

Electric scooter-related orthopedic injuries: the experience of an Italian orthopedic center and literature review

Francesco Luceri ,¹ Valerio Monteleone ,¹ Pietro Simone Randelli ^{2,3}

¹Clinica Ortopedica—CTO, ASST Gaetano Pini, Milano, Italy
²Laboratory of Applied Biomechanics, Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milano, Italy

³Clinica Ortopedica, ASST Gaetano Pini, Milano, Italy

Correspondence to

Dr Valerio Monteleone; v.monteleone30@gmail.com

Received 24 June 2023

Accepted 19 January 2024

ABSTRACT

Background With the increasing prevalence of electric scooters, a concomitant increase in the number of specific injuries, emergency department (ED) admissions and hospital admissions have been reported.

Objectives Analyze patient flow changes in the ED with a focus on e-scooter-related injuries through a case series and a comparison with the contemporary literature.

Data sources A systematic literature review was performed on Medline/PubMed and Embase using terms related to the topic.

Data collected from two-wheeled vehicle trauma patients at our Italian ED from May 1 to October 31, 2021, were analyzed for the case series.

Study eligibility criteria Studies were included if they evaluated populations with an e-scooter-related injury referred to the ED with precise localization and nature of the injury reported.

Participants and interventions Data collected from the literature studies and from our case series included overall ED patient numbers, patient demographics, injury mechanism, location of the injury, discharge diagnosis, and performance of surgery.

Study appraisal and synthesis methods All studies were checked in order to establish the coherence with the purposes of this review. Data from the contemporary literature and from this case series were compared.

Results During a 6-month period, 280 patients had e-scooter injuries, resulting in 292 traumas, including 123 fractures, primarily in the elbow. Surgical intervention was necessary for 28 patients. The review included nine papers, highlighting that injuries to the upper and lower extremities and head were frequent in e-scooter-related incidents. The upper extremities were the most common fracture location.

Limitations The study is a retrospective, single-center study without a comparison group, focusing exclusively on orthopedic injuries.

Conclusions or implications of key findings The prevalence of electric scooters, which offer an affordable and eco-friendly mode of transport, is steadily increasing. It is important to focus on injury risk mitigation through effective public health policies, thereby lowering costs to society.

INTRODUCTION

Standing electric scooters (e-scooters) were first introduced in 2017.¹ Nowadays, they have become increasingly popular as a part of urban micro-mobility. Their popularity increased during the

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Despite the well-known increase in electric scooter-related accidents in the literature, this study aims to highlight the changes in patient flow within the emergency department of an Italian orthopedic center, with a specific focus on orthopedic injuries related to e-scooters. It will compare these findings with contemporary literature.

WHAT THIS STUDY ADDS

⇒ Our study highlights the high number of admissions and hospitalizations due to these traumas, offering additional information on the epidemiology of this type of injury.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This could serve as an incentive to enhance safety policies. Simultaneously, it is fundamental to increase the level of attention from the orthopedic community toward this type of trauma, given its inevitable future increase.

COVID-19 pandemic, partly because people sought alternatives to both cars and overcrowded public transport. Due to their widespread availability and opportunity to end the ride anywhere in the city, e-scooters were a smart alternative to support social distancing. Moreover, these micromobility vehicles are considered a valid, green and cost-effective alternative to carbon fossil-based vehicles.

On the e-scooter, the rider stands with the feet in line, at the two ends of the platform are the two wheels, while the steering bar is attached to a stick reaching approximately the waistline. For rental e-scooters, the speed limit is automatically set to a 25 km/hour, which decreases to 6 km/h in pedestrian areas.²

In 2021, 17.9 million e-scooter rentals were reported, doubling compared with the previous year. Likewise, the number of subscriptions to e-scooter rental services significantly increased (+144% compared with 2020). In 2021, a total of 45.900 e-scooters were available for rent in 39 Italian cities. The mean ride duration reported is about 11 min, while the average traveling distance is 2.3 km.³ Thanks to the increasing popularity of this phenomenon, the Italian government published a decree regarding e-scooter usage in August 2022. The decree outlines the technical features e-scooters

© Author(s) (or their employer(s)) 2024. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Luceri F, Monteleone V, Randelli PS. *Trauma Surg Acute Care Open* 2024;**9**:e001197.

must have in order to circulate on Italian territory, including requirements for lights, plates, weight and several technical issues.² Moreover, an update of the Italian traffic laws was developed in order to include e-scooters: people underage can rent an e-scooter, but if they do, the use of a helmet is mandatory.⁴ The lack of a requirement for specific training before rental, as well as the absence of a specific license and driving regulations, exposes riders to a high risk of trauma. Hence, this phenomenon is opening the doors to a new field of orthopedic traumatology. In the scientific literature, there is an increasing number of case series regarding e-scooter-related injuries. These studies reported a growing number of e-scooter-related injuries, emergency department (ED) admissions and hospital admissions. One of the first studies on the subject described a high incidence of orthopedic injuries in a hospital in California, with the most common injuries being those affecting soft tissue, craniofacial areas and limbs.⁵

Although e-scooters may not typically be considered a mode of transportation that may cause high-energy injuries comparable to motorcycle injuries, casualties and healthcare costs for e-scooter-related injuries have been reported, making it crucial to highlight this topic to the general public.⁶⁻⁸

The aim of this study was to analyze the patient flow changes in the ED of an Orthopaedic Trauma Hub in Milan (Italy) from May to November 2021 with a special focus on e-scooter-related injuries and a comparison with the modern literature.

MATERIALS AND METHODS

A case series and systematic review were performed in order to delve deeper into the significant issue of the increasing incidence of scooter-related injuries worldwide.

Patient population

A retrospective case analysis was performed on all acute referrals and presentations of two-wheeled vehicles related to the ED of Gaetano Pini-CTO Institute between May 1 and October 31, 2021.

Traumas related to an exclusively orthopedic ED, in facilities that do not have other surgical and intensive therapies, were taken into consideration. For this reason, the patients who access it are exclusively orthopedic in nature, with at most soft tissue contusions, superficial abrasions and minor head injuries without cranial fractures and with a Glasgow Coma Scale (GCS) of 15. In the eventuality that patients with non-orthopedic issues were identified, they were initially clinically stabilized and then transferred to the general ED of multidisciplinary institutions.

The number of overall ED patients, patient demographics, mechanism and anatomical location of injury, discharge diagnosis and surgical need were analyzed. Data collection was performed according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.⁹ All operative notes and radiological imaging of the injuries were reviewed. The study protocol was approved by the Institutional Review Board; approval was obtained for this study and conforms to the ethical guidelines of the 1975 Declaration of Helsinki. No financial funding was received to perform this study. Informed consent was obtained from each patient.

Systematic review

A systematic literature review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for transparent reporting of systematic reviews and meta-analyses.¹⁰ Database search

included Medline/PubMed, Embase in July 2022. Medline/PubMed database was searched for the terms ((electric scooter) OR (e-scooter)) AND ((trauma) OR (injury)); Embase database was searched for the terms (electric AND scooter OR 'e scooter') AND (trauma OR injury).

Inclusion criteria encompassed prospective and retrospective observational studies evaluating orthopedic injuries associated with e-scooter usage in both adult and pediatric populations, with or without concurrent soft tissue contusions or head traumas, as referred to the ED. The selected studies were required to provide precise information regarding the localization and nature of reported injuries. Only English-language, peer-reviewed studies were considered for inclusion. Systematic reviews and meta-analyses were included to extract primary original studies.

Exclusion criteria comprised studies that did not assess therapeutic approaches (surgical vs conservative), studies exclusively focused on e-scooter injuries involving another vehicle, studies reporting solely non-orthopedic injuries, studies without full-text availability and those categorized as case reports, small case series (involving fewer than 20 patients/fractures), commentaries, letters to the editor or biomechanical reports.

Results were first screened by title and abstract in order to exclude studies not related to the topic. For those still suitable, the full text was collected to establish coherence with the purposes of this review. Two independent authors (FL and VM) performed these steps and results were then matched, resulting as comparable.

Descriptive analysis of the results is presented with frequency (N), percentages (%) and calculated means \pm SD ($M \pm SD$). Categorical variables are presented as frequency (N) and percentages (%). Statistical significance was set at $p < 0.05$.

RESULTS

A total of 28 169 patients presented to the ED from May 1 to October 31, 2021: 1955 (6.9%) were involved in two-wheeled vehicle injuries. Of 280 (14.3%) reported an e-scooter injury, 1105 (56.5%) a bicycle injury and 570 (29.2%) a motorbike injury (table 1).

Out of the 280 individuals involved in e-scooter accidents, 203 were men, with a mean age of 29 years. Seventy-two patients were younger than 18 years. The demographic features of the patients are reported in table 2.

All patients were evaluated with an imaging exam in the ED, with the most common imaging studies being radiographs (290 X-Rays on 280 patients). Among the 290 E-scooter-related traumas reported, 123 (42%) were fractures, and 167 (58%) were contusions (table 3).

In e-scooter accidents, the most common modality of collision was the loss of balance resulting in a fall (82%), rather than collisions with other objects/people/vehicles. The most common fracture locations were the upper extremity with the elbow being the

Table 1 Two-wheeled accidents in total of ED accesses in our ED department from May 1 to October 31, 2021

ED accesses	N=28 159
Two-wheeled trauma	1955 (7%)
E-scooter trauma	280 (1%)
Bike trauma	1105 (4%)
Motorbike trauma	570 (2%)

Values are expressed as number (percentage), median (range). ED, emergency department.

Table 2 Demographic features of the patients involved in e-scooter traumas presenting to our ED department from May 1 to October 31, 2021

Features	N=280
Under 18 years	72 (26%)
Male	203 (73%)
Female	77 (27%)
Mean age	29 (7–72)

Values are expressed as number (percentage), mean (range). ED, emergency department.

most frequently involved joint. The most common localization for soft tissue contusions in the upper limb was the wrist and hand region (table 3)

All the contusions concerned soft tissues, and there were no major lacerations.

In the lower limb, ankle fracture was the fracture most frequently observed, making it also the most common joint requiring a surgical procedure (7 surgeries out of 31 traumas). Nonetheless, hip traumas were most likely to result in surgery (five surgeries out of seven traumas, 71%). The most common localization of soft tissue contusion in the lower limb was the knee (table 3).

Table 3 Demographic features of the patients involved in e-scooter traumas accessing to our ED department from May 1 to October 31, 2021

Zone	Soft tissue contusion	Fracture	Total trauma	Surgery (% total trauma)
Hip	2 (1%)	5 (4%)	7 (2%)	5 (71%)
Thigh and lower leg	2 (1%)	8 (7%)	10 (3%)	5 (50%)
Ankle	20 (12%)	11 (9%)	31 (11%)	7 (21%)
Knee	39 (24%)	9 (7%)	48 (17%)	5 (10%)
Foot	7 (4%)	8 (7%)	15 (5%)	–
Shoulder	17 (10%)	3 (2%)	20 (7%)	1 (5%)
Upper arm and forearm	1 (1%)	8 (7%)	9 (3%)	3 (33%)
Clavicle	2 (1%)	6 (5%)	8 (3%)	1 (12%)
Elbow	12 (7%)	30 (24%)	42 (15%)	–
Wrist	21 (13%)	19 (15%)	40 (14%)	1 (2%)
Hand	17 (10%)	10 (8%)	27 (9%)	–
Spinal	8 (5%)	1 (1%)	9 (3%)	–
Thorax (ribs)	7 (4%)	5 (4%)	12 (4%)	–
Head	4 (2%)	–	4 (1%)	–
Multi-district (>2 zone)	8 (5%)	–	8 (3%)	–
Total	167 (100%)	123 (100%)	290 (100%)	28 (9.6%)
Mechanism of injuries	Tot: 280			
Fall	230 (82%)			
Collision	50 (18%)			
Time presentation	Tot: 280			
Daytime (<18:00)	172 (61%)			
Night-time (>18:00)	108 (39%)			

ED, emergency department.

Traumas related to an exclusively orthopedic ED, in facilities that do not have other surgical and intensive therapies, were taken into consideration. For this reason, the patients who access it are exclusively orthopedic in nature, with at most occasional soft tissue contusions, superficial abrasions and sometimes minor head injuries without cranial fractures or intracranial bleeding. All the patients were hemodynamically stable with a normal GCS. Twenty-eight patients had a documented Injury Severity Score (ISS) with a median ISS of 5 (range: 4–6). An ISS was not calculated or documented for patients who did not undergo surgery. No patient who underwent surgery experienced complications or required intensive care unit access; the average length of hospital stay was 7 days (range: 2–13). The majority of scooter-related injuries occurred before 18:00.

Literature review

The systematic literature review was performed in PubMed/Medline and Embase in July 2022. The literature search flow-chart according to PRISMA Guidelines is illustrated in figure 1, summarizing the current data from the paper included in the literature review.

A total of nine studies related to electric scooter orthopedic injuries were included in the literature review (table 4).

Electric scooter injuries were analyzed to evaluate injury patterns specifically regarding type, incidence and treatment. The majority of studies were retrospective analysis of ED or trauma service databases. Not all the analyzed studies have reported all types of injuries, and similarly, sometimes patients have reported more than one injury. For these reasons, the sum of injuries does not always reach the 100% of the ‘number of injuries’ column.

English *et al* and Uluk *et al* were the studies reporting the highest number of e-scooter traumas^{11 12} both with 41 traumas/month, while the lowest rate was found by Bascones *et al*¹³ with five traumas/month. In all studies, outcome was reported for both the riders and the non-riders injured in the accident.

Most of the studies also analyzed the use of a helmet, reporting an overall low rate of helmet use. At the time of the study, there were no helmet requirement laws in the European countries analyzed. In contrast, in the USA, helmet and ‘rules of the road’ regulations (eg, riding on sidewalks vs streets) vary by locality.

Overall, the population in the studies considered was young: median age was under 40 for all studies. Siow *et al* and Genc *et al* observed a low rate of causalities.^{14 15} Siow reported a statistical positive correlation between age and ISS, with older patients experiencing more severe traumatic injuries.¹⁵

Bodansky and English also evaluated the site where the accident had occurred (sidewalks, street, pedestrian area).^{12 16} In the study by Bodansky *et al*, patients on e-scooter rentals were most commonly injured on roads, while those on private scooters were mainly injured on pavements. All injuries occurring in pedestrian zones were on rental e-scooters.¹⁶

Most of the studies reported alcohol usage: nearly half of the patients had been drinking alcohol in the study by Rizzo *et al*.¹⁷ The highest rate of hospitalization was found by Bascones *et al*, with more than half of patients needing hospitalization.¹³

Nine studies localized all injuries into similar body regions (shoulder/humeral fracture, clavicle fracture, elbow fracture, wrist/hand fracture, acetabular/femoral fracture, knee fracture, lower leg fracture, ankle/foot fracture, head fracture and spinal/ribs fracture)

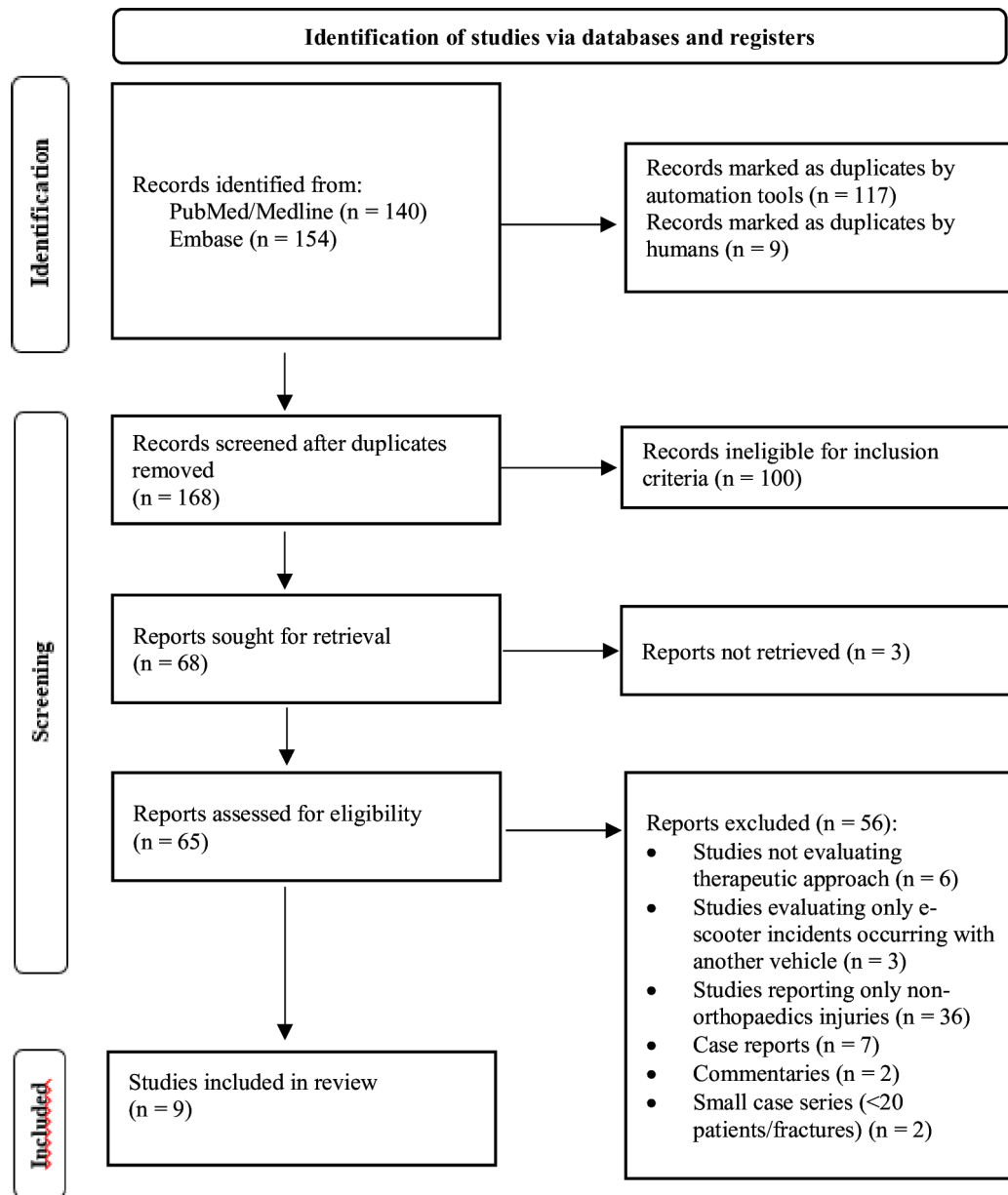


Figure 1 Flowchart according to PRISMA guidelines. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Upper limb trauma

In eight studies, the most commonly injured region was the upper extremity; Siow *et al* found that 47% of all the fractures were localized in this area: elbow and hand/wrist fractures accounted for 40% of the total¹⁵; similar results were found by Coelho *et al* (57% of upper limb fracture),¹⁸ Rizzo *et al* (56% of upper limb fracture)¹⁷ and Bodansky *et al* (68% of upper limb fracture)¹⁶; these three authors found that the most fractured joints were wrists and hands that represented, respectively, 44%, 41% and 47% of all fractures evaluated

Lower limb trauma

In six out of nine studies, the foot and ankle area were the most frequently involved in fractures within the lower limb, accounting for 17% of the total fractures observed by Bodanski *et al*.¹⁶ Similarly, for Bascones *et al*,¹³ it was 18%, which was the same rate as knee fractures in the study. The other studies found a value around 10% of fractures of the foot/ankle area.

Coelho *et al*¹⁸ reported a rate of 21% of knee and tibial fractures, making it the second most involved area after hand and wrist.

DISCUSSION

In our study, we found that e-scooter-related traumas are very common events, representing a burden for the orthopedic ED; we found a rate of almost 50 injuries per month of patients involved in e-scooter trauma. The upper extremities were the most common fracture location. These findings are in line with those found in literature.

The emerging general population awareness of climate change, together with the need for solo traveling because of COVID-19 pandemic, led to a widespread expansion of e-scooter rental worldwide.^{19 20} The evolving spread of e-scooters calls for an understanding of their potential consequences, as injuries are common with this type of or mode of transportation. Being a novel technology, the literature on the topic is still limited.

Table 4 Studies analyzed

Author	Year	Country	Age, years, (range)	Sex, M, (%)	Underage (<18years)	Helmet use	Alcohol	Total ED patients	Escoter trauma	Number of injuries	Soft tissue injury	Clavicle fracture	Shoulder+ upperarm fracture	Elbow fracture	Wrist+hand fracture	Acetabular femur+ thigh fracture	Knee fracture	Lower leg fracture	Ankle/foot fracture	Head fracture	Spinal-ribs fracture	Hospitalization rate	Surgical procedure	Mechanism of injury	
Genc Yavuz et al ¹⁴	May–November 2020 (6m)	Turkey	26 (15–57)	37 (53%)	6 (9%)	3 (4%)	2 (3%)	–	70 (11/m)	70	32 (46%)	–	–	2 (3%)	1 (0+1%)	–	–	–	–	1 (0+1%)	28 (40%)	2 (0+3%)	4 (6%)	5 (7%)	Fall: 66 (94.2%) Collision: 4 (5.8%)
Slow et al ¹⁵	November 2017–January 2020 (6m)	USA	37	300 (62%)	9 (4%)	14 (3%)	141 (29%)	–	485 (19/m)	213*	–	13 (6%)	3 (0+1%)	56† (26%)	0† (14%)	2 (5+6 (1+2+3+3))	8 (4%)	6 (3%)	11 (10 (5+5))	95 (20%)	8 (0+4%)	178 (37%)	77 (36%)	–	
Coelho et al ¹⁶	May 2019–May 2020 (12m)	Spain	30.8	238 (60%)	50 (13%)	55 (19%)	–	18 000	397 (33/m)	422	203 (48%)	9 (5%)	13 (0+6%)	4 (2%)	77† (39+5%)	1 (1+0+0 (1+5+0+0))	9 (5%)	27 (14%)	15 (3 (8+2))	–	2 (4 (1+2+2))	98 (25%)	98 (23%)	Fall: 341 (85.9%) Collision: 56 (14.1%)	
Stomann et al ¹⁷	July 2019–March 2020 (9m)	Germany	34 (15–67)	53 (70%)	2 (3%)	1 (1%)	–	31 500	76 (8/m)	100	–	–	7 (0+19+0%)	7 (19%)	8 (22%)	1 (0+0 (3+0+0+0))	2 (6%)	–	3 (1 (8+3+3))	6 (17%)	1 (0+3%)	20 (26%)	22 (22%)	Fall: 70 (92.1%) Collision: 6 (7.9%)	
Rizzo et al ¹⁷	April–November 2019 (7 m)	USA	31 (5–62)	35 (56%)	–	–	26 (42%)	–	62 (9/m)	86	12 (14%)	3 (3%)	–	10 (12%)	19 (16 (22+19))	3 (3+0 (0+3+0+0))	8 (9%)	2 (2%)	7 (3 (8+3+3))	–	–	18 (29%)	30 (35%)	Fall: 55 (89%) Collision: 7 (11%)	
Bascones et al ¹⁸	January 2018–December 2020 (36m)	Spain	37	92 (55%)	2 (1%)	–	–	–	167 (5/m)	185	56 (30%)	10 (9%)	9 (8+1%)	16 (14%)	17 (3 (14+3))	1 (0+1 (1+0+1+1))	21 (18%)	4 (3%)	13 (8 (11+7))	5 (4%)	1 (1 (1+1+1))	105 (63%)	85 (46%)	–	
Uluk et al ¹¹	June–December 2019 (6 m)	Germany	29 (5–81)	129 (52%)	10 (4%)	3 (1%)	49 (20%)	–	248 (41/m)	325	211 (65%)	3 (4%)	7 (0+9%)	12 (15%)	9 (11 (11+14))	1 (2+0 (1+2+2+0+0))	2 (2%)	3 (4%)	6 (3 (7+4))	19 (24%)	2 (0 (1+0+0))	61 (25%)	57 (17%)	Fall: 141 (57%) Collision: 39 (16%) Other: 68 (27%)	
Bodansky et al ¹⁹	October 2020–May 2021 (7 m)	UK	26 (16–72)	25 (49%)	–	–	4 (8%)	–	51 (7/m)	59	14 (25%)	3 (7%)	2 (0+5+0+0)	4 (9%)	9 (11 (21+26))	2 (2+0 (0+5+0+0))	4 (9%)	–	–	–	–	5 (10%)	8 (13%)	–	
English et al ²⁰	September–November 2018 (3m)	USA	30 (22–43)	74 (60%)	–	2 (2%)	–	25 250	124 (41/m)	191	–	–	5 (7%)	10 (14%)	16 (23 (23+6))	1 (0+1 (0+1+0+0))	4 (6%)	7 (10%)	10 (10%)	12 (17%)	4 (0 (6+0+0+0))	35 (28%)	26 (14%)	Fall: 105 (84.7%) Collision: 19 (15.3%)	

*Authors report forearm/wrist/hand together.

†Authors report only orthopedic injuries.

‡Authors report only radial and/or ulnar fractures.

§Authors report only patellar fractures, and tibial fractures.

¶Authors report lower arm and hand/wrist together, in the same way they report foot/ankle together.

ED, emergency department.

The analyzed studies are heterogeneous in terms of sample size, the number of patients included and the number of e-scooter-related traumas per month. However, the number of injuries observed is often significantly higher than the former. Nonetheless, the different studies took place in different parts of the world and for different periods of time, so the results might not be fully comparable.

As they tend to have a speed comparable to bicycles, most of the traumas tend to be of relatively low severity, even if the study from Bascones¹³ showed a high rate of hospitalization. Most of the e-scooter-related injuries observed in our study were minor, while 10% of the injuries required surgery.

From our data, the most frequent injury mechanism appears to be the loss of balance, resulting in a fall (82%), followed by collisions with objects, people or other vehicles (18%). This finding aligns with data in the literature, where the data of loss of balance are the most frequent cause ranging from 84.7% in English *et al* to 94.2% in Yavuz and colleagues.^{12 14} The only exception is the study by Uluk *et al*,¹¹ which finds a falling rate of 57%, though it includes other causes of injury like ‘hurt themselves at E-scooter’ or ‘tandem driving’.

In their study, Suominen *et al* found a head fracture in 15.8% of their patients and intracranial imaging lesion in 19.5% of the time.²¹ This analysis could be important for cities that are trying to have a helmet law for electric scooter users. Toofany *et al* found that the most common e-scooter injuries were the combination of head trauma with injuries to the upper and lower extremities.²²

The use of knee and elbows pads should be promoted to prevent injuries to the limbs. The most common localization of injury is the extremities, in particular, upper limb: young age could play a role in this localization because reflexes are ready to make the patient assume a defense position while falling. The radius is the most frequently fractured bone: it was seen by Ishmael and colleagues that radial head fracture was the most common elbow lesion, and similarly, distal radius was the most common lesion in the wrist and hand region. Cases of terrible triad injury of the elbow (combination of elbow dislocation, radial head/neck fracture and a coronoid fracture) were also described.⁵ Similarly, in our study, we found that radius was the most fractured bone following electric scooter accidents. According to the literature, distal radius fractures represent the most common fractures in adults with high-energy trauma, being the documented typical mechanism in younger patients.²³

Siow *et al* described that although the most common orthopedic injuries involved the upper extremity, several patients sustained high-energy lower extremity injuries, including open fractures, pelvic ring injuries, fractures of the acetabulum, hip, femur, tibial plateau and pilon.¹⁵ Regarding the site of injuries, our observations are in line with the available literature: the knee was the joint most commonly affected by trauma. Lower limb injuries, which usually involved the knee, ankle and foot, were probably due to the attempt of the rider to break a fall by placing a foot on the road surface to regain balance.²⁴ Coelho and colleagues found that lower limb fractures were more commonly treated with surgery than upper limb; this may be causally related to the speed at the time of the accident.¹⁸ This is in line with what was found in our study. Rizzo *et al* described a significant association between upper versus lower extremity trauma and the presence of open versus closed fractures, indeed, five lower extremity fractures were open compared with one upper extremity fracture.¹⁷

Moreover, several studies stressed the low rate of helmet use and the significant rate of alcohol intoxication among electric

scooter users. The studies we analyzed show very different data across the world in terms of casualties, hospitalization rate and the role of alcohol consumption. The latter could be due to different reasons, such as the sole declaration by the patient of having been drinking versus blood examination of alcoholemia. Moreover, there is no information about whether alcoholemia test was mandatory or was only requested at clinicians’ discretion. In our study, there was no information regarding drug and/or alcohol abuse. The high rate of alcohol intoxication, coupled with the higher rate of injuries occurring during nighttime, could be linked to the lack of a requirement for a driving license to rent an e-scooter. Störmann and Coelho have indeed observed a higher rate of e-scooter-related injuries during the evening hours and during the summertime.^{18 25} This data are in contrast with what we found in our cohort, where most of the electric scooter-related injuries occurred before 18:00.

English *et al* described the high number of imaging exams requested for e-scooter traumas, reporting that 91% of the patients required some type of imaging, including plain films (71% of all patients) and CT (40% of all patients).¹² Therefore, as the number of e-scooter traumas rise, so do the costs related to ED admissions. In a 2-month study, Mayhew and colleagues noticed that 221 plain films and 47 CT scans were performed on 63 patients referred to radiology, which ran into e-scooter-related injuries.⁶ In a 7-month study from Auckland (New Zealand), 246 medical-ward admissions were registered, with 49 patients undergoing surgery, with an average cost of 1693\$ (Australian Dollar) per injury. Twenty-seven per cent of injuries were considered to be related to alcohol abuse.⁸

Literature on the topic is relatively limited because of the recent implementation of the vehicles, but few studies have extensively investigated the literature on the use of e-scooter like ours. Our study revealed that e-scooter accidents constituted a significant proportion of two-wheeled vehicle accidents presenting at the orthopedic ED of a tertiary center. Future studies are necessary to fully understand the impact of this type of vehicle on orthopedic surgery, considering the growing market for e-scooters, as new companies keep emerging, but with regulatory policies lagging. The lack of updated policies could play a significant role in the spread of e-scooter-related accidents. Therefore, future studies are required to assess if the development of adequate policies could prevent at least some of the injuries currently occurring.

CONCLUSION

E-scooters are a new, cheap, green and easily accessible means of transport which are understandably increasing in popularity. Although this mode of transportation has many positive attributes, the most significant flaw that needs to be promptly addressed is the risk of injuries. Injuries could be prevented with adequate policies, resulting in a decrease in public cost. It is, therefore, necessary to establish safety policies in line with those for motorcycles, such as the requirement for a driver’s license, the mandatory use of safety devices like helmets and the prohibition of driving after consuming alcohol and drugs. Simultaneously, it is fundamentally important to educate the orthopedic community about the increasing incidence of this relatively new mechanism of trauma.

Acknowledgements The authors acknowledge the support of the APC central fund of the University of Milan

Contributors Concept and design: FL, VM, PSR. Data collection: FL, VM. Paper writing: FL, VM, PSR. Critical revision of the manuscript: PSR. All authors approved the final version of the manuscript and have nothing to declare. FL is responsible for the overall content as the guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests PSR declares that he is consultant for Arthrex, Depuy, Microport and Medacta—these activities were not related to the current study. The other authors have nothing to declare.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Institutional Review Board called Comitato Tecnico Scientifico per la Ricerca e la Formazione. The present work presents the characteristic of a retrospective analysis on aggregate data of the Hospital. The investigators did not receive any information of the single specific patients, not even in anonymous form. Therefore, the Ethical Committee's approval for this study is not required and the publication of the present paper is allowed in the present form. No patients' identifying data were included in this study. The study was performed according with the Helsinki Declaration. For these reasons, no informed consent to participate in the study was taken.

Provenance and peer review Not commissioned; externally peer-reviewed.

Data availability statement All data relevant to the study are included in the article.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Francesco Luceri <http://orcid.org/0000-0002-7247-1800>

Valerio Monteleone <http://orcid.org/0009-0002-4799-1238>

Pietro Simone Randelli <http://orcid.org/0000-0001-9331-820X>

REFERENCES

- Trivedi TK, Liu C, Antonio ALM, Wheaton N, Kreger V, Yap A, Schriger D, Elmore JG. Injuries associated with standing electric Scooter use. *JAMA Netw Open* 2019;2:e187381.
- Available: <https://www.gazzettaufficiale.it/eli/id/2022/08/30/22A04913/sg>
- Available: <https://osservatoriosharingmobility.it/wp-content/uploads/2022/10/6-Rapporto-Nazionale-sharing-mobility.pdf>
- Available: https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2021-11-09&atto.codiceRedazionale=21A06656&elenco30giorni=false
- Ishmael CR, Hsiue PP, Zoller SD, Wang P, Hori KR, Gatto JD, Li R, Jeffcoat DM, Johnson EE, Bernthal NM. An early look at operative Orthopaedic injuries associated with electric Scooter accidents: bringing high-energy trauma to a wider audience. *J Bone Joint Surg Am* 2020;102:e18.
- Mayhew LJ, Bergin C. Impact of E-Scooter injuries on emergency Department imaging. *J Med Imaging Radiat Oncol* 2019;63:461–6.
- BBC. Man killed in electric Scooter crash in. 2018. Available: <https://www.bbc.com/news>
- Bekhit MNZ, Le Fevre J, Bergin CJ. Regional Healthcare costs and burden of injury associated with electric Scooters. *Injury* 2020;51:S0020-1383(19)30608-4:271–7..
- Elm E von, Altman DG, Egger M, Pocock SJ, Göttsche PC, Vandenbroucke JP. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–8.
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71.
- Uluk D, Lindner T, Dahne M, Bickelmayer JW, Beyer K, Slagman A, Jahn F, Willy C, Möckel M, Gerlach UA. E-Scooter incidents in Berlin: an evaluation of risk factors and injury patterns. *Emerg Med J* 2022;39:295–300.
- English KC, Allen JR, Rix K, Zane DF, Ziebell CM, Brown CVR, Brown LH. The characteristics of Dockless electric rental Scooter-related injuries in a large U.S. city. *Traffic Injury Prevention* 2020;21:476–81.
- Bascones K, Maio Méndez TE, Yañez Siller FA. E-Scooter accidents: A new epidemic. *Rev Esp Cir Ortop Traumatol* 2022;66:S1888-4415(21)00137-5:135–42..
- Genc Yavuz B, Zengin Temel T, Satilimis D, Güven R, Çolak Ş. Analysis of electric Scooter injuries admitted to the emergency service. *Ir J Med Sci* 2022;191:915–8.
- Siow MY, Lavoie-Gagne O, Politzer CS, Mitchell BC, Harkin WE, Flores AR, Schwartz AK, Girard PJ, Kent WT. Electric Scooter Orthopaedic injury demographics at an urban level I trauma center. *J Orthop Trauma* 2020;34:e424–9.
- Bodansky DMS, Gach MW, Grant M, Solarì M, Nebhani N, Crouch-Smith H, Campbell M, Banks J, Cheung G. Legalisation of E-Scooters in the UK: the injury rate and pattern is similar to those of bicycles in an inner city metropolitan area. *Public Health* 2022;206:15–9.
- Rizzo MG, Allegra PR, Yakkanti R, Luxenburg D, Dodds SD. Electric Scooters as a source of orthopedic injuries at a level-I trauma center. *J Orthop* 2022;31:86–91.
- Coelho A, Feito P, Corominas L, Sánchez-Soler JF, Pérez-Prieto D, Martínez-Díaz S, Alier A, Monllau JC. Electric Scooter-related injuries: A new epidemic in Orthopedics. *J Clin Med* 2021;10:3283.
- Dean MD, Zuniga-Garcia N. Shared E-Scooter trajectory analysis during the COVID-19 pandemic in Austin, Texas. *Transportation Research Record: Journal of the Transportation Research Board* 2023;2677:432–47.
- Hollingsworth J, Copeland B, Johnson JX. Are E-Scooters polluters? the environmental impacts of shared Dockless electric Scooters. *Environ Res Lett* 2019;14:084031.
- Suominen EN, Sajanti AJ, Silver EA, Koivunen V, Bondfolk AS, Koskimäki J, Saارين AJ. 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 (Wien)* 2022;164:643–53.
- Toofany M, Mohsenian S, Shum LK, Chan H, Brubacher JR. Injury patterns and circumstances associated with electric Scooter collisions: a Scoping review. *Inj Prev* 2021;27:490–9.
- Candela V, Di Lucia P, Carnevali C, Milanese A, Spagnoli A, Villani C, Gumina S. Epidemiology of distal radius fractures: a detailed survey on a large sample of patients in a suburban area. *J Orthop Traumatol* 2022;23:43.
- Choron RL, Sakran JV. The integration of electric Scooters: useful technology or public health problem *Am J Public Health* 2019;109:555–6.
- Störmann P, Klug A, Nau C, Verboket RD, Leiblein M, Müller D, Schweigkofler U, Hoffmann R, Marzi I, Lustenberger T. Characteristics and injury patterns in electric-Scooter related accidents—A prospective two-center report from Germany. *J Clin Med* 2020;9:1569.