resulting in a mild injury.

Table 17. Distribution of crash outcomes based on alcohol use among e-scooter riders

Alcohol usage levels in crashes	Death or severe injury	Mild injury	No injury
Yes	19 (26.0%)	46 (63.0%)	8 (11.0%)
No	143 (27.3%)	254 (48.6%)	126 (24.1%)
Refused testing	0 (0.0%)	1 (100.0%)	0 (0.0%)

5.3.3 Road conditions

Table 18 presents the distribution of crash outcomes by road surface condition. Crashes occurring on dry and clean road surfaces most commonly resulted in mild injuries (50.9%), followed by death or severe injuries (26.6%) and no-injury outcomes (22.5%). On dry surfaces with sand or gravel present, more than half of the crashes resulted in death or severe injury (55.6%). However, the number of such cases was minimal and should be interpreted with caution. On a wet road, mild injuries accounted for 45.7%, death or severe injuries for 28.3%, and no-injury crashes for 26.1%. Overall, the available data suggest that reduced surface quality, particularly the presence of sand or gravel, may be associated with increased injury severity in e-scooter crashes.

Table 18. Distribution of crash outcomes based on road surface condition

Road surface condition	Death or severe injury	Mild injury	No injury
Dry and clean	144 (26.6%)	276 (50.9%)	122 (22.5%)
Dry, sand and gravel	5 (55.6%)	4 (44.4%)	0 (0.0%)
Wet	13 (28.3%)	21 (45.7%)	12 (26.1%)

Table 19 presents the distribution of crash outcomes by road structure condition. On roads assessed as being in good condition, crashes most commonly resulted in mild injuries (51.5%), followed by severe injuries or death (25.2%) and no injuries (23.4%). In contrast, crashes occurring on roads with minor structural damage showed a higher proportion of severe outcomes (42.9%). In comparison, mild injuries accounted for 45.7% of cases. The highest relative share of death or severe injuries was observed on roads in poor condition, where 64.3% of crashes resulted in severe outcomes (although the number of such cases was limited). Altogether, the results indicate a potential association between deteriorating road infrastructure and increased crash severity, with poorer infrastructure associated with more severe injury outcomes.

Table 19. Distribution of crash outcomes based on road structure condition

Road structure condition	Death or severe injury	Mild injury	No injury
Good	138 (25.2%)	282 (51.5%)	128 (23.4%)
Minor damage	15 (42.9%)	16 (45.7%)	4 (11.4%)
Poor	9 (64.3%)	3 (21.4%)	2 (14.3%)

5.3.4 Crash characteristics and circumstances

The majority of e-scooter crashes occurred in areas with a posted speed limit of 50 km/h, which is typical for urban road networks. Considerably fewer crashes were recorded in areas with lower speed limits (≤40 km/h), while crashes in areas with speed limits above 50 km/h were relatively rare. This distribution reflects e-scooter riders' predominant exposure to urban traffic environments, providing context for interpreting differences in crash outcomes across speed limit categories.

In areas with speed limits of 40 km/h or lower, mild injuries were the most common outcome (50.6%), followed by no-injury crashes (26.0%) and death or severe injuries (23.4%) (Table 20). In 50 km/h zones, crashes showed a similar pattern, with mild injuries accounting for 49.7% of cases, death or severe injuries for 27.9%, and no-injury outcomes for 22.4%. In areas with speed limits above 50 km/h, mild injuries were predominant (66.7%), while no-injury crashes were relatively rare (9.5%). Although the number of crashes in higher-speed areas was limited, the results suggest that higher-speed environments may be associated with a greater likelihood of injury in e-scooter crashes.

Table 20. Distribution of crash outcomes based on speed limit in the crash area

Speed limit of crash area (km/h)	Death or severe injury	Mild injury	No injury
≤40	18 (23.4%)	39 (50.6%)	20 (26.0%)
50	139 (27.9%)	248 (49.7%)	112 (22.4%)
>50	5 (23.8%)	14 (66.7%)	2 (9.5%)

The distribution of crash outcomes by public lighting functionality in the crash area is shown in Table 21. Most crashes occurred in areas with functional public lighting, again reflecting the predominance of illuminated urban environments. In these areas, mild injuries were the most common outcome (51.9%), followed by death or severe injuries (30.4%) and no-injury crashes (17.7%). Crashes in areas without public lighting were relatively rare, with mild injuries accounting for 48.7% of cases. Based on differences in injury severity across lighting conditions, public lighting functionality alone does not fully explain variations in crash outcomes.

Table 21. Distribution of crash outcomes based on public lighting functionality in the crash area

Public lighting	Death or severe injury	Mild injury	No injury
Functional	48 (30.4%)	82 (51.9%)	28 (17.7%)
Non-functional	93 (26.4%)	172 (48.9%)	87 (24.7%)
Not present	12 (30.8%)	19 (48.7%)	8 (20.5%)

The most common crash types involving e-scooter riders were classified as other crashes, followed by side-impact collisions and run-off-road crashes. Collisions from opposite directions and collisions with objects near or on the road were less frequent.

Table 22 delivers the distribution of crash outcomes by crash type. Run-off-road crashes were associated with the highest proportion of death or severe injuries (39.5%) and the lowest share of no-injury outcomes (2.5%), indicating a particularly high severity of this crash type. Side-impact collisions most often resulted in mild injuries (54.5%), while severe outcomes were relatively less common (18.6%). Collisions with objects near or on the road were predominantly associated with mild injuries (53.8%). The results indicate notable differences in injury severity by crash type, with run-off-road crashes posing the greatest risk of severe outcomes for e-scooter riders.

Table 22. Distribution of crash outcomes based on crash type

Type of crash	Death or severe injury	Mild injury	No injury
From opposite directions	12 (27.9%)	18 (41.9%)	13 (30.2%)
Side impact	29 (18.6%)	85 (54.5%)	42 (26.9%)
Run-off-road	32 (39.5%)	47 (58.0%)	2 (2.5%)
Collision with object near / on the road	8 (30.8%)	14 (53.8%)	4 (15.4%)
Other	81 (27.8%)	137 (47.1%)	73 (25.1%)

In addition to the crash type, important information is also the circumstances of the crash itself. Prevailing, the most frequently recorded crash circumstances involved illegal or inappropriate speed, followed by other circumstances and disregard of right-of-way or yield rules.

Crashes involving illegal or inappropriate speed showed the highest proportion of death or severe injuries (36.1%), along with a relatively low share of no-injury outcomes (14.5%), indicating a higher overall severity for this circumstance (Table 23). Disregard of right-of-way or yield most commonly resulted in mild injuries (58.0%), while severe outcomes were less frequent (21.7%). Alike patterns were observed for improper vehicle movement, improper inclusion into traffic, and improper turning, where mild injuries accounted for more than half of the cases.

Table 23. Distribution of crash outcomes based on the circumstances of the crash occurrence

Crash circumstances	Death or severe injury	Mild injury	No injury
Illegal / inappropriate speed	60 (36.1%)	82 (49.4%)	24 (14.5%)
Disregard of right-of-way / yield	15 (21.7%)	40 (58.0%)	14 (20.3%)
Careless handling of the vehicle	4 (30.8%)	6 (46.2%)	3 (23.1%)
Improper movement of vehicles on the road	14 (20.9%)	35 (52.2%)	18 (26.9%)
Improper inclusion into traffic	12 (20.7%)	31 (53.4%)	15 (25.9%)
Improper turning	3 (21.4%)	8 (57.1%)	3 (21.4%)
Other	54 (25.7%)	99 (47.1%)	57 (27.1%)

Table 24 presents the distribution of crash outcomes by road element at the crash location. The largest number of cases appeared on straight road sections and at intersections, reflecting the most common riding environments for e-scooter users.

Crashes on straight road sections were associated with a relatively high proportion of death or severe injuries (32.7%), while mild injuries remained the most frequent outcome (49.5%). At intersections, more than half of crashes resulted in mild injuries (56.2%), with severe outcomes accounting for 22.5% of cases. Curves also showed a relatively high share of severe outcomes (30.8%), although the number of such crashes was limited.

Crashes occurring on sidewalks, bicycle paths, and pedestrian or calm traffic zones showed a higher proportion of no-injury outcomes compared to other locations, particularly on sidewalks (35.7%) and bicycle paths (30.0%). However, pedestrian or calm traffic zones exhibited the highest relative share of death or severe injuries (47.1%). The relatively small sample size limits the interpretation of these data. Still, it is certainly concerning that serious injuries to riders occur in traffic-calmed zones or vulnerable road users' dedicated areas.

Table 24. Distribution of e-scooter crash outcomes by road element at the crash location on the roadway

Crash circumstances	Death or severe injury	Mild injury	No injury
Intersections	38 (22.5%)	95 (56.2%)	36 (21.3%)
Straight road section	70 (32.7%)	106 (49.5%)	38 (17.8%)

Crash circumstances	Death or severe injury	Mild injury	No injury
Curve	12 (30.8%)	23 (59.0%)	4 (10.3%)
Pedestrian crossing	5 (17.9%)	15 (53.6%)	8 (28.6%)
Sidewalk	18 (25.7%)	27 (38.6%)	25 (35.7%)
Bicycle path	4 (13.3%)	17 (56.7%)	9 (30.0%)
Pedestrian / calm traffic zone	8 (47.1%)	4 (23.5%)	5 (29.4%)
Other	7 (23.3%)	14 (46.7%)	9 (30.0%)

Crashes also differ in the number of vehicles that were involved. Table 25 brings up the distribution of crash outcomes by the number of vehicles involved in the crash. Single-vehicle crashes were associated with the highest proportion of death or severe injuries (40.6%) and a very low share of no-injury outcomes (5.4%). Crashes involving two vehicles most commonly resulted in mild injuries (48.8%), whereas no-injury outcomes were substantially more frequent (36.2%) than in single-vehicle crashes. Crashes involving three or more vehicles were relatively rare and showed mixed outcomes.

Interestingly, the findings underline single-vehicle crashes as a potential significant contributor to severe injury outcomes among e-scooter riders. Also, such results indicate that there is room for improvement among e-scooter riders, in the form of additional education, skill training, knowledge of the infrastructure, and similar.

Table 25. Distribution of e-scooter crash outcomes by number of vehicles involved

No. of vehicles in crash	Death or severe injury	Mild injury	No injury
1	106 (40.6%)	141 (54.0%)	14 (5.4%)
2	48 (15.0%)	156 (48.8%)	116 (36.2%)
3 or more	8 (50.0%)	4 (25.0%)	4 (25.0%)

6. INJURIES AND HEALTH CONSEQUENCES OF TRAFFIC CRASHES INVOLVING E-SCOOTERS: ANALYSIS OF DATA FROM SLOVENIAN HOSPITAL EMERGENCY CENTRES

The increased use of e-scooters has also led to an increase in traffic crashes involving users of these vehicles. As a result, there has also been an increase in the number of injuries requiring individuals to seek emergency medical assistance. In this chapter, we present an overview of data obtained from emergency centres in Slovenian hospitals. We will analyse the data from the University Medical Centre Ljubljana in particular detail, as they are the only ones to have provided more detailed information that allows for in-depth insights into the nature of injuries and the circumstances of crashes.

6.1 Data on injured persons from emergency centres in Slovenian hospitals

As part of the project, we asked Slovenian hospitals for data on the number of patients admitted to emergency departments due to injuries related to riding a scooter – more specifically, due to falling off a scooter.

The emergency centre at Celje General Hospital reported that they collect data separately according to the object causing the injury (folding scooter) and the cause of the injury (falling off a scooter), and provided us with data for a combination of both categories. Between 2014 and 2018, there were no recorded cases of injuries due to falls with folding scooters. In 2019, they recorded one case, in 2020 and 2021 six cases each, in 2022 eight cases, and in 2023 fourteen cases. The most significant increase was recorded in 2024, when there were as many as 60 cases of injuries caused by falls from folding scooters. These data show a clear upward trend in injuries related to the use of scooters, especially in recent years.

The Emergency Centre of the Brežice General Hospital reported that in 2023, they treated 3 patients with injuries related to falls from scooters in 2023, and in 2024, this number increased to 27. Among them, all 3 injured in 2023 were men, while in 2024 there were 18 men and 9 women. All those injured in 2023 were treated on an outpatient basis, while in 2024 one person was hospitalised (more detailed information on the length of hospitalisation is not available without additional insight). The locations of the crashes are reported to be scattered – among other places, injuries occurred on the road, in the outdoor areas of residences and in public areas, with several cases without a precisely defined location of the event.

Below, we present the data we received from the University Medical Centre Ljubljana. They were the only ones to provide us with detailed information on injuries related to scooter falls, so we present them separately and in somewhat greater detail.

6.1.1 Data on injuries from the University Medical Centre Ljubljana

We received detailed data from the University Medical Centre Ljubljana on patients injured in scooter crashes in 2023 and 2024 (including certain data for the years from 2019 onwards relating to subsequent related treatments). The data includes numerous elements that enable a more in-depth analysis of the circumstances and consequences of crashes, including: code and description of the cause of injury, diagnosis and its description, method of arrival of the injured person (e.g. ambulance, helicopter), time of injury, location and detailed description of the crash site, and cost of medical treatment.

6.1.2 Descriptive analysis of traffic crash data

It is important to note that the data we received does not allow us to distinguish between users of classic scooters and electric scooters. In most cases, the type of scooter is not specifically indicated in the records, so the analysis includes all injuries sustained in scooter crashes, regardless of whether they involved a conventional or electric scooter.

As we cannot use personal data to identify individuals, we used the number of unique hospital admissions based on a combination of the date and time of injury to determine the number of people who came to the clinical centre due to injuries related to a fall while riding a scooter. In this way, we recorded 611 such cases in 2023 and 551 in 2024 (additional admissions were recorded: 2019: 1 person, 2020: 2 persons, 2021: 9 persons, 2022: 31 persons).

In the following analysis, we will attempt to present basic data on arrivals at the centre (Figure 30), injured persons and locations of injuries, such as: gender (Figure 31), age (Figure 32), place of occurrence (Figure 33) and description of the place of occurrence, linking this information to unique crash events. This means that an individual who was treated multiple times due to a single scooter crash (e.g., due to multiple visits or follow-up examinations) will only be counted once in this analysis. With this approach, we want to avoid duplication of basic demographic data. All further analyses will be performed at the level of individual hospital admissions, as recorded in the “Admission” variable. This variable specifies the time and links the unit to which the patient was referred, so the same person may appear more than once – for example, if they were treated in several different units on the same day or were transferred from one unit to another.

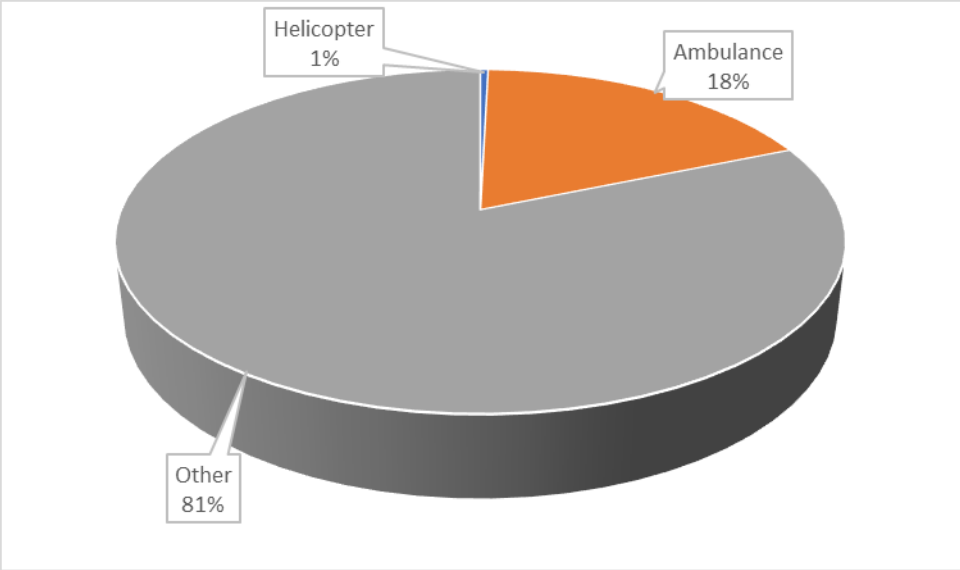

Figure 30. Mode of arrival at hospital for injuries caused by falling off a scooter (N = 1218)

An analysis of the manner of arrival (Figure 30) of those injured in scooter crashes at the hospital shows that in the vast majority of cases (990 cases) other forms of arrival were involved, most likely including self-reporting or arrival by private transport or with the help of another person. In 223 cases, the injured arrived by ambulance, indicating more serious injuries or situations where an immediate response by the emergency medical services was required. There were also 5 recorded cases of arrivals by helicopter, which clearly indicates the most serious cases, which probably involved severe injuries or events in areas that were more difficult to access.

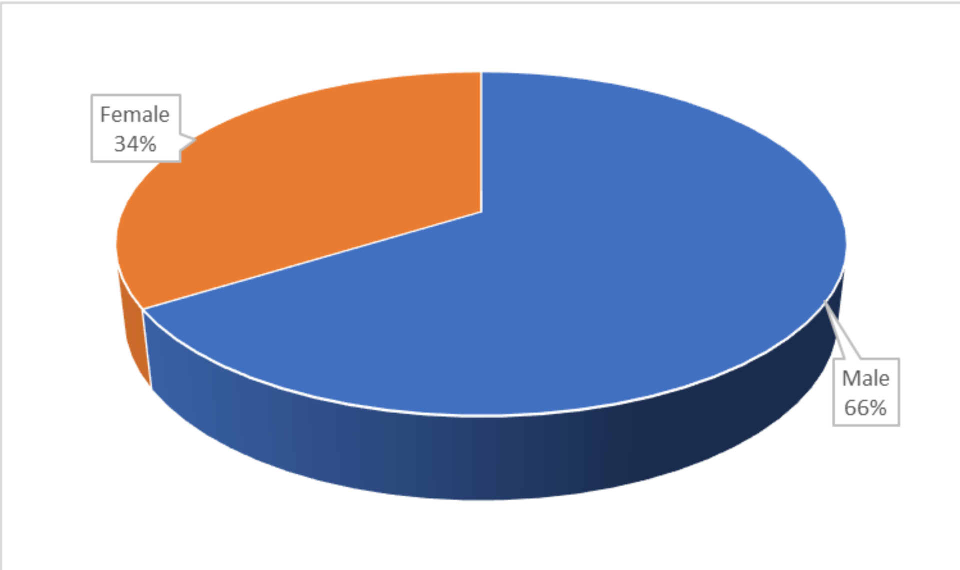

Figure 31. Gender structure of those injured in scooter falls (N = 1219)

Based on the pie chart shown (Figure 31), we can conclude that the University Medical Centre Ljubljana treated more injuries caused by falls from scooters among men during the period in question (2023–2024), treated more men injured in scooter falls – they accounted for 66% of all cases treated, while women accounted for 34%.

The pie chart shows (Figure 32) the distribution of injuries caused by scooter falls by age group. Children under the age of 12 account for the largest share (21%), which indicates greater vulnerability or perhaps less experience among the youngest users. This is followed by the 26 to 40 age group with 20%. The 14 to 17 and 18 to 25 age groups are equally represented, each with 14%. The 12 to 13 and 41 to 50 age groups each account for 12% of all cases, while there are relatively few injuries among those over 51 (7%). These data show that injuries are spread across different age groups, with a higher concentration among children and adults in early middle age.

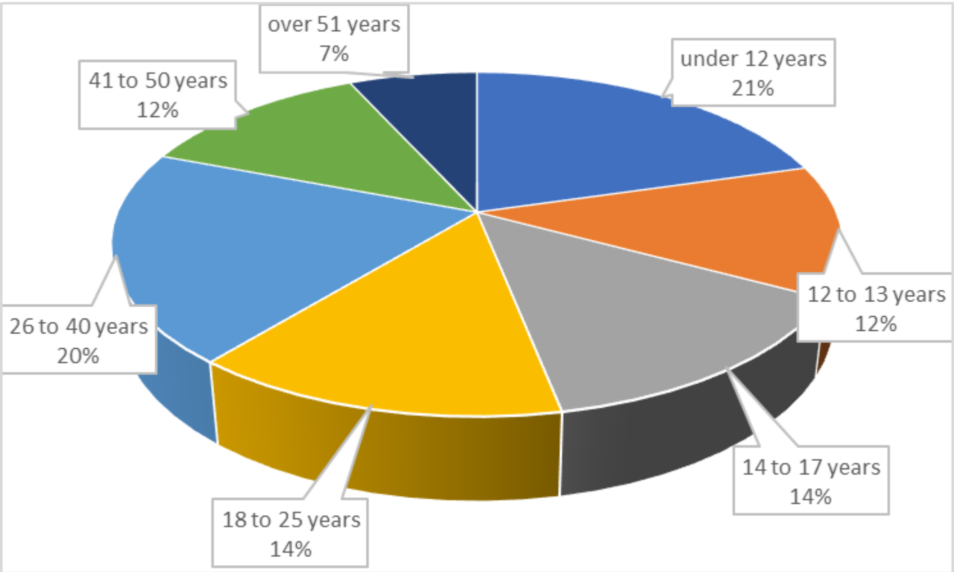

Figure 32. Age structure of people injured in scooter falls (N = 1211)

An analysis of data on the location of crashes (Figure 33) in which scooter users were injured shows that most injuries occur on roads, where 596 cases were recorded, representing by far the largest share. This confirms that scooters are often used in traffic environments where users are exposed to greater dangers. This is followed by the category "other specified locations" with 281 cases, which includes diverse but clearly defined locations, and sports areas with 154 injuries, indicating that crashes often occur during leisure and recreational use. The number of injuries at home (125 cases) is also surprisingly high. Injuries in unspecified locations (31 cases) and in schools or public administration areas (27 cases) are less common but still present. Very few injuries were recorded in commercial areas (3) and industrial/construction areas (1), while no cases were recorded in the categories of residential institutions and farms.

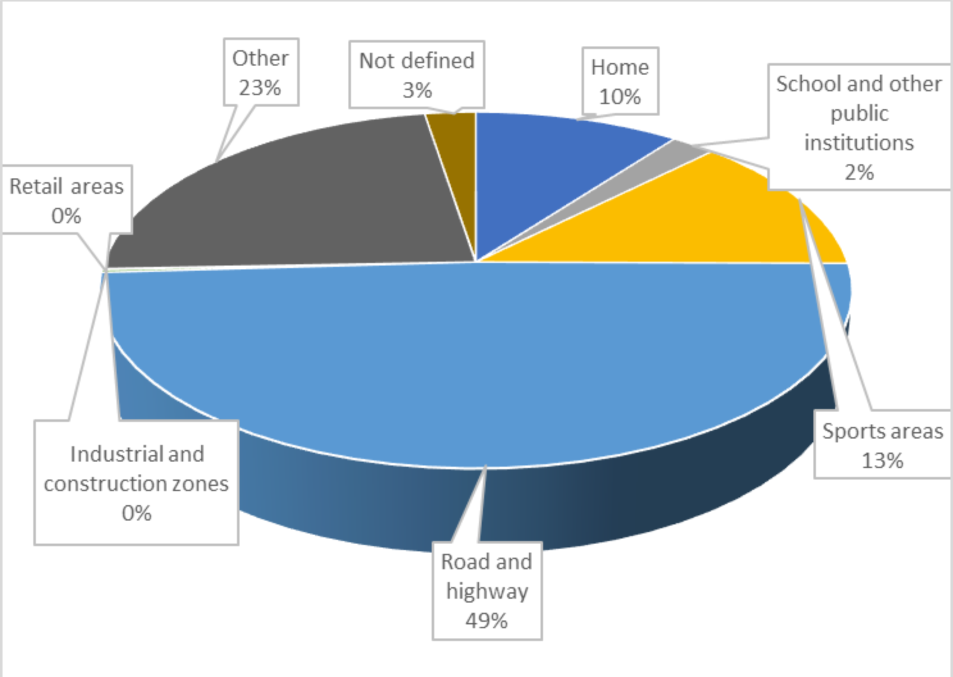

Figure 33. Locations of crashes/injuries (N = 1218)

An analysis of the specific locations of crashes in which scooter users were injured confirms the findings of the more general classification, while also providing a more detailed insight into the specific environments where falls occur. Most crashes occurred on roads (609 cases) and pavements (296 cases). The most exposed locations are therefore:

- Road: 609;
- Pavements: 296;
- Other specified location of the event: 66;
- Outside the home, other: 58;
- Other specified sports facilities: 38;
- Outdoor sports area: 27;
- Residential area, other specified: 14;
- Private driveway, car park, garage, auxiliary garage (carport), path: 12;
- Public park: 11;
- Other designated road: 9;
- Public playground: 9;
- Kindergarten, childcare: 8;
- Sports areas at schools and other educational institutions: 7;
- Garden: 6;
- Residential area, undefined: 6;
- Cycle path: 6;
- Undefined location of event: 6;
- School, university: 5;
- Playgrounds at schools and other educational institutions: 5;
- Car park: 4;

- Playground in residential area: 2;
- Public transport areas and facilities: 2;
- Other specified industrial or construction facilities: 2;
- Undefined landscape: 2;
- Living room, bedroom: 1;
- Stairs in a building: 1;
- Sports hall: 1;
- Undefined sports facility: 1;
- Undefined roadway: 1;
- Other defined transport area: other: 1
- Other defined recreational area, cultural or public building: 1;
- Other defined landscape: 1.

Each individual patient who arrived at the clinical centre was admitted or referred to one or more departments depending on the nature and severity of their injuries. In many cases, treatment required diagnosis, treatment or monitoring in several different units. Below (Figure 34) we show the distribution of injured persons according to the number of visits or referrals to individual units.

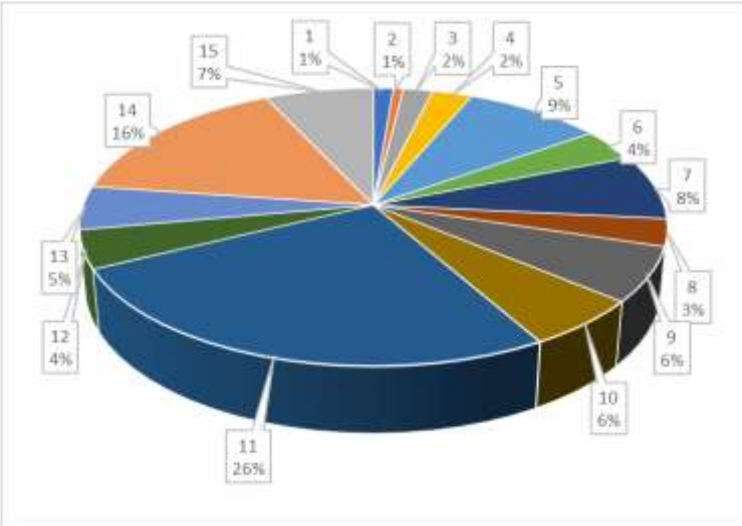

Figure 34. Frequency of treatment of injured persons in several clinical units (N = 1218)

The results show (Figure 34) that the largest group of injured persons was treated in only one unit (mostly the Traumatology Clinic/Emergency Clinic for Traumatological Surgery) – there were 785 such cases, representing more than two-thirds of all injured persons. This indicates that for most injured persons, the extent of their injuries or clinical picture allowed for comprehensive treatment in a single department without additional transfers. Approximately 15% of injured persons (173 cases) were referred to two units, which may indicate the need for additional diagnostic procedures or more complex treatment. With the increase in the number of units to which an individual was assigned, the number of cases gradually decreases – e.g., 99 injured persons were assigned to three units, 72 to four, and so on. Only in extremely rare cases (e.g., 1 case with 25 and even 41 units) are these likely to be specific or administratively demanding cases that deviate from the average. These results confirm that most injuries can be managed within one or two units, while more extensive treatment is required in only a small number of cases.

An analysis of data on injuries sustained by patients due to falls from scooters reveals a wide variety of diagnoses covering injuries to numerous anatomical areas – from the main bones of the facial region, through injuries to the forearm, hand and elbow, to the joints of the feet and lower legs. Minor contusions, wounds and fractures are common, but serious injuries are also present, e.g., trimaleolar fractures, subarachnoid haemorrhages or complex fractures of multiple bones. In the following report, we present the most common injuries recorded in 2023 and 2024 to show the range and frequency of individual diagnoses by institution. These were (injury, number of cases; one person may appear more than once – multiple diagnoses):

- Superficial scalp injury, contusion: 162;
- Fracture of the lower part of the radius, unspecified part: 140;
- Contusion of other parts of the wrist and hand: 109;
- Fracture of the upper part of the radius, head: 98;
- Knee injury: 87;
- Wound on other parts of the head: 80;
- Concussion – intracranial injury: 60;
- Elbow contusion: 58;
- Contusion of the shoulder and upper arm: 53;
- Superficial injury to other parts of the head, contusion: 53;
- Clavicle fracture, middle part: 44;
- Fracture of the lower part of the radius and ulna: 43;
- Trimaleolar fracture: 41;
- Fracture of upper part of tibia, other: 40;
- Superficial injury to the scalp, unspecified: 35;
- Chest contusion: 33;
- Fracture of the diaphysis of the forearm and radius: 33;
- Sprain and strain of the ankle joint, unspecified: 31;
- Fracture of the foot: 30;
- Fracture of the lower part of the tibia, with fracture of the fibula: 29;
- Acromioclavicular syndesmosis: 29;
- Fracture of the navicular bone of the wrist: 29;
- Fracture of the lateral malleolus: 25;
- Fracture of the upper part of the humerus, unspecified part: 24;
- Fracture of the lower part of the tibia, other: 22;
- Contusion of other and unspecified parts of the foot: 21;
- Fracture of the diaphysis of the tibia, other: 21;
- Fracture of the cheekbones and upper jawbone: 21;
- Fracture of the lower part of the humerus, supracondylar: 20;

- Fracture of the lower part of the radius, with dorsal angulation: 20;
- Fracture of the first joint of any other toe: 19;
- Finger contusion without nail damage: 18;
- Contusion of the lower back and pelvis: 18;
- Fracture of any other metacarpal bone, unspecified: 18;
- Traumatic subarachnoid haemorrhage: 18;
- Wound on other parts of the shin: 18;
- Tear of the anterior cruciate ligament of the knee: 17;
- Fracture of the diaphysis of the humerus: 17;
- Further treatment involving removal of plates and other internal fixation devices: 16;
- Hip contusion: 16;
- Fracture of the patella: 16;
- Fracture of the nasal bones: 15;
- Fracture of any other finger, unspecified: 15;
- Trochanteric fracture: 15;
- Bimalleolar fracture: 15;
- Posterior dislocation of the elbow: 15;
- Fracture of the upper part of the humerus, large knot: 14;
- Multiple fractures of the forearm: 14;
- Fracture of the second cervical vertebra: 14;
- Fracture of the lower part of the radius, second and multiple fractures: 13;
- Anterior dislocation of the shoulder joint: 12;
- Tooth fracture: 12;
- Fracture of the diaphysis of the tibia: 12;
- Fracture of the upper part of the ulna, olecranon: 11;
- Wound on finger(s) without damage to the nail: 10;
- Fracture of the orbital floor: 10;
- Sprain and strain of other parts of the ankle joint: 10;
- Injury, unspecified: 10;
- Fracture of the middle phalanx of any other finger: 10;
- Fracture of the femoral diaphysis: 10;
- Fracture of the medial malleolus: 9;
- Clavicle fracture, external part: 9;
- Fracture of the upper part of the humerus, surgical neck: 9;
- Fracture of the diaphysis of the ulna, unspecified part: 9;
- Head wound, unspecified part: 8;
- Contusion of the abdominal wall: 8;
- Wound on the lip and in the oral cavity, lip. 8;
- Wound on the elbow: 8;
- Fracture of the tibia: 8;
- Knee dislocation, unspecified: 8;

- Acetabular fracture: 8;
- Contusion of finger(s) with nail injury: 7;
- Fracture of upper part of clavicle, neck: 7;
- Sprain and strain of the wrist, unspecified: 7;
- Fracture of the diaphysis of the radius, unspecified part: 7;
- Scalp wound: 7;
- Tooth loosening: 7;
- Epidural haematoma: 7;
- Skull base fracture: 7;
- Fracture of the tibial diaphysis with fracture of the fibula: 6;
- Pain after insertion of internal orthopaedic prosthetic devices, implants and transplants: 6;
- Fracture of the upper part of the tibia with fracture of the fibula: 6;
- Multiple rib fractures, including two ribs: 6;
- Fracture of the distal phalanx of another finger: 6;
- Rupture of the articular cartilage of the knee, fresh: 6;
- Multiple rib fractures, involving four or more ribs: 6;
- Superficial injury to the scalp, other: 6;
- Fracture of the lower part of the humerus, medial condyle: 6;
- Sprain and strain of the cervical spine: 6;
- Fracture of any other finger: 6;
- Fracture of the lower jaw, unspecified part: 6;
- Infection of a wound after surgery, not classified elsewhere: 6;
- Fracture of the first metacarpal bone, unspecified: 6;
- Dislocation of the patella: 6;
- Traumatic subdural haematoma: 6;
- Fracture of the lunate bone of the wrist: 6;
- Fracture of the lower part of the radius, with volar angulation: 5;
- Fractures of other and unspecified parts of the wrist and hand: 5;
- Wound on other parts of the wrist and hand: 5;
- Sprain and strain of other and unspecified parts of the knee: 5;
- Fracture of the lower part of the tibia: joint fracture with volar angulation: 5;
- Contusion of the ankle joint: 5;
- Fracture of any rib (except the first): 5;
- Wound to the ankle joint: 5;
- Wound on other parts of the foot: 5;
- Contusion of the thigh: 5;
- Sprain and strain of other and unspecified parts of the foot: 5;
- Shoulder dislocation, unspecified: 5;
- Tear of the posterior cruciate ligament of the knee: 5;
- Fracture of upper humerus, other and multiple parts: 5;
- Fracture of the lower part of the humerus, T fracture: 5;

- Fracture of the neck of the femur, central part: 4;
- Meniscus rupture, fresh: 4;
- Multiple fractures of the tibia: 4;
- Wrist bone fracture, unspecified: 4;
- Fracture of the calcaneus: 4;
- Other superficial injuries of the tibia: 4;
- Fracture of the thoracic vertebrae, T7 and T8: 4;
- Sprain and strain of finger(s), unspecified: 4;
- Contusion of the eyelid and eye area: 4;
- Multiple fractures affecting the skull and facial bones: 4;
- Fracture of the lower jaw, in multiple places: 4;
- Multiple wounds to the head: 4;
- Superficial injury to the nose, unspecified: 4;
- Tear of the medial collateral ligament of the knee: 4;
- Fracture of the lumbar vertebra, L2: 4;
- Finger dislocation, unspecified: 4;
- Clavicle fracture, unspecified part: 4;
- Fracture of the base of the first metacarpal bone: 4;
- Multiple fractures of the lumbar spine and pelvis: 4;
- Multiple clavicle fractures: 3;
- Injury to the muscle(s) and tendon(s) of the rotator cuff of the shoulder: 3;
- Fracture of the diaphysis of the radius, lower part with dislocation of the head of the ulna: 3;
- Superficial injury to the wrist and hand, unspecified: 3;
- Contusion on other and unspecified parts of the shin: 3;
- Contusion on other and unspecified parts of the forearm: 3;
- Shin abrasion: 3;
- Anterior knee dislocation: 3;
- Injury to other muscles and tendons in the shin area: 3;
- Fracture of other parts of the forearm: 3;
- Intercondylar fracture: 3;
- Traumatic cerebral oedema: 3;
- Multiple fractures of the metacarpal bones: 3;
- Fracture of the base of another metacarpal bone: 3;
- Fracture of the seventh cervical vertebra: 3;
- Dislocation of the interphalangeal joint of the finger: 2;
- Sprain and strain of other parts of the wrist: 2;
- Wound on the penis: 2;
- Other superficial injuries to the forearm: 2;
- Wound on the hip: 2;
- Wound on the nose, skin wound: 2;
- Fracture of the lumbar vertebra, L1 2;

- Fracture of the neck of another metacarpal bone: 2;
- Superficial injury to the nose, contusion: 2;
- Fracture of the upper part of the hyoid bone, unspecified part: 2;
- Wound on the lip and in the oral cavity, multiple wounds on different parts of the oral cavity: 2;
- Superficial injury to other parts of the head, other: 2;
- Wound on the lip and in the oral cavity, oral mucosa: 2;
- Injury to the spleen, unspecified: 2;
- Diffuse brain injury, major: 2;
- Fracture of the arch: 2;
- Superficial injury to the lip and oral cavity, contusion: 2;
- Superficial injury to other parts of the head, abrasion: 2;
- Fracture of the lower part of the humerus, unspecified: 2;
- Wound on the wrist and hand, part unspecified: 2;
- Abrasion of the wrist and hand: 2;
- Dislocation of the carpometacarpal joint of the wrist: 2;
- Wound on the knee: 2;
- Fracture of the lower jaw, condylar process: 2;
- Fracture of the triquetrum of the wrist: 2;
- Spleen injury, haematoma: 2;
- Subtrochanteric fracture: 1;
- Fracture of the femoral neck, unspecified: 1;
- Elbow dislocation, unspecified: 1;
- Thigh wound: 1;
- Superficial head injury, location unspecified, abrasion: 1;
- Wound on the cheek and temporomandibular region, lower jaw area: 1;
- Dislocation of the condyle: 1;
- Fracture of the lower jaw, symphysis: 1;
- Other superficial injuries to the hip and thigh: 1;
- Abrasion of the ankle and foot: 1;
- Other superficial injuries to the ankle and foot: 1;
- Superficial injury to the forearm, unspecified: 1;
- Fracture of the big toe: 1;
- Wound on finger(s) with nail injury: 1;
- Wound on upper arm, area unspecified 1
- Sprain and strain of other and unspecified parts of the shoulder girdle: 1;
- Wound on the lip and in the oral cavity, palate: 1;
- Superficial injury to the shoulder and upper arm, unspecified: 1;
- Other injuries to unspecified area of body: 1;
- Other superficial injuries to the shoulder and upper arm: 1;
- Wound to the eyeball and eye area: 1;
- Fracture of the thumb, unspecified: 1;

- Sprain and strain of shoulder joint: 1;
- Fracture of the distal phalanx of the thumb: 1;
- Sprain and strain of other hip ligaments: 1;
- Sprain and strain of joints and ligaments of other and unspecified parts of the neck: 1;
- Sprain and strain of the acromioclavicular syndesmosis: 1;
- Superficial injury to the nose, abrasion: 1;
- Superficial injury to the nose, other: 1;
- Facial nerve injury: 1;
- Other intracranial injuries: 1;
- Multiple brain injuries: 1;
- Multiple wounds to the wrist and hand: 1;
- Fracture of the lower jaw, subcondylar: 1;
- Multiple superficial injuries to the wrist and hand: 1;
- Superficial injury to other parts of the neck, other: 1;
- Wound on the lip and in the oral cavity, unspecified area: 1;
- Sprain and strain of the radiocarpal joint of the wrist: 1;
- Wound on the lip and in the oral cavity, tongue and floor of the mouth: 1;
- Sprain and strain of the calcaneofibular ligament: 1;
- Other superficial injuries to the abdomen, lower back and pelvis, other: 1;
- Fracture of the forearm, part unspecified: 1;
- Fracture of the skull and facial bones, part unspecified: 1;
- Focal injury to the cerebrum: 1.

Falls from electric scooters often cause injuries that require various forms of medical treatment, ranging from emergency medical assistance at the scene of the crash to long-term hospital treatment and rehabilitation. In addition to the physical and psychological consequences for individuals, such events also represent a significant financial burden for the healthcare system. The costs of treating injuries related to the use of scooters (UKC Ljubljana) are presented below (Figure 35).

The highest recorded cost of medical treatment directly related to a scooter crash in the UKC Ljubljana data is €107,371. This amount was needed to treat a case diagnosed with multiple brain injuries, which shows how super challenging and long-term treating serious head injuries can be. In addition to this highest value, several other head and neck injuries are also among the most expensive – for example, skull base fracture, traumatic brain oedema, subarachnoid haemorrhage and traumatic subdural haematoma, with individual treatments exceeding €50,000.

It is important to note that these amounts are linked to individual treatments, while many injured persons underwent several consecutive or combined medical procedures, which means that the total cost of treatment per person may be significantly higher than the above figures.

Figure 35. Amount of treatment per person

6.1.3 Links between injury characteristics

We were interested in whether there were statistically significant differences in the characteristics of individual injuries in traffic crashes depending on the gender of the individual involved in the crash. The variables for which we found statistically significant differences were: description of the location of the traffic crash, description of the diagnosis and the amount of individual treatment. To determine whether the proportion of traffic crashes with different locations differs statistically significantly according to gender, we used the Chi-square test of independence. Based on the results presented in the table below (Table 26), we can conclude that, overall, more than two-thirds of traffic crash participants are male. Looking at individual crash locations, we observe a similar trend, with the exception of schools and other institutions and public administration areas, where there were approximately 12% more female participants in traffic crashes than male participants. Based on the results of the Hi-square test of independence, we conclude that the differences presented are statistically significant (χ^2= 88.22, p<0.01), which means that the gender of the traffic crash participant is the reason for these differences. Due to frequencies lower than 5, the test is not representative for the following areas/locations: commercial areas and service areas, as well as industrial and construction areas.

Table 26. Statistically significant differences in traffic crashes with different locations of occurrence based on the gender of the person involved in the traffic crash

	Total number of traffic crashes in all places of origin		Hi-square value statistics	Statistical characteristic
Gender	N	%	88.2223	<0.001
Male	1664	67.6		
Female	797	32.4		
Total	2461	100		

	Commercial area and service activity area activities		Roads and motorways		Home		Other designated areas	
Gender	N	%	N	%	N	%	N	%
Male	2	66.7	976	73.2	101	52.9	271	56.5
Female	1	33.3	357	26.8	90	47.1	209	43.5
Total	3	100	1333	100	191	100	480	100

	Industrial and construction areas		Undefined locations		Schools and other institutions and areas in public administration		Sport areas	
Gender	N	%	N	%	N	%	N	%
Male	5	100	45	76.3	18	43.9	150	65.8
Female	0	0	14	23.7	23	56.1	78	34.2
Total	5	100	59	100	41	100	228	100

To determine whether the proportion of traffic crashes with different medical diagnoses differs statistically significantly according to gender, we used the chi-square test of independence. For diagnoses: pain after insertion of internal orthopaedic prosthetic devices, diffuse brain injury, other injuries, epidural haematoma, intercondylar fracture, dislocations, multiple injuries and fractures, abrasions of body parts, specific surface injuries, individual types of wounds and specific types of wounds and fractures, due to the small number of units in each category, the Chi-square test did not show representativeness, which is why we only present representative results below. Based on the results presented in the following table (Table 27), we can conclude that bilamellar fractures and trimaleolar fractures are injuries that occur more frequently in women, while contusions are injuries that are fairly evenly distributed between the sexes, while for all other injuries, the percentage of men differs statistically significantly (χ^2= 662.61, $p<0.01$).

Table 27. Statistically significant differences in traffic crashes with different medical diagnoses according to the gender of the traffic crash participant

	Total number of traffic crashes with different diagnoses				Hi-square value statistics		Statistical characteristic	
Gender	N		%					
Male	1664		67.6		662.61		<0.001	
Female	797		32.4					
Total	2461		100					
	Bimalleolar fracture		Further treatment: removal of fixation devices		Traumatic subarachnoid haemorrhage		Superficial head injury, contusion	
Gender	N	%	N	%	N	%	N	%
Male	6	40	6	37.5	13	72.2	31	58.5
Female	9	60	10	62.5	5	27.8	22	41.5
Total	15	10	16	100	18	100	53	100
	Superficial injury scalp, unspecified		Superficial injury scalp, contusion		Concussion – internal skull injury		Wound on other parts of the head	
Gender	N	%	N	%	N	%	N	%
Male	21	60	115	71	39	65	57	71.3
Female	14	40	47	29	21	35	23	28.7
Total	35	100	162	100	60	100	80	100
	Tear of the middle cruciate ligament of the knee		Trimaleolar fracture		Contusion of other parts of the wrist and hand		Contusion of the knee	
Gender	N	%	N		N	%	N	%
Male	11	64.7	13	31.7	80	73.4	42	48.3
Female	6	35.3	28	68.3	29	26.6	45	51.7
Total	17	100	41	100	109	100%	87	100
	Elbow impact		Chest impact chest		Finger contusion without nail injury		Contusion of the shoulder and upper arm	
Gender	N	%	N	%	N	%	N	%
Male	33	56.9	22	66.7	8	44.4	33	62.3
Female	25	43.1	11	33.3	10	55.6	20	37.7
Total	58	100	33	100	18	100	53	100
	Fracture of the diaphysis of the radius and ulna		Fracture of the diaphysis of the tibia, other		Fracture of other metacarpal bones		Fracture of the second finger	
Gender	N	%	N	%	N	%	N	%
Male	25	75.8	16	76.2	13	72.2	10	66.7
Female	8	24.2	5	23.8	5	27.8	5	33.3
Total	33	100	21	100	18	100	15	100
	Fracture of the cheekbones and upper jaw		Fracture of the patella		Fracture of the lower part of the tibia		Fracture of the lower part of the radius and forearm	
Gender	N	%	N	%	N	%	N	%
Male	16	76.2	11	68.8	17	77.3	30	69.8
Female	5	23.8	5	31.3	5	22.7	13	30.2
Total	21	100	16	100	22	100	43	100

	Breakage of the lower part of the scapula and other Multiple fractures		Fracture of the lower part of the tibia, undefined part		Fracture of the lower part of the scapula with dorsal angulation		Fracture of the lower part of the humerus	
Gender	N	%	N	%	N	%	N	%
Male	8	61.5	74	52.9	8	40	7	35
Female	5	38.5	66	47.1	12	60	13	65
Total	13	100	140	100	20	100	20	100
	Fracture of the metatarsal bone		Fracture of the upper part of the tibia		Fracture of the upper part tibia, head		Fracture of the outer of the fibula	
Gender	N	%	N	%	N	%	N	%
Male	21	70	28	70	90	91.8	17	68
Female	9	30	12	30	8	8.2	8	32
Total	30	100	40	100	98	100	25	100
	Sprain and strain of the ankle joint							
Gender	N	%						
Male	21	67.7						
Female	10	32.3						
Total	31	100						

We used the T-test for independent samples to determine statistically significant differences in the average costs of hospital treatment based on the patient's gender. Based on the results presented in the table below (Table 28), we conclude that the average cost of treatment for women is higher (M=740.91 euros) compared to the average cost of treatment for men (M=660.81 euros), but the differences are not statistically significant (t=-0.472, p>0.05), which means that we cannot claim that the patient's gender is the reason for these differences.

Table 28. Statistically significant differences in the amounts of individual medical treatments by gender of traffic crash participants

	Treatment cost			t-value Statistics	Statistical significance
Gender	N	Average	Standard deviation	-0.472	0.318
Male	1645	660.81	3932.1		
Female	789	740.91	3892.35		

Next, we were interested in whether there were statistically significant differences in the characteristics of individual injuries in traffic crashes depending on the age of the individual involved in the crash. The variables for which we found statistically significant differences were again the same: description of the location of the traffic crash, description of the diagnosis and the amount of individual treatment. Based on the year of birth of the individual, we classified traffic crash participants into four age categories: 1 – born between 1943 and

1984, 2 – born between 1985 and 2000, 3 – born between 2001 and 2012, and 4 – born in 2012 or later[5].

To determine whether the proportion of traffic crashes with different locations of occurrence differs statistically significantly according to the age category of the traffic crash participant, we used Chi-square test of independence. Based on the results presented in the following table (Table 29), we can conclude that, overall, participants in traffic crashes are fairly evenly represented in all four age categories, with the largest number in the age category born between 2001 and 2012. Based on the results of the chi-square test of independence, we conclude that the differences presented are statistically significant (χ2= 914.32, p<0.01), which means that the age category of a traffic crash participant can be considered a reason for these differences. Due to frequencies lower than 5, the test is not representative for the following locations: commercial and service areas, industrial and construction areas, schools and other institutions, and public administration areas. More than 70% of participants in traffic crashes on roads and motorways were born in 2000 or earlier, in contrast to crashes on sports grounds, where more than 90% of participants were born in 2000 or later.

Table 29. Statistically significant differences in traffic crashes with different locations of occurrence according to the age category of the traffic crash participant

	Total number of traffic crashes in all locations		Hi-square value statistics	Statistical characteristic
Year of birth	N	%	914.32	<0.001
up to 1984	615	26.3		
1985	560	23.9		
2001	670	28.6		
2013	495	21.2		
Total	2340	100		

	Commercial areas and service activity areas activities		Roads and motorways		Home		Other designated areas	
Year of birth	N	%	N	%	N	%	N	%
up to 1984	1	33.3	497	37.3	8	4.2	73	15.2
1985-2000	1	33.3	455	34.1	14	7.3	69	14.4
2001	0	0	328	24.6	51	26.7	177	36.9
2013	1	33.3	53	4	118	61.8	161	33.5
Total	3	100	1333	100	191	100	480	100

	Industrial and construction areas		Unspecified locations		Schools and other institutions and areas in public administration		Sport areas	
Year of birth	N	%	N	%	N	%	N	%
up to 1984	0	0	27	45.8	0	0	9	3.9
1985-2000	5	100	7	11.9%	0	0	9	3.9

[5] Here, the age scale is not the same as that used in the analysis of traffic crashes and offences due to statistically significant differences (which, in the case of the scale used for crashes and offences, do not show statistically significant differences due to the small number of individuals in the group).

2001	0	0	16	27.1	11	26.8	87	38.2
2013	0	0	9	15.3	30	73.2	123	53.9
Total	5	100	59	100	41	100	228	100

To determine whether the proportion of traffic crashes with different medical diagnoses differs statistically significantly depending on the age of the traffic crash participant, we again used the Chi-square test of independence. For diagnoses for which the Chi-square test did not show representative results in the following table (Table 30) due to an insufficient number of units in each category, we did not present them. The chi-square test showed statistical significance (χ2= 2160.86, p<0.01), which means that we can conclude that the age category of individual participants in traffic crashes is the reason for the differences in the incidence of individual diagnoses.

Table 30. Statistically significant differences in traffic crashes with different medical diagnoses according to the gender of the traffic crash participant

	Total number of traffic crashes with different diagnoses		Hi-square value statistics	Statistical characteristic
Year of birth	N	%		
up to 1984	664	27	2160.86	<0.001
1985	599	24.3		
2001	689	28		
2013	509	20.7		
Total	2461	100		

	Superficial injury other parts of the head, contusion		Superficial injury scalp		Superficial injury scalp, contusion		Earthquake – inside the skull injury	
Year of birth	N	%	N	%	N	%	N	%
up to 1984	7	13.2	8	22.9	49	30.2%	30	50
1985	9	17	10	28.6	32	19.8	6	10
2001-2012	15	28.3	12	34.3	39	24.1	14	23.3
2013	22	41.5	5	14.3	42	25.9	10	16.7
Total	53	100	35	100	162	100	60	100
	Wound on other parts of the head		Contusion of other parts of the wrist and hand		Contusion of the knee		Contusion of the elbow	
Year of birth	N	%	N		N	%	N	%
up to 1984	13	16.3	17	15.6	14	16.1	7	12.1%
1985-2000	12	15	13	11.9	22	25.3	9	15.5
2001	22	27.5	54	49.5	39	44.8	23	39.7
2013	33	41.3	25	22.9	12	13.8	19	32.8
Total	80	100	109	100	87	100	58	100
	Fracture of the second metacarpal bone, undetermined		Fracture of the clavicle, middle part		Fracture of the lower part of the scaphoid		Fracture of the metatarsal	
Year of birth	N	%	N	%	N	%	N	%
up to 1984	5	27.8	12	27.3	19	13.6	5	16.7
1985-2000	5	27.8%	20	45.5	9	6.4	5	16.7
2001	2	11.1	7	15.9	54	38.6	6	20
2013	6	33.3	5	11.4	58	41.4	14	46.7
Total	18	100	44	100	140	100	30	100

We used one-way analysis of variance (ANOVA test) to determine statistically significant differences in average hospital treatment costs based on the age of the traffic crash participant. Based on the results presented in the table below (Table 31), we find that the average cost of treatment is highest in the age category of those born before 1984, amounting to €1,188.64, and the lowest in the category of those born from 2013 onwards, amounting to €116.49. The differences found are statistically significant (F=7.287, p<0.01). To determine statistically significant differences between different pairs of age categories, we performed a Tukey HSD Post Hoc test, which showed that the average treatment amount differs statistically significantly between the categories of those born before 1984 and those born between 2001-2012 and between those born before 1984 and those born in 2013 or later.

Table 31. Statistically significant differences in the amounts of individual medical treatment costs per participant in a traffic crash of a traffic crash participant

Amount of treatment				F-statistic value	Statistical significance	Tukey HSD Post Hoc Test
Year of birth	N	Average	Standard deviation			
up to 1984 (1)	657	1188.64	6054.44	7.287	<0.001	1>3* 1>4*
1985-2000 (2)	596	696.5	2298.13			
2001-2012 (3)	676	616.46	3816.82			
2013- (4)	505	116.49	94.22			
Total	2434	686.77	3918.61			

**Statistically significant difference p<0.05.*

7. CONCLUSIONS: A COMPARATIVE ANALYSIS OF SLOVENIA AND CROATIA

The comparative analysis of electric scooter (e-scooter) safety and traffic offences between Slovenia and Croatia reveals clear similarities in rider behaviour and safety challenges, but also notable differences linked to legislation, data coverage, and reporting methods. Importantly, direct statistical comparisons between the two countries are not possible, as the datasets differ in scope, classification, and time coverage. In Slovenia, police and hospital analyses cover "light motor vehicles" from 2021 to April 2025, a category that includes e-scooters but also other motorised devices with a design speed below 25 km/h. In contrast, Croatia's dataset (2023–2024) focuses on personal mobility devices, a legal category explicitly including e-scooters but also hoverboards and unicycles. Additionally, Slovenia's dataset combines offence data, crash records, and emergency-hospital information, while the Croatian data are based solely on police-reported road crashes. These methodological differences mean that while trends can be qualitatively assessed, numerical indicators (e.g., crash rate, injury percentage) cannot be statistically compared with precision.

Despite these data limitations, the overall findings indicate several fundamental similarities between the two countries. *Both Slovenia and Croatia are experiencing rapid growth in e-scooter usage,* particularly in urban areas, reflecting a wider European transition toward micromobility. In both cases, this trend has led to a marked increase in traffic offences, collisions, and hospital-treated injuries. Based on Slovenian data available, more than 3,300 offences and 905 traffic crashes were recorded involving light motor vehicles between 2021 and April 2025, showing a consistent year-on-year rise. A similar escalation is visible in Croatia, where 613 crashes were officially recorded over 2023–2024, with a significant increase in 2024. Seasonal patterns coincide closely: e-scooter incidents in both countries are most frequent during warmer months (May–September) and decline sharply in winter, consistent with seasonal riding activity and greater user exposure in summer.

Demographic patterns are another shared feature. In both Slovenia and Croatia, males dominate the statistics, representing around 80–85% of offenders or injured riders. These findings correspond to broader European research showing that men are more likely to engage in higher-risk behaviour when using e-scooters, such as speeding, riding without a helmet, or using the road under the influence of alcohol. Furthermore, younger riders—particularly those between 14 and 25 years—form the largest group of users involved in offences or crashes, while older users (especially over 35 or 50 years) are much more likely to sustain serious or fatal injuries, reflecting reduced physical resilience and reaction capacity with age.

Both countries exhibit similar behavioural risk factors, with excessive or inappropriate speed representing by far the most frequent cause of crashes. Slovenian data show that speeding is responsible for around 36% of crashes, followed by failure to yield the right-of-way (22%) and wrong-way driving or improper positioning (17%). In Croatia, crashes linked to excessive speed and loss of control were also associated with the highest proportion of deaths or severe injuries (more than one-third of all serious cases). Moreover, alcohol consumption appears as a recurring contributing factor, particularly during weekend evenings. Helmet use is critically low in both countries—Croatian data show that over 80% of injured riders were not wearing helmets, while Slovenian hospital records confirm a similar pattern, with a sizable proportion of injuries affecting the head, face, and upper limbs.

The environmental and infrastructural context also exhibits strong parallels. In both Slovenia and Croatia, most crashes occur in urban traffic environments, most often on dry asphalt roads and under clear or cloudy weather conditions, which suggests that human behaviour rather than external environmental factors is the central determinant of crash occurrence. Most violations and crashes occur on urban roads with speed limits of around 50 km/h, which further underlines the exposure of e-scooter riders to mixed traffic with motor vehicles. In both countries, single-vehicle crashes—where riders lose control and fall without colliding with another vehicle—account for the largest share of total crashes and demonstrate the dangers stemming from instability, inappropriate speed, or limited riding experience.

Despite these similarities, several key differences were found between Slovenia and Croatia in *injury severity, data structure, and underlying legal framework*. From a severity perspective, Croatian data indicate a substantially higher share of severe or fatal outcomes—27.1% of crashes resulted in death or serious injury, with mild injuries accounting for about half of all cases. In Slovenia, on the other hand, minor injuries dominate (about 72%), and only roughly 16% of traffic crashes caused serious harm, with just two fatalities recorded during the observed period. However, as the definition of a "light motor vehicle" in Slovenia also includes mopeds or motorised bicycles and not only e-scooters, the datasets are not directly comparable. The Croatian dataset, though narrower in time, is more accurately confined to e-scooter cases, but lacks complementary hospital data, which means some incidents and injuries likely remain unrecorded.

Another difference lies in *data comprehensiveness*. Slovenia provides a more integrated picture, combining police statistics with hospital information, including detailed medical diagnoses, modes of injury, locations of crashes, and treatment costs. The University Medical Centre Ljubljana alone recorded more than 1,100 admissions due to scooter-related injuries in 2023–2024, with the highest costs exceeding €100,000 per patient for severe head trauma. Injuries most commonly affect the head, arms, wrists, and legs. In comparison, Croatian police data provide valuable insights into traffic crash mechanisms and environmental conditions but lack hospital-based health outcomes, making clinical impact analysis more difficult. These differences in data depth and coding systems are among the main reasons why statistical comparability between Slovenia and Croatia cannot be achieved at this stage.

Legal and infrastructural frameworks also diverge. In Slovenia, e-scooters are still formally regulated as a subtype of light motor vehicle under the Road Traffic Rules Act (ZPrCP), meaning they share traffic classification codes with small mopeds and self-propelled devices.

Conversely, Croatia's Road Traffic Safety Act defines personal mobility devices as a distinct vehicle category, which allows for more precise data attribution to e-scooters. Nonetheless, enforcement and compliance challenges are evident in both countries. Slovenian offence data show that violations of helmet rules, technical conditions, and driver eligibility, as well as speeding, are widespread, while in Croatia, insufficient rider training, low risk awareness, and infrastructure gaps play major roles in crashes.

In summary, while the two countries differ in definitions, reporting systems, and regulatory maturity, they share remarkably similar behavioural risk patterns and urban exposure profiles. *In both Slovenia and Croatia, e-scooter crashes are predominantly urban, seasonal, male-dominated, speed-related, and involve a high frequency of head and limb injuries due to low helmet use*. The main difference lies in the severity distributions and data structures: Croatian data focus narrowly on crashes leading to personal injury, with a higher proportion of serious outcomes, while Slovenian datasets cover a wider range of incidents, including minor violations and hospital visits of varying severity.

Because the statistical datasets are not harmonised, valid quantitative comparisons—such as calculating relative risk, injury rate per kilometre, or comparative crash frequency—are not feasible. Differences in timeframes, case definitions, legal classifications, and reporting criteria would distort any cross-national metrics. Future research should therefore prioritise the development of a unified reporting framework for micromobility safety, compatible with EU transport statistics and WHO injury surveillance guidelines. This would ensure that both Slovenia and Croatia can systematically track e-scooter safety indicators, evaluate interventions, and assess the effectiveness of policy measures over time.

Nevertheless, the qualitative evidence clearly points to a shared need for comprehensive safety policies. Both countries would benefit from introducing mandatory helmet regulations, stricter speed control and alcohol enforcement, and public education campaigns targeting younger riders. Improved infrastructure measures, such as dedicated micromobility lanes, smoother surface maintenance, and clear separation of pedestrian and e-scooter space, would further reduce conflict points and improve rider safety. Ultimately, while the data differ, both Croatia and Slovenia face the same underlying challenge—how to integrate e-scooters safely and sustainably into their urban transport systems while reducing the growing public health and economic burden associated with e-scooter crashes.

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