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Characteristics and costs of electric scooter injuries in Helsinki: a retrospective cohort study

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Abstract

Background and purpose The incidence of electric scooter (e-scooter) injuries has increased drastically in numerous countries after widespread availability of shared e-scooters. The economic impact on society from a broader perspective has not been studied. We aimed to estimate the incidence of e-scooter injuries, describe the injury patterns, and estimate the costs of e-scooter injuries.

Patients and methods: We performed a retrospective cohort study including all e-scooter-related injuries presented in the three adult emergency departments in Helsinki in 2021. We collected the patient data from the university hospital information system. Injury severity was evaluated based on the Abbreviated Injury Score. The cost of the hospital treatment was analyzed based on our hospital district's service price listing. In addition, we recorded the total amount of sick leave days and estimated their economic impact.

Results In total, 446 e-scooter injuries were identified and taken into the analysis (434 affecting riders and 12 non-riders). The median age of the patients was 26 (IQR 22–33), and 59% were male. 257 (58%) of the of the injuries were minor, whereas 155 (35%) were moderate, 30 (7%) serious, 3 (0.7%) severe, and one (0.2%) critical. Furthermore, 220 (49%) of the patients sustained head injuries. A major spike in accident incidence was seen during the weekend (Friday to Sunday) nights, accompanied by a proportional increase in patients with alcohol intoxication. Including both the costs of the hospital care and absence from work, the approximated total cost of e-scooter injuries was 1.7 million euros, with a median cost of a single accident being 1148 euros (IQR 399–4263 €).

Interpretation: Considerable number of the injuries are moderate, severe, or worse. Comprehensive preventive measures must be conducted to decrease the incidence of e-scooter injuries. The use of helmets should be strongly encouraged to prevent severe head injuries. The nighttime bans during weekends and speed limits on e-scooters appear to be justifiable.

Keywords E-scooter, Electric scooter, Injury, Accident, Traffic accident, Cost, Injury prevention

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Background

Electric scooters (e-scooters) have become a widespread means of transport globally, especially in large metropolitan cities. The arrival of shared e-scooter rental companies has contributed largely to the popularity of this emerging mode of transportation. [1]. Unfortunately, as a by-product, e-scooter-related accidents have increased drastically in numerous countries [2–6].

The incidence of e-scooter-related accidents has been reported as 60 injuries per 100 000 rides [7]. In most countries, the overall incidence has increased rapidly after the introduction of shared e-scooter companies [3, 6]. Compared to cycling, the risk for injuries is approximately 3.8 times higher [8]. The most typical injuries consist of head injuries, fractures of the extremities, and superficial wounds. However, more severe injuries requiring intensive care or even fatality have been reported. [6, 9–12]

There has been a rising number of publications on e-scooter injuries in recent years. However, most studies focus solely on a single category of injuries[13, 14] or cases from a single hospital [9]. To our knowledge, the incidence of accidents in proportion to e-scooter usage has been estimated only by Bekhit et al. [7].

In the current literature, there are only a few cost estimates for e-scooter injuries, which vary greatly depending on the country [7, 15]. However, these numbers focus solely on the cost of hospital treatment. Economical impact on society from a broader perspective has not been studied.

The objective of this study was to estimate the incidence of e-scooter injuries requiring hospital treatment and describe the injury patterns and severity. In addition, we aimed to estimate the costs of e-scooter injuries to the healthcare system and society.

Patients and methods

Setting

We performed a retrospective cohort study assessing all e-scooter-related injuries in Helsinki between January 2021 and December 2021. We analyzed all patients enrolled in the adult emergency departments (ED): one level I trauma center and two level IV trauma centers. The level I trauma center has a 24-hour capability to provide total care for all trauma patients with in-house surgeons on-call and is responsible for high-level trauma care for the whole Hospital district in southern Finland. The level IV trauma centers have a 24-hour capability to treat mild and moderate-level trauma patients and provide a primary evaluation of more severe trauma patients before referral to the level I trauma center. In Helsinki, the three hospitals are the only public hospitals to treat acute trauma patients.

The population base of Helsinki was 656 920 residents on 31.12.2020, with the mean age being 41 years and 53% being female [16]. During the study period, five shared e-scooter rental companies with a total fleet of approximately 4700 e-scooters were in operation [17]. The e-scooters were rented via a mobile application for users over 18 years old. In Finland, the maximum speed of e-scooters is 25 km/h by law. Furthermore, helmets are strongly encouraged but are not officially controlled.

During the study period, the city of Helsinki and the e-scooter rental companies constituted several restrictions for rental e-scooter usage. First, on the 7th of July 2021, the maximum speed limit was lowered to 15 km/h in several inner-city areas. Second, on the 3rd of September 2021, the use of rental e-scooters was prohibited on Friday and Saturday nights between 00.00 and 05.00. In addition, the top speed was lowered to 20 km/h during the daytime and 15 km/h between 00.00 and 05.00 on other days.

Data inquiry

We performed an initial data inquiry to detect e-scooter-related injuries using a keyword search from the hospital information system consisting of ED and ambulance records. Four different e-scooter-related words, including their inflected forms, were used. Next, the authors HV and LT examined all the detected patient records. Consequently, only the cases where the e-scooter involvement was definite were included. All remaining patients over 16 years old were included in the study. Exclusive inclusion and exclusion criteria are presented in Fig. 1.

Patient demographics

We collected the demographic factors from the ED visit. The collected variables were age, sex, time of the injury, injury mechanism, the person affected by the injury, helmet usage, and alcohol intoxication status. If the exact time of injury was not available, we set the injury time as the time when the patient registered at the ED. The breath alcohol level was recorded if measured at the ED or ambulance. In addition, alcohol intoxication was assessed as a binominal value considering the clinical assessment of the ED doctors if the breath alcohol level was not measured. Furthermore, we sought to obtain data regarding e-scooter ownership (shared vs. private e-scooter), but the data was available only in 84 (18%) cases, and therefore, the variable was abandoned.

Injury patterns and severity

We collected all sustained injuries based on the diagnoses from the e-scooter hospital episode according to the International Classification of Diagnoses-10 (ICD-10). In case of missing diagnoses, we added the injuries if they were described with enough precision in the patient

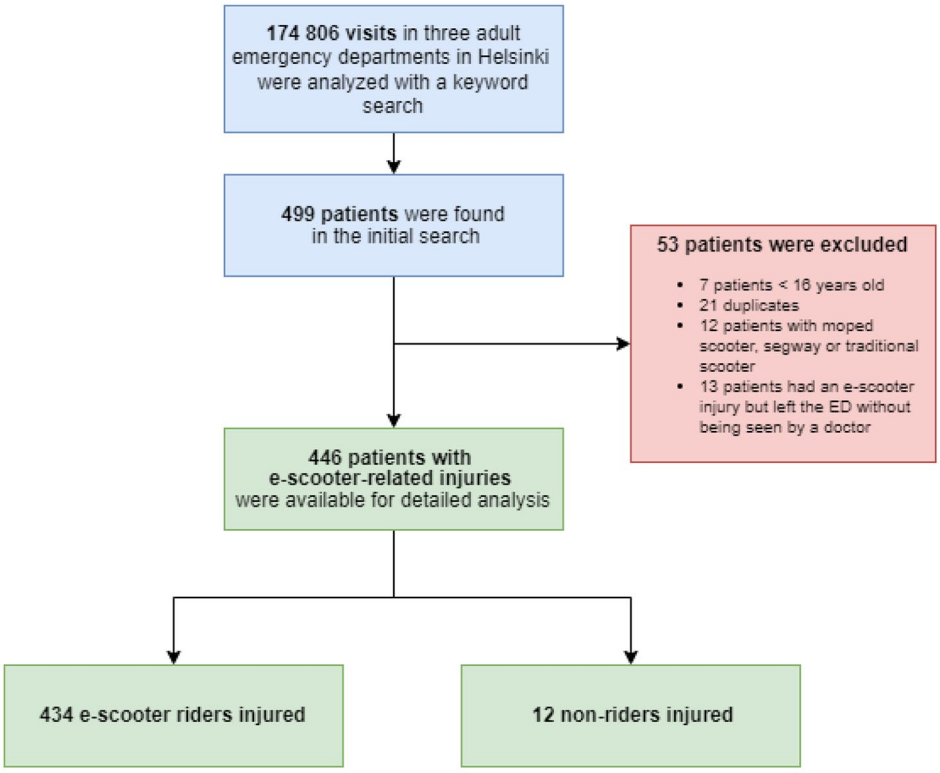

Fig. 1 Flow chart of the Inclusion and exclusion criteria

records. The injuries are presented based on their anatomical location and severity.

Every patient's most severe injury was graded retrospectively based on Abbreviated Injury Score (AIS) from the Abbreviated Injury Scale [18] to minor, moderate, serious, severe, or critical. According to AIS, superficial wounds, muscle or ligament sprains, mild contusions, dental injuries, and mild concussions with no loss of consciousness or equivalent were graded as minor. Moderate injuries were closed fractures of distal extremities, major ligament tears (e.g. knee cruciate ligament tear), and equivalent. Open fractures, fractures proximal femur, comminuted facial fractures, basilar skull fractures, and intracranial hemorrhages with coma of less than 6 hours and no definite diffuse axonal injury (DAI) were graded as serious injuries. Furthermore, intracranial hemorrhages requiring decompressive craniectomy, severe intracranial hemorrhages with coma of more than 6 hours or diagnosed DAI, and severe internal organ hemorrhages were graded as severe or critical.

To estimate the total effect of all injuries on the patient, we calculated the New Injury Severity Score (NISS) [19]. Accordingly, patients with ISS 1–8 were graded as minor, ISS 9–14 were graded as moderate, and ISS≥15 were graded as major trauma patients, respectively.

Follow-up

After the initial ED visit, we followed up the patients from our hospital information system for a minimum of 2 months or to the end of the e-scooter-related hospital episode if the treatment continued beyond 2 months. If the patient required hospital admissions, we recorded the length and type of hospital admission. In addition, all scheduled additional injury-related hospital visits and surgeries were recorded and analyzed. Finally, we recorded the total number of radiographs (native radiographs, computed tomography scans, and magnetic resonance imaging), laboratory tests, and the number of sickness absence days the physician dictated for each patient during all hospital visits.

Cost analysis

The estimation of costs for the whole treatment (ED visits, inpatient care, outpatient visits, surgical procedures, radiological imaging, and laboratory tests) was done according to our hospital district's service price listing for 2021, which was based on NordDRG diagnosis related group system. [20]. In our hospital district, the service price listing describes the costs billed from the patients' home city after their care. A price was sought for all events during the hospital episode. If the price of an event was unequivocal, the lowest suitable value was used.

Table 1 Patient and injury characteristics of the e-scooter injuries. The reported values are counts (%) on binominal variables and medians (IQR) for continuous variables, if not otherwise specified.

	Total	
	(n = 446)	
Age, years, median (IQR)	26.0	(21.6–32.8)
Male sex	260	(58.3%)
Alcohol intoxication[a]	201	(45.1%)
Breath alcohol, ‰, mean (S.D)[b]	1.5	(0.7)
Helmet usage	14	(3.1%)
AIS[c]		
Minor	257	(57.6%)
Moderate	155	(34.8%)
Serious	30	(6.7%)
Severe	3	(0.7%)
Critical	1	(0.2%)
ISS[d]		
Minor (1–8)	407	(91.3%)
Moderate (9–14)	32	(7.2%)
Major (≥ 15)	7	(1.6%)
The use of EMS[e]	189	(43.3%)
Initial place of treatment		
Level I trauma center	84	(18.8%)
Level IV trauma center	362	(81.2%)
ICU[f]**admission, n (%)**	5	(1.1%)
Length of stay, days, median (range)	2	(1–8)
Hospital ward admission, n (%)	60	(13.5%)
Length of stay, days, median (IQR)	3	(1–5)
Operative treatment, n (%)	53	(11.9%)

a. Alcohol intoxication by breath alcohol level, or clinical assessment of the ED doctors

b. Data available from 162 patients

c. Classification of injuries by Abbreviated Injury Score

d. Classification of injuries by Injury Severity Score

e. EMS = Emergency medical services

f. ICU = Intensive care unit

According to the Finnish social system, the pay for short-term absence (≤ 10 working days) is covered by the employer, and the Social Insurance Institution of Finland covers long-term absence (> 10 days). To further estimate sick leave costs for the work providers and society, we used the Finnish Ministry of Social Affairs and Health evaluation in 2014. Accordingly, we used an inflation-corrected price of 203,91 €/day for short-term and 158.83€/day for long-term sickness absence. [21, 22]

Statistics

We acquired descriptive statistics using cross-tabulations. Nominal values were presented as counts (percentages). Continuous values were presented as medians or means based on whether the values complied with Gaussian distribution. Medians were reported with interquartile range (IQR) for large groups or range for smaller (n < 50) groups. Means were reported with standard deviation (S.D.). The normality of continuous values was assessed visually using histograms and Q-Q plots, and with the skewness value of the distribution. We used the statistical program SPSS 28.0.1 (IBM corp. released on the 10th of November 2021) for the statistical analysis.

Table 2 Injury mechanisms. In total, there were 446 persons injured in an e-scooter-related accident

	N	(%)
Rider injured	434	(97.3%)
The rider fell	374	(83.9%)
Non specified	353	(79.1%)
Tripped over a curb	18	(4.0%)
Two persons on a same scooter fell	15	(3.4%)
Tripped over a tram rail	3	(0.7%)
Collision	40	(9.0%)
with an object	19	(4.3%)
with a moving car	13	(2.9%)
with a cyclist	4	(0.9%)
with another e-scooter	4	(0.9%)
Injured while riding[a]	5	(1.1%)
Non-rider injured	12	(2.7%)
Pedestrian hit by e-scooter	9	(2.0%)
Bicyclist collided with an e-scooter	3	(0.7%)

a. Sprain injury when setting foot on ground while riding or hit by the handlebar when breaking

Ethics and approval

Organizational approval was gained for all participating hospitals (HUS/44/2021). As the study was retrospective and did not require interaction with the patients, it does not classify as a medical study by the definition of Finnish law. Therefore, the study was granted an exemption from requiring ethical committee processing.

Results

We identified 466 e-scooter-related injuries, of which 446 fulfilled our inclusion criteria (Fig. 1). In 434 cases, the injured person was the rider, whereas in 12 cases, a pedestrian or a cyclist was injured. The median age of the patients was 26 years (IQR 22–33, range 16–92) for riders and 46 years (range 17–66 years) for non-riders. 260 (59%) riders injured were male (Table 1).

Injury characteristics

The most common injury mechanism was a fall (n = 374), followed by collision (n = 40). Furthermore, in 15 accidents, two people rode on the same scooter. 13 scooter riders sustained a collision with a moving car. The non-riders were either pedestrians (n = 9) or bicyclists (n = 3) that got hit by or collided with an e-scooter rider (Table 2).

According to abbreviated injury score 58% (n = 257) of injuries were considered minor, whereas 35% (n = 155)

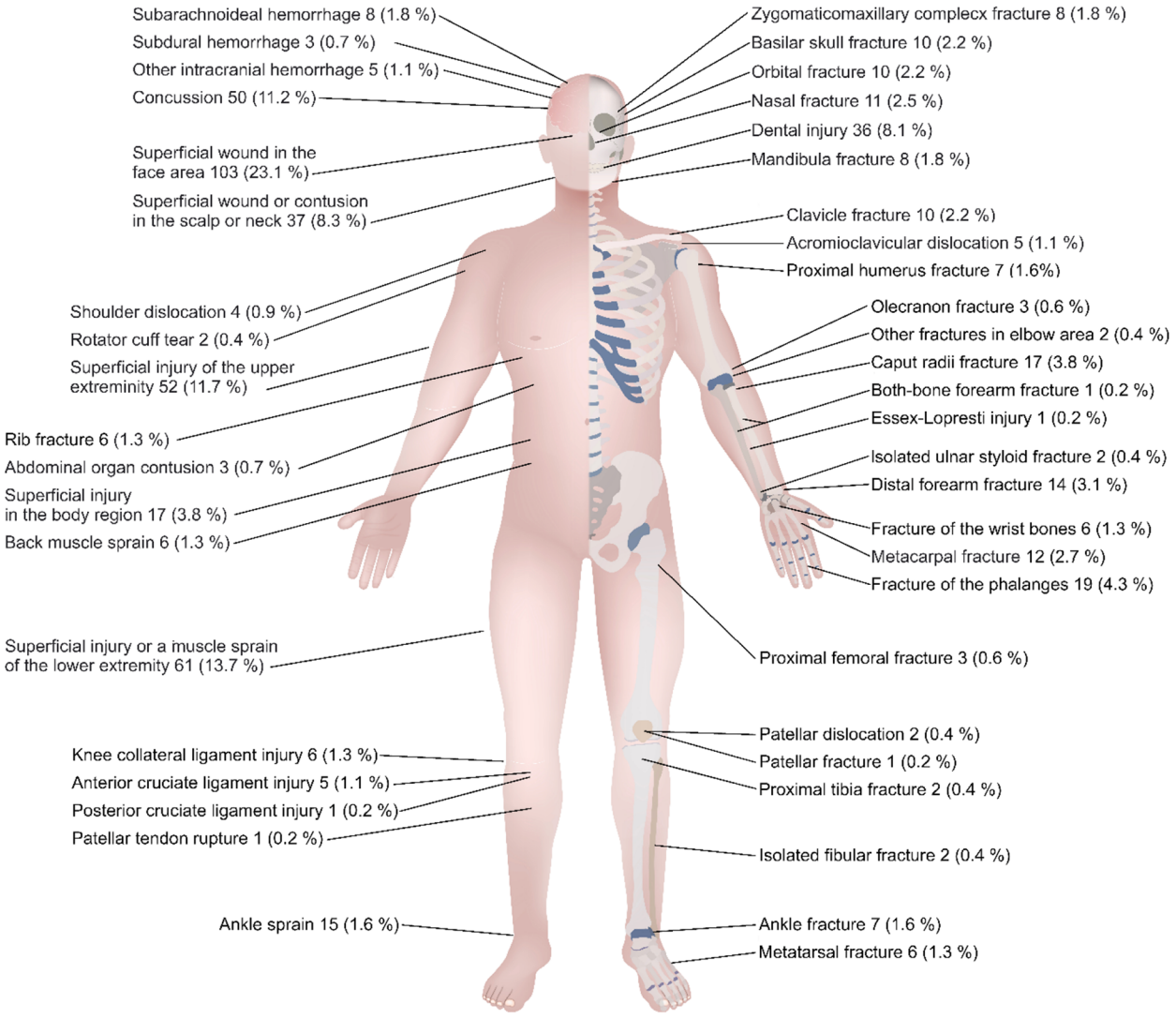

Fig. 2 Anatomical locations of the all injuries sustained in e-scooter accidents. A single patient might present multiple injuries

were moderate, and 8% (n=34) serious, or worse. Three patients had severe injuries, of which two were intracranial hemorrhages, and one was a splenic artery hemorrhage requiring angioembolization. One patient sustained a critical traumatic brain injury requiring an emergency decompressive craniectomy. The non-riders sustained only minor (n=10) or moderate (n=2) injuries. Distinct categorizations of the injury severity are presented in Table 1.

The most common injury site was head and face with 220 (49%) injured patients. Of these patients, 50 (11%) were diagnosed with a concussion, and 16 (3.6%) sustained an intracranial hemorrhage. The upper and lower extremities were injured in 142 (32%) and 113 (25%) patients, respectively. Excluding minor injuries, the most common injuries were fractures of the hand (n=31) and distal forearm (n=13). Including all locations, 151 (34%) patients sustained fractures. All injuries are presented in detail in Fig. 2.

Affecting factors and temporal distribution

In total, 201 (45%) patients were reported to be intoxicated by alcohol at the time of the injury. The effect of intoxication was emphasized during nighttime as 75% of the patients injured between 00.00 and 5.00 were reported to be intoxicated (Fig. 3). Helmet use was reported in 14 (3%) riders, although in 303 (70%) cases, there was no definite information available on helmet use.

Most of the accidents happened in July (n=131), followed by June (n=101) and August (n=75), respectively (Fig. 4). 51% (n=227) of the accidents happened before

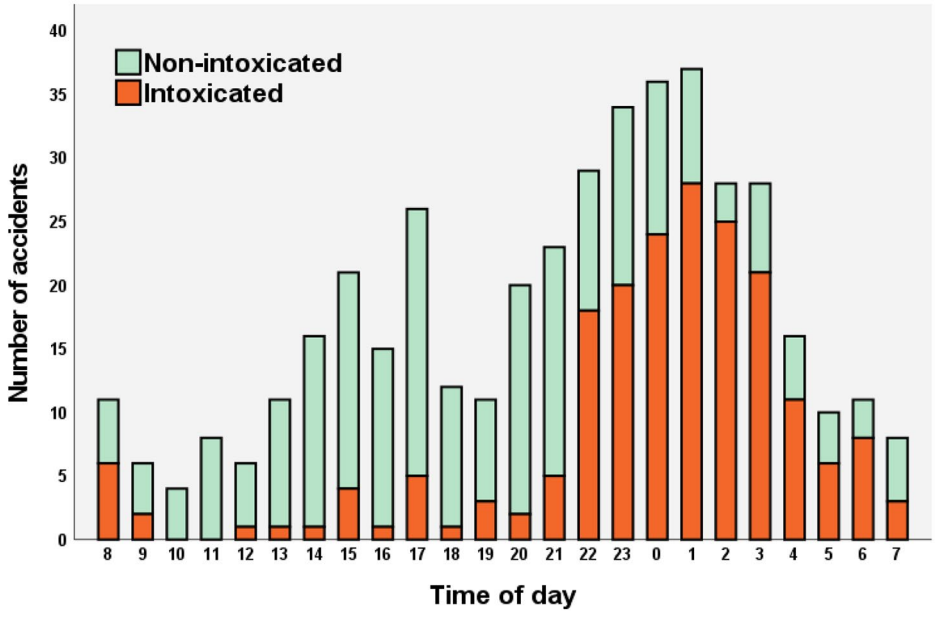

Fig. 3 Histogram of time of day of the accidents and proportion of alcohol intoxication

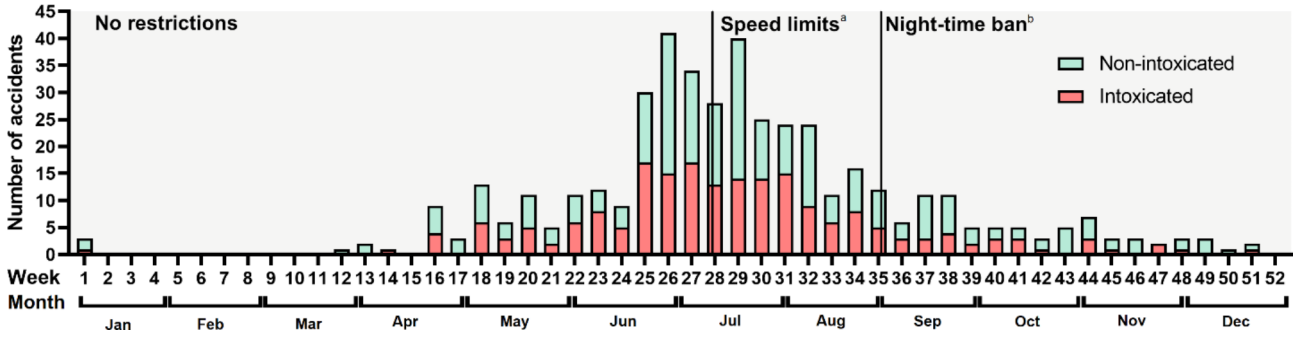

Fig. 4 E-scooter accidents during the year reported by weekly accident incidence. The restrictions in operation are shown
a. Speed restrictions of 15 km/h in specific inner-city locations
b. Shared e-scooter services rental ban on Fridays and Saturdays between 00.00 and 05.00. In addition, the top speed was set to 20 km/h during the daytime and to 15 km/h between 00.00 and 05.00 (except on Fridays and Sundays)

the speed restrictions in the inner-city and 84% (n=375) before the weekend nighttime ban, respectively. In total, 55% (n=246) of the accidents happened during the weekend (Friday 15:00 to Sunday 24:00) (Fig. 5). There was a major spike in accident incidence during late weekend evenings and nights (Fig. 3).

Aftercare

Overall, 60 (13%) patients were admitted to a hospital after their ED visit, 2 of which were non-riders. 5 riders required intensive care, with a median length of ICU treatment being 2 days (range 1–8). The rest were admitted directly to traditional hospital wards. The median length of stay in the hospital was 2 days (IQR 1–5 days).

Overall, 189 (42%) patients required additional doctor appointments after their primary ED visit, whereas 309 patients (69%) visited some type of healthcare professional (including doctors' appointments, physiotherapy, nurse appointments, dental appointments, and psychologist appointments).

Operative treatment was required in 53 (12%) patients, one of which was a non-rider. In total, 60 operations were made in the follow-up period. Orthopaedic procedures on extremities were most common (n=46), with operations on distal forearm fractures (n=7), fractures of hand bones (n=6), and ankle fractures (n=5) being the most frequent In addition, 8 maxillofacial and 5 neurosurgical procedures were performed. A single patient required a radiological angioembolization due to major bleeding in the splenic artery (Table 3).

Cost analysis

The total cost of hospital care, including ED visits, imaging, inpatient care, surgeries, and follow-up visits, was

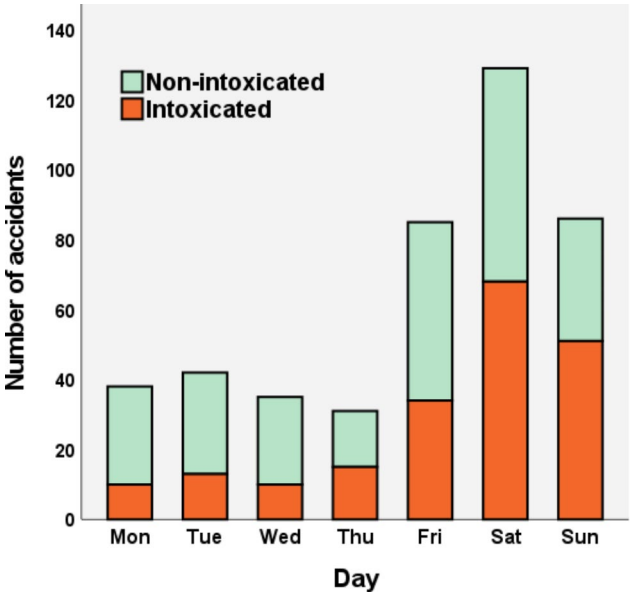

Fig. 5 Histogram of accidents during the week and proportion of alcohol intoxication.

Table 3 Operative treatment of the injuries. In total, there were 60 operations on 53 patients

	N
Orthopaedic operations	46
Upper extremity operations	26
Distal forearm fracture fixation	7
Hand bone fixation	6
UCL stabilization in MCP 1	3
Proximal humerus fracture fixation	2
Shoulder ligament stabilization	2
Clavicle fracture fixation	2
Other operations on upper extremities	4
Lower extremity operations	20
Ankle fracture fixation	5
Proximal tibia fixation	4
Proximal femoral fracture fixation	3
Knee ligament reconstruction via arthroscopy	3
Other operations on lower extremities	5
Maxillofacial operations	8
Zygomaticomaxillary complex fracture fixation	3
Mandibula fracture stabilization	4
Le Fort Maxilla fracture stabilization	1
Neurosurgical operations	5
Decompressive craniectomy	1
Trepanation	1
Other neurosurgical operations	3
Other operations	1
Angioembolization of splenic artery	1

a. Diaphyseal both-bone fracture fixation, Essex-Lopresti stabilization, Olecranon fracture fixation, Plate removal

b. Patellar tendon repair, Tibia diaphyseal fracture fixation with a cephallomedullary nail, Surgical wound revision (n = 3)

c. Cranioplasty and neurosurgical wound revision surgeries (n = 2)

approximately 866 889 €. A median of 1059 € (IQR 296–1966 €) was billed per patient.

Based on the physician's statements, a total of 13.5 years (4928 days) of sick leave was prescribed for 178 patients. Of those affected, the median length of sick leave was 14 days (IQR 5–38 days). In total, this inflicted an estimated 284 047 € of expenses for the employers and 561 464 € for the Social Insurance Institution of Finland.

Including the cost of the hospital care and follow-up and the prescribed sick leaves, the cumulative cost of the e-scooter injuries was approximately 1.71 million euros, with a median cost of 1148 € (IQR 399–4263 €) per patient. A detailed presentation of the economic impact of e-scooters is found in Table 4.

Discussion

Although e-scooters are a convenient emerging mode of transport, the risk of injuries enhances the disadvantages. This study has demonstrated that while most e-scooter injuries are minor, 42% are moderate, severe, or worse. In our material, 13% of the patients required hospital admission, and 11% required surgical interventions. Furthermore, the median cost of an injury was 1148 € with a total cost of 1,7 million €. This research provides insights for the decision-making on whether the price and loss in health are worth the usefulness of a new emerging travel mode.

Our findings on injury characteristics complement those of earlier publications. It is well established that people presenting themselves to the ED with an e-scooter injury are most often males (54–67%) in their late twenties or early thirties [3–7, 10–12, 23, 24]. In 92–96% of the cases,the injured are the riders themselves [4, 6, 10, 25]. As was also seen in our material, the most common site of injury is typically the head (27–47% of the cases) [3, 5, 10, 11, 25, 26], althouh in some publications, the extremities have been the predominant site [4, 24]. Nevertheless, a growing body of published work indicates that e-scooter injuries' characteristics are well known.

A notable finding of our study was that most accidents happened during weekends and nighttime. Unfortunately, a greater portion of patients was also intoxicated during these times. Similar findings have also been reported in previous publications, although the correlation between alcohol usage and weekend nighttime is not well established in these publications [11, 14, 26, 27]. Although driving while intoxicated is technically forbidden by the law and the rules of shared e-scooter companies, effective surveillance is not possible as currently, there is no penalization limit on breath alcohol level regarding e-scooters in Finland. As a result, the city of Helsinki and the e-scooter rental companies banned the use of shared e-scooters during the nighttime (00.00–05.00) at the beginning of September 2022. Anderson

Table 4 Cost analysis for e-scooter injuries

	Persons affected		Total amount	Mean cost	Total cost
	(n = 446)		n	€/item	€
The use of EMS	189	(42.4%)	189	850 €	160 650 €
ED admission					
Primary care	369	(80.2%)	377	205 €	77 080 €
Specialized care	120	(26.0%)	150	505 €	60 600 €
Laboratory measurements	62	(13.9%)	968	7,7 €	7 468 €
Radiographs					
Native x-rays	253	(55.0%)	501	35 €	17 535 €
Computed tomography	11	(6.7%)	369	140 €	51 660 €
Magnetic resonance imaging	3	(1.8%)	12	200 €	5 800 €
Inpatient care					
ICU treatment	5	(1.1%)	16 d	1 521 €	24 343 €
Other hospital wards	57	(12.8%)	355 d	322 €	114 282 €
Outpatient care					
Phycisian appointments	189	(42.4%)	275	259 €	71 362 €
Dentist appointments	38	(8.5%)	68	190 €	7 220 €
Physiotherapist appointments	55	(12.3%)	132	120 €	15 840 €
Nurse's appointments	18	(4.0%)	25	200 €	5 000 €
Other appointments	9	(1.9%)	17	205 €	1 845 €
Operative treatment[a]	51	(11.4%)	57	4 509 €	234 459 €
Hospital care, total					**886 888 €**
Sickness absence					
Short-term (≤ 10 days)	173	(38.8%)	1393 d	204 €/d	284 047 €
Long-term (> 10 days)	103	(23.9%)	3535 d	159 €/d	561 464 €
Sickness absence, total	**173**	**(38.8%)**	**4928 d**		**845 511 €**
Cost, total					1 712 400 €

a. including costs in anesthesiology

et al. examined the effect of a similar nighttime ban on e-scooter rentals (9 p.m. to 4 a.m.) in the city of Atlanta (USA), after which a decrease in e-scooter accidents was seen. However, the effect on ED time of arrival was not significant in their study (p = 0.16). [28] Considering the high incidence of injuries during late evenings and nights in our material, the rental ban on nighttime appears to be justifiable. However, extensive conclusions cannot be drawn as the period with restrictions were brief and seasonal factors affect e-scooter usage drastically.

Mandatory helmet use has been brought up in many publications [4, 11, 27, 29]. In our material, nearly half of the patients sustained a head injury. These varied from mild contusions to lifethreatening intracranial bleeding. Similar to our material, the reported helmet usage has been typically 2–4% in the ijured [4, 10, 12, 24, 27, 30]. In countries where helmet use is mandatory, helmets have been reported in 20–45% of the injured [4, 31]. On the ther hand, compulsory helmet use seems to decrease the usage of e-scooters [32]. From the standpoint of injury prevention, this would be desirable, although this would limit the users' freedom. Moreover, the effectiveness of helmet usage is not well studied on e-scooters. Mitchell et al. found in their small-scale study (n = 54) that helmet usage reduced the presence of head injuries with OR of 0,18 (95% CI 0,04−0,83) [31]. In comparison, the preventive effectiveness of helmet usage is well established in cycling, where it is estimated to provide a 63 to 88% reduction in head injuries [33]. Thus, we believe helmets should be strongly couraged on e-scooters to prevent severe head injuries.

The estimates for costs for e-scooter injuries vary depending on the country. For example, Bekhit et al. estimated in New Zealand, that the cost of a single e-scooter injury was approximately 1 000 € (1693 NZD) (Bekhit et al., 2020), whereas in the United States average cost is estimated to be between 1100 € (1213 USD, median) and 90 000 € (95 710 $, mean)[15, 24]. Furthermore, the average cost in Australia was 364 € [31]. Unquestionably, the methods for cost estimations vary, but undoubtedly, e-scooter usage comes with a cost.

While the present study was made with precision, there are also several weaknesses. First, we did not have an exact ICDcode for e-scooter injuries, so we had to inquire the patients via a keyword search. As a result, some e-scooter injuries might have gone unnoticed. Nonetheless, the number of patients was large, and the loss of patients can be considered random. Thus, a selection bias can be regarded as minimal, and the injury proportions are accurate. Second, due to the retrospective

nature of the data, the distinction between vehicles could not be made entirely accurately. There is a possibility that the ED personnel might have miscategorized some vehicles. Furthermore, the distinction between privately owned and shared e-scooters was not possible. As there are no distinct protocols, the amount of helmet usage and alcohol intoxication might be underreported. Third, some milder injuries are also treated in private hospitals. Thus, the reported incidence underestimates the actual hospital-requiring e-scooter injury rate. However, the hospitals in the study treat the vast majority of EDrequiring accidents in our city; therefore, the reported incidences are solid estimates of the actual incidence. Finally, the costs from sick leaves were based on mean salary and did not include any additional costs from substitutes or extra work from other employees. In addition, we did not have the patients' occupational status. Thus, the cost approximation from dictated sick leaves encases a moderate margin of error.

The main strength of the study is that while many studies focus on a restricted pool of patients (e.g., patients of a single hospital, craniofacial injuries, or injuries requiring surgical care), we report all emergency care requiring e-scooter injuries from the whole city – varying from mild trauma to life-threatening accidents. In addition, we performed a comprehensive estimation of the economic impacts of the e-scooters. While there are studies with a greater quantity of patients, the studies exploit national registries with a larger number of inaccuracies [3]. All things considered, the present study adds considerably to the current knowledge of e-scooter-related injuries.

Conclusion

While most e-scooter injuries are minor, a considerable proportion of the injuries are moderate, severe, or worse, including patients requiring intensive care and operative treatment. Comprehensive preventive measures must be conducted to decrease the incidence of e-scooter injuries. The nighttime bans and speed limits on rental e-scooters during weekends appear to be justifiable means to decrease the disadvantages - both from individual and social perspectives.

List of abbreviations

E-scooter	Stand up electric scooter.
ED	Emergency department.
AIS	Abbreviated Injury Score.
ISS	Injury Severity Score.
IQR	Inter Quartile Range.
EMS	Emergency Medical Services.
ICU	Intensive Care Unit.

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Authors' contributions

HV conceptualized and planned the core study design. VH, KV, MC, and AK reviewed and proposed improvements for the study design. HV and LT performed the data enquiry. HV analyzed the data, performed the statistical analysis, and wrote the core manuscript. All authors contributed to the interpretation of the data and manuscript revision and approved the final manuscript.

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Data availability

The datasets generated and analyzed during the current study are not publicly available due to potential other publications utilizing the data but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

An organizational approval was sought to access the data from all participating hospitals (HUS/44/2021). An ethical committee was not consulted as the study was retrospective and did not require any interaction with the patients.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

1. Haworth N, Schramm A, Twisk D. Changes in shared and private e-scooter use in Brisbane, Australia and their safety implications. Accid Anal Prev. 2021 Dec 1;163(106451). DOI:https://doi.org/10.1016/J.AAP.2021.106451.
2. Badeau A, Carman C, Newman M, Steenblik J, Carlson M, Madsen T. Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. American Journal of Emergency Medicine. 2019 Aug 1;37(8):1531–3. DOI:https://doi.org/10.1016/j.ajem.2019.05.003.
3. Farley KX, Aizpuru M, Wilson JM, Daly CA, Xerogeanes J, Gottschalk MB, et al. Estimated Incidence of Electric Scooter Injuries in the US From 2014 to 2019. JAMA Netw Open. 2020;3(8). DOI:https://doi.org/10.1001/jamanetworkopen.2020.14500.
4. Coelho A, Feito P, Corominas L, Francisco Sánchez-Soler J, Pérez-Prieto D, Martínez-Diaz S, et al. Electric Scooter-Related Injuries: A New Epidemic in Orthopedics. Clin Med. 2021;10(15). DOI:https://doi.org/10.3390/jcm10153283.
5. Namiri NK, Lui H, Tangney T, Allen IE, Cohen AJ, Breyer B. Electric Scooter Injuries and Hospital Admissions in the United States, 2014–2018. 2020;155(4):357–9. DOI:https://doi.org/10.1001/jamasurg.2019.5423.
6. Shichman I, Shaked O, Factor S, Weiss-Meilik A, Khoury A. Emergency department electric scooter injuries after the introduction of shared e-scooter services: A retrospective review of 3,331 cases. World J Emerg Med. 2022 Jan 1;13(1):5–10. DOI:https://doi.org/10.5847/WJEM.J.1920-8642.2022.002.
7. Bekhit MNZ, le Fevre J, Bergin CJ. Regional healthcare costs and burden of injury associated with electric scooters. Injury. 2020 Feb 1;51(2):271–7. DOI:https://doi.org/10.1016/j.injury.2019.10.026.
8. Cicchino JB, Kulie PE, McCarthy ML. Injuries related to electric scooter and bicycle use in a Washington, DC, emergency department. Traffic Inj Prev. 2021;22(5):401–6. DOI:https://doi.org/10.1080/15389588.2021.1913280.
9. Shichman I, Shaked O, Factor S, Elbaz E, Khoury A. Epidemiology of Fractures Sustained During Electric Scooter Accidents: A Retrospective Review of 563 Cases. J Bone Joint Surg Am. 2021 Jun 16;103(12):1125–31. DOI:https://doi.org/10.2106/JBJS.20.01746.
10. Trivedi TK, Liu C, Anna;, Antonio LM, Wheaton N, Kreger V, et al. Injuries Associated With Standing Electric Scooter Use. JAMA Netw Open. 2019;2(1):187381. DOI:https://doi.org/10.1001/jamanetworkopen.2018.7381.

11. Moftakhar T, Wanzel M, Vojcsik A, Kralinger F, Mousavi M, Hajdu S, et al. Incidence and severity of electric scooter related injuries after introduction of an urban rental programme in Vienna: a retrospective multicentre study. Arch Orthop Trauma Surg. 2021;141:1207–13. DOI:https://doi.org/10.1007/s00402-020-03589-y.
12. Siow MY, Lavoie-Gagne O, Politzer CS, Mitchell BC, Harkin WE, Flores AR, et al. Electric Scooter Orthopaedic Injury Demographics at an Urban Level I Trauma Center. J Orthop Trauma. 2020 Nov 1;34(11):e424–9. DOI:https://doi.org/10.1097/BOT.0000000000001803.
13. Factor S, Shaked O, Atlan F, Pritsch T, Shichman I. Electric Scooter–Related Upper Limb Fractures: Analysis of 458 Cases. J Hand Surg. 2021. DOI:https://doi.org/10.1016/J.JHSA.2021.09.033.
14. Suominen EN, Antti ·, Sajanti J, Silver EA, Koivunen V, Bondfolk AS, et al. Alcohol intoxication and lack of helmet use are common in electric scooter-related traumatic brain injuries: a consecutive patient series from a tertiary university hospital. Acta Neurochir. 2022 Mar;164:643–53. DOI:https://doi.org/10.1007/s00701-021-05098-2.
15. Lavoie-Gagne O, Siow M, Harkin WE, Flores AR, Politzer CS, Mitchell BC, et al. Financial impact of electric scooters: a review of injuries over 27 months at an urban level 1 trauma center (cost of e-scooter injuries at an urban level 1 trauma center). Treauma Surg Acute Care Open. 2021;6. DOI:https://doi.org/10.1136/tsaco-2020-000634.
16. Jaakkola A, Vass T, Saarto S, Haglund L. Tilastotietoa Helsingistä 2021 [Internet]. Helsingin kaupunginkanslia, kaupunkitietoyksikkö. 2021 [cited 2022 Apr 25]. Available from: https://www.hel.fi/hel2/tietokeskus/julkaisut/pdf/21_06_09_Tilastotietoja_Helsingist%C3%A4_2021.pdf.
17. Fluctuo. City Dive [Internet]. 2022 [cited 2022 Apr 25]. Available from: https://dive.fluctuo.com/.
18. Association for the Advancement of Automotive Medicine. The Abbreviated Injury Scale 2015 revision. Chicago, IL.; 2015.
19. Osler T, Baker SP, Long W. A Modification of the Injury Severity Score That Both Improves Accuracy and Simplifies Scoring. Journal of Trauma and Acute Care Surgery. 1997;43(6).
20. Helsinki University Hospital. Service price list and principles of productization and pricing [Internet]. 2021 [cited 2022 Apr 25]. Available from: https://www.hus.fi/en/about-us/administration-and-decision-making/finances/pricing.
21. Statistics Finland. Value of money converter [Internet]. 2021 [cited 2022 Apr 25]. Available from: https://www.stat.fi/tup/laskurit/rahanarvonmuunnin_en.html.
22. Rissanen M, Kaseva E. Cost of lost labour input Ministry of Social Affairs [Internet]. Helsinki F. 2014 [cited 2022 Apr 25]. Available from: https://stm.fi/en/value-of-lost-labour-input-in-finland.
23. Lavoie-Gagne O, Siow M, Harkin W, Flores AR, Girard PJ, Schwartz AK, et al. Characterization of electric scooter injuries over 27 months at an urban level 1 trauma center. American Journal of Emergency Medicine. 2021 Jul 1;45:129–36. DOI:https://doi.org/10.1016/j.ajem.2021.02.019.
24. Bloom MB, Noorzad A, Lin C, Little M, Lee EY, Margulies DR, et al. Standing electric scooter injuries: Impact on a community. Am J Surg. 2021 Jan 1;221(1):227–32. DOI:https://doi.org/10.1016/j.amjsurg.2020.07.020.
25. Ingstrup Nielsen K, Erland Nielsen F, Wistisen Rasmussen S. Injuries following accidents with electric Injuries following accidents with electric scooters scooters. Dan Med J. 2021;68(2):9200697.
26. Uluk D, Lindner T, Dahne M, Bickelmayer JW, Beyer K, Slagman A, et al. E-scooter incidents in Berlin: an evaluation of risk factors and injury patterns. Emergency Medicine Journal. 2022 Jan 31;0:1–6. DOI:https://doi.org/10.1136/EMERMED-2020-210268.
27. Blomberg SNF, Rosenkrantz OCM, Lippert F, Christensen HC. Injury from electric scooters in Copenhagen: a retrospective cohort study. BMJ Open. 2019;9:33988. DOI:https://doi.org/10.1136/bmjopen-2019-033988.
28. Anderson B, Rupp JD, Moran TP, Hudak LA, Wu DT. The effect of night-time rental restrictions on E-scooter injuries at a large urban tertiary care center. Int J Environ Res Public Health. 2021 Oct 1;18(19). DOI:https://doi.org/10.3390/IJERPH181910281.
29. Crowe B sen, Elkbuli A. Electric scooter-related injuries: the desperate need for regulation. Am J Emerg Med. 2021. DOI:https://doi.org/10.1016/J.AJEM.2021.01.014.
30. English KC, Allen JR, Rix K, Zane DF, Ziebell CM, Brown CVR, et al. The characteristics of dockless electric rental scooter-related injuries in a large U.S. city. Traffic Inj Prev. 2020;21(7):476–81. DOI:https://doi.org/10.1080/15389588.2020.1804059.
31. Mitchell G, Tsao H, Randell T, Marks J, Mackay P. Impact of electric scooters to a tertiary emergency department: 8-week review after implementation of a scooter share scheme. E. 2019;31:930–4. DOI:https://doi.org/10.1111/1742-6723.13356.
32. Lo D, Mintrom C, Robinson K, Thomas R. Shared micromobility: The influence of regulation on travel mode choice. N Z Geog. 2020 Aug 1;76(2):135–46. DOI:https://doi.org/10.1111/nzg.12262.
33. Thompson DC, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database of Systematic Reviews. 1999 Oct 25;(4). DOI:https://doi.org/10.1002/14651858.CD001855.

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