

# Head injury resulting from scooter accidents in Rome: differences before and after implementing a universal helmet law

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**Objectives:** To estimate the incidence rates and related determinants of head injuries before and after the implementation of a new universal helmet law in Italy. **Methods:** The investigation took place in the Emergency Room of the Accident and Emergency Department, Teaching Hospital 'Umberto I', Rome, in 1999 (before the new law), and 2000 (two periods after the new law). Personal data, injury circumstances, helmet use, others involved in injury and health data, were collected. Incidence rates by time period were calculated and differences between groups were analysed. Logistic regression models were conducted to assess the association between head trauma and potential determinants. **Results:** The incidence rate of all injury among scooter riders rose from 64.36/10 000 person-years before the new law (1999) to 98.05/10 000 person-years afterwards. The incidence rate of head trauma among scooter riders showed an opposite trend, i.e. a decrease from 26.65/10 000 person-years (1999) to 8.88/10 000 person-years in the second post-legislation period. Helmet use among injured scooter riders rose from 5% before the new law to 90% afterwards. Helmet use is a protective factor for being a patient with head trauma, in all the periods considered (OR 0.24–0.44). After implementation of the new law, age (18+) showed a protective effect as well (OR 0.42–0.44). **Conclusion:** Helmet use has a protective effect on head trauma among scooter riders. One year after implementing a universal law, helmet use has increased substantially and a sharp reduction in head trauma among persons older than 18 years could be observed.

**Keywords:** epidemiology, head trauma, helmet law, Italy, road traffic injury, scooter injuries

## Introduction

Over the past decades, the number of fatal injuries related to the use of two-wheeled motor vehicles (i.e. scooters) in Italy has been high in comparison with other industrialized countries and it is likely that many of these fatalities could have been prevented. In particular, head injuries and their negative consequences are largely preventable by wearing a helmet, as has been demonstrated in several studies.<sup>1–6</sup> There is evidence that helmet use decreases the severity of injury, mortality and costs of medical care in two-wheeled motorcycle-related crashes.<sup>4,7–13</sup> Moreover, it is well-known that helmet use significantly reduces the risk of brain injury and its long-term complications.<sup>6,14</sup>

It has been reported that the introduction of helmet laws leads to an increased use of helmets and a reduction of the number of hospital admissions, serious injuries and costs related to head trauma.<sup>15–19</sup> In some states of the USA, however, universal motor helmet laws have been withdrawn recently, which has led to a negative impact on population health. Bledsoe *et al.*<sup>20</sup> demonstrated that repeal of the mandatory helmet law in Arkansas was associated with an increased morbidity associated with non-helmeted motorcycle riders involved in a crash, and with an increased use of hospital resources. Kyrychenko and McCartt<sup>21</sup> showed that after the repeal of the universal helmet law in Florida, the observed

helmet use declined from nearly 100% in 1998, before the law change, to 53% thereafter, and motorcyclist death rates increased for riders of all gender and age groups.

Universal helmet laws, covering the whole population, are therefore of primary importance in limiting the consequences of scooter injuries.

In Italy, however, the compulsory use of helmets has long been restricted to persons beneath 18 years of age. Much later than in other countries (March 2000), a universal helmet law was implemented in Italy including mandatory helmet use for scooter drivers older than 18 years old (Law n. 472, 07/12/1999; G.U. n. 294, 16/12/1999).<sup>22</sup>

The aim of the present study is to estimate the incidence rates and related determinants of head injuries resulting from scooter injuries before and after the implementation of the new universal helmet law.

## Methods

### Study design

A surveillance study was conducted at the Emergency Department of Policlinico 'Umberto I' in Rome, in the following periods: March–June 1999 (before the new universal helmet law for scooter drivers and passengers); March–June 2000 (first post-legislation period, indicated as 'A') and September–November 2000 (second post-legislation period, indicated as 'B').

This hospital is a teaching hospital in the third Municipality of the historical centre of Rome (figure 1).

### Data collection

Data were collected by health care providers with a specific form validated in a previous study conducted in the cities of Rome and Naples,<sup>10</sup> that covers issues not routinely collected at the Emergency Department. This form includes

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demographic data of injured people, and information on injury circumstances, helmet use and type of injury, using a matrix describing the location and the severity of the lesions.<sup>23</sup>

Data collection took place at the Emergency Department interviewing the patient at the time of admission. When a severely injured patient was admitted, data collection was conducted with next to kins.

### Statistical analysis

Incidence rates were calculated using the new cases of injury resulting from scooter crashes in the study periods as the numerator. The denominator was estimated by the population of the catchment area in the three periods. Data imputation was conducted using a common database (DbIV). Crude relative risks (and 95% CI) indicating the risk of having a head trauma after a scooter injury for a certain exposure in relation to not exposure was calculated. Non-parametric tests were used ( $\chi^2$  and Yates correction) in order to assess differences between groups. For continuous variables, Kruskal–Wallis tests were conducted. The statistical significance was set at  $P < 0.05$ .



**Figure 1** The localization of the third municipality in the historical centre of Rome

Moreover, a multivariate model was conducted taking as dependent variable 'being a patient with head trauma', and as covariates the following: helmet use (yes/no), age group ( $\geq 18$  years/ $< 18$  years), type of injury (collision with other vehicles/no collision), gender (female/male).

The statistical analysis was conducted using SPSS statistical package, release 12.0.

### Results

Before the implementation of the new universal helmet law for scooter drivers, we estimated an incidence rate of all injury of 64.36/10 000 person-years, while the estimate was 79.45/10 000 person-years in the first post-legislation period (A) and 98.05/10 000 person-years in the second post-legislation period (B). Thus, taking the 1999 incidence rate as reference, after implementing the new universal helmet law we found for all injury an RR of 1.23 and 1.52 for periods A and B, respectively.

In table 1, the characteristics of scooter drivers (all injury) are shown by period of time. It can be observed that as far as age is concerned, the age group showing a decreasing, although not significant, proportion of all scooter-related injuries is 18–29 years, while for people under 18 and above 30 years a slight increase was observed. Concerning gender, a significant decreasing proportion of hospitalizations was observed in male scooter drivers ( $P = 0.0004$ ), while in females this trend did not happen. Helmet use has shown a spectacular increase among injured scooter riders, rising from 15% before the new law to 97% (period A) and 90% (period B) afterwards. Table 1 further shows an opposite pattern by type of crash: injury without collision shows a decreasing proportion and scooter-car accidents show an increasing trend ( $P < 0.0001$ ).

Before the implementation of the new universal helmet law for scooter drivers, we estimated an incidence rate of head trauma of 26.65/10 000 person-years, while the estimate was 21.15/10 000 person-years in the first post-legislation period (A) and 8.88/10 000 person-years in the second post-legislation period (B). Thus, taking the 1999 incidence rate as reference, after implementing the new universal helmet law we found an RR for head trauma of 0.79 (95% CI: 0.68–0.90) and 0.33 (0.19–0.48) for periods A and B, respectively.

Looking at the characteristics of scooter drivers with head trauma (table 1), by period of time, interestingly, for each group within each variable, considering 1999 injuries and head

**Table 1** Characteristics of injured scooter drivers, including frequency distribution and ORs of head trauma

	All injury 1999 (%)	All injury 2000 A (%)	All injury 2000 B (%)	<i>P</i>	Head trauma 1999 <i>N</i> (%)	Head trauma 2000 A <i>N</i> (%)	Head trauma 2000 A OR (95% CI)	Head trauma 2000 B <i>N</i> (%)	Head trauma 2000 B OR (95% CI)
Age group (years)									
<18	29 (7.5)	29 (6.1)	52 (8.9)		11 (7.4)	8 (5.0)	0.62 (0.18–2.16)	9 (18.0)	0.34 (0.11–1.09)
18–29	213 (55.5)	241 (50.8)	281 (48)	0.104	98 (65.3)	79 (50.0)	0.57 (0.38–0.85)	29 (58.0)	0.14 (0.08–0.22)
$\geq 30$	142 (37.0)	204 (43.1)	252 (43.1)		41 (27.3)	71 (45.0)	1.32 (0.81–2.15)	12 (24.0)	0.12 (0.06–0.25)
Gender									
Males	235	295	365		100 (66.7)	93 (58.9)	0.62 (0.43–0.90)	26 (52)	0.10 (0.06–0.17)
Not hospitalized	200 (85.1)	272 (92.2)	344 (94.2)	<0.001					
Hospitalized	35 (14.9)	23 (7.8)	21 (5.8)						
Females	149	179	220	0.533	50 (33.3)	65 (41.1)	1.13 (0.70–1.83)	24 (48)	0.24 (0.14–0.43)
Not hospitalized	139 (93.3)	164 (91.6)	207 (94.1)						
Hospitalized	10 (6.7)	15 (8.4)	13 (5.9)						
Helmet use									
Yes	19 (5)	461 (97.2)	527 (90)	<0.001	13 (8.7)	146 (92.4)	0.21 (0.07–0.62)	41 (82)	0.04 (0.01–0.12)
No	365 (95)	13 (2.8)	58 (10)		137 (91.3)	12 (7.6)	19.97 (2.67–415.7)	9 (18)	0.31 (0.14–0.67)
Type of injury									
No collision	233 (60.7)	235 (49.6)	229 (39.1)		63 (42.0)	85 (53.8)	1.53 (1.01–2.31)	18 (36.0)	0.44 (0.24–0.80)
Scooter–scooter	20 (5.2)	40 (8.4)	34 (5.8)	<0.001	10 (6.7)	23 (14.6)	1.35 (0.40–4.56)	3 (6.0)	0.10 (0.02–0.50)
Scooter–car	131 (34.1)	199 (42)	322 (55.1)		77 (51.3)	50 (31.6)	0.24 (0.14–0.39)	29 (58.0)	0.07 (0.04–0.12)
Total injuries	384	474	585		150	158		50	

*P*-value refers to statistical testing in relation to injury in the three periods

trauma as a reference, a decreasing trend of the risk of head trauma is observed. Contrary to persons below 18 years of age, head trauma among scooter drivers older than 18 years was sharply reduced after the new law. As a result, the proportion of scooter riders younger than 18 years has increased significantly ( $P=0.0005$ ). As far as the estimate of the relative risks is concerned, we can observe that the most dramatic change regards people of more than 30 years of age (from  $OR=1.32$  to  $OR=0.12$ ). Helmet use among scooter riders with head trauma has shifted from 90% not wearing before the new law to 82% wearing in the second post-legislation period. As far as the estimate of the relative risks is concerned, in 2000 we observed for helmeted scooter-injured drivers a decreasing trend of the risk (from  $OR=0.21$  to  $OR=0.04$ ).

It is interesting to note that all injury resulting from scooter accidents showed an increase in periods A and B in 2000, while for head trauma we observed a decrease. In fact, in 1999, 12.43% of lesions were localized to the head, while this localization covered, respectively, 7.8 and 3.85% of cases in both the periods in 2002 ( $\chi^2=58.89$ ;  $P<0.0001$ ) (table 2). This has been accompanied by a rising share of lower extremity injury on the contrary.

In the three periods, the average number of lesions occurred in each injured scooter drivers seems to substantially decline, ranging from 3.33 in 1999 to 3.22 in 2000 A and to 1.91 in 2000 B ( $P<0.0001$ ). Regarding the mean hospital stay for hospitalized injured people, it goes from 7.1 days before the new law (1999) to 8.7 and 5.6 days in both the periods in 2000, respectively ( $P=0.0043$ ) (data not shown).

In table 3, the results of multiple logistic regression are shown. Helmet use is a protective factor for being a patient with head trauma, in all the periods considered (the protective effect goes from a decreasing risk of 76% in 1999 to 56% in the second post-legislation period). It can be noted that after implementing the new law, scooter drivers older than 18 years show a lower likelihood of suffering from head trauma compared with younger persons ( $OR=0.44$  and  $OR=0.42$ , respectively for periods A and B, in 2000).

**Table 2** Number of patients seen at the Emergency Department following a scooter injury, by place of lesion, in the three periods

Periods	Total (%)		
	1999	2000 A	2000 B
Head	159 (12.43)	119 (7.79)	43 (3.85)
Trunk	100 (7.82)	103 (6.74)	83 (7.44)
Upper extremity	408 (31.9)	450 (29.45)	370 (33.15)
Lower extremity	547 (42.77)	798 (52.22)	577 (51.7)
≥3 regions	65 (5.08)	58 (3.8)	43 (3.86)
Total (%)	1279 (100)	1528 (100)	1116 (100)

**Table 3** Results of multiple logistic regression

Variable	1999 OR (95% CI)	2000 A OR (95% CI)	2000 B OR (95% CI)
Helmet use			
No (reference)	1	1	1
Yes	0.24 (0.11–0.51)	0.32 (0.18–0.53)	0.44 (0.20–0.98)
Age group (years)			
<18 (reference)	1	1	1
≥18	1.08 (0.50–2.33)	0.44 (0.21–0.91)	0.42 (0.19–0.93)
Collision			
No (reference)	1	1	1
Yes	1.13 (0.72–1.79)	1.24 (0.83–2.01)	1.15 (0.63–2.12)
Gender			
Male (reference)	1	1	1
Female	0.99 (0.63–1.54)	1.14 (0.73–1.71)	1.69 (0.93–3.05)

Dependent variable: patient with head trauma

## Discussion

We conducted a pre–post study in which, in the same hospital location, we tried to estimate the effect of the implementation of the new universal law on compulsory helmet use for scooter drivers and passengers of all ages, in Italy.

First of all, we confirmed helmet efficacy in head trauma prevention in injuries among two-wheeled motor vehicles as previously reported in the scientific literature.<sup>2,4,5,7,24</sup> In Italy, non-helmeted riders and passengers are 2–4 times more likely to sustain a head trauma than helmeted users of scooters.

On the other hand, we observed in the post-legislation periods that other anatomical regions such as the lower extremities showed a greater relative contribution to scooter injuries, and this is similar to what has been reported by other authors.<sup>14</sup>

Secondly, our study showed a large effect of the new universal helmet law on the proportion of scooter drivers wearing the helmet. This is witnessed by the proportion of helmet use in injured scooter drivers in our study, rising from 5% before the new law to 90% afterwards. Thirdly, we observed a large reduction of the risk of being a patient with head trauma for people above 18 years of age, in both the after-law periods.

The extension of mandatory helmet use to people above 18 years of age is associated with reduced average hospital stay and, as a consequence, to reduced economic impact of injuries for scooter riders, confirming the results of previous studies.<sup>9,15–17,26–28</sup>

We argue that for several reasons, our results on the effectiveness of the new helmet law in Italy appear robust. We demonstrated a specific effect on head trauma contrary to other injury, and a specific effect on persons older than 18 years contrary to younger persons. These results were specifically aimed at by the new law. Moreover, we demonstrated a sustained effect in two post-legislation periods. Finally, the increased use of helmets combined with the reduction of head trauma shows consistency among results.

Nevertheless, our study, such as all surveillance-based research, may have suffered from several limitations. This could have affected the results of our multivariate model in particular, since, not all factors that may influence the likelihood and severity of injuries could be included. This concerns, for example, speed at impact and blood alcohol concentration, because they are not routinely collected after a scooter injury. As far as the possible presence of confounding or misclassification is concerned, we can argue that helmet use might have limited the number of accidents with a deadly outcome, but in our experience no scooter-injured drivers died, and we do not know anything about the deaths of scooter drivers who were not brought to the Emergency Department. Moreover, selection bias could have occurred. But, since helmet use is able to reduce injury severity, helmeted scooter riders are probably under-represented, which could have led to an underestimation of the protective effect of wearing a helmet, in particular after implementation of the new law. Finally, concerning selection bias we are confident that in a city like Rome, the source population is formed essentially by residents, while tourists and people from other parts of Italy on scooters could represent a vast minority, and this is witnessed by the nationality and by place of residence of injured scooter drivers.

Further research on this topic is certainly required, such as regarding the protective effect of several types of helmet. A case-control study from Tsai *et al.*<sup>29</sup> showed an efficacy in the reduction of brain injuries with ‘full-face helmets’ as opposed to ‘partial-face helmets’.

In addition, research with respect to the sustainability of helmet law effectiveness seems highly needed. It has been

shown that both educational aspects and police controls seem to be fundamental in order to produce sustainable effects of a helmet law. But in this field, good intentions are not always followed by good results in the long term. In Italy, after the implementation of the first law on compulsory helmet use in 1989 (which covered scooter users under 18 years of age only), the proportion of helmet users increased rapidly both in motorcyclists (from 15.1% to 96.5%) and scooter riders (from 4.0% to 50.5%). However, after a short period these proportions decreased, reaching values of almost 20%.<sup>30</sup> This shows that our research needs repetition with a longer follow-up period. If negative results will be found for riders older than 18 years as well, behavioural research into determinants of non-compliance to helmet laws should be started. This type of research can support the further development of scooter and motorcycle education reflecting the importance of helmet use. Swaddiwudhipong *et al.*<sup>31</sup> demonstrated that health promotion interventions in this field are effective in increasing helmet use rate among motorcycle riders.

A combined approach of legislation and education, supported by behavioural research, could be the key to sustainable prevention of head trauma among scooter riders in Italy and other countries, such as developing countries, where this problem is expected to rise in future.

Effective preventive strategies in the field of road traffic injuries need to take into consideration several approaches. As an example, in Italy the strong relationship between road traffic events and the deduction of points from the driver's licence suggests that police control may play a key role in preventing road traffic injuries.<sup>32</sup> In the *World Report on Road Traffic Injury Prevention* and in *Preventing Road Traffic Injury: A Public Health Perspective for Europe*, these strategies have been documented including many factors, among which the most important are speed control and provision of safer conditions for vulnerable road users, including users of two-wheeled motor vehicles.<sup>33,34</sup>

*Conflict of interest:* None declared.

## Key points

- Helmet efficacy in head trauma prevention in injuries among two-wheeled motor vehicles was confirmed as previously reported in the scientific literature. Non-helmeted riders and passengers are 2–4 times more likely to sustain a head trauma than helmeted users of scooters in Italy.
- In the post-legislation periods, other anatomical regions (lower extremities arms) showed a greater relative contribution to scooter injuries.
- A large effect of the new universal helmet law was observed on the proportion of scooter drivers wearing the helmet. This is witnessed by the proportion of helmet use in scooter drivers injured in our study, rising from 5% before the new law to 95% afterwards.
- The main target of the new helmet law was achieved: we observed a large reduction of the risk of being a patient with head trauma for people above 18 years of age, in both the after-law periods.

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