Effect of Italy’s motorcycle helmet law on traumatic brain injuries

F Servadei, C Begliomini, E Gardini, M Giustini, F Taggi, J Kraus

Objectives: To evaluate the impact of a revised Italian motorcycle-moped-scooter helmet law on crash brain injuries.


Setting: Romagna region, northeastern Italy, with a 2000 resident population of 983,534 persons.

Participants: Motorcycle-moped rider survey for helmet use compliance and all residents in the region administrative organisation of the Italian health care system, uniformly distributed over the national territory, monitored the use of helmets in their areas. This survey included about 300,000 moped riders. About half of the units also provided data concerning emergency department visits due to moped crashes before and after the new law was implemented.

Methods

Helmet use

The Italian National Health Institute, in anticipation of a revised helmet law, undertook an independent survey (Casco 2000) to measure use of the motorcycle helmets in the country. As shown in previous studies, the introduction of a new helmet law does not necessarily guarantee their use. In the period February to June 2000, 57 local health care units (the administrative organisation of the Italian health care system), uniformly distributed over the national territory, monitored the use of helmets in their areas. This survey included about 300,000 moped riders. About half of the units also provided data concerning emergency department visits due to moped crashes before and after the new law.
Helmet use in Romagna

The Romagna region is located in the north east of Italy and has three districts: Ravenna, Rimini, and Forlì-Cesena; the total resident population in 2000 was 983 534. During the summer this number doubles because of the large number of tourists who are attracted to the many holiday resorts, pubs, and discos in the region.

Data for the Romagna region from the Casco 2000 survey showed that before the introduction of the revised helmet law (February to March 2000), the percentage of correct helmet use was only 19.5% in a stratified sample of 25 356 motorcycle and moped drivers. In the period after enforcement of the revised law (April to June 2000), the percentage increased to 97.5% in a sample of 39 327 motorcycle and moped drivers. This change was due to a public campaign in the media and to strong police enforcement.

Traumatic brain injury data

To evaluate the effects of the helmet law on TBI in Romagna, we examined the admission database of the Neurosurgery Division at the “Bufalini” Hospital, the only neurosurgical centre in the region. This hospital is equipped with computed tomography image transmission from all peripheral hospitals in the region. Guidelines for head injury management, coupled with computed tomography image transmission, resulted in the centralization of all brain injured patients requiring surgery or having the potential for an evolving intracranial lesion.

Furthermore, all comatose patients needing intracranial pressure monitoring are transferred to the Bufalini Hospital since the only neurointensive care unit is located in this hospital. Therefore, the TBI admission database of the Bufalini Hospital contains all of the most “severe” cases of TBI in all of Romagna. TBI patients from motorcycle crashes were identified electronically in this database.

Non-resident patients admitted for TBI were eliminated from the database. The incidence rate of motorcycle crash related TBI admission to the neurosurgery/neurointensive care unit (per 100,000 population per year) was based on census data for the resident population.

For purposes of this study, 30 March 1999 to 29 March 2000 was designated as the pre-law year (1999), and 30 March 2000 to 29 March 2001 was the post-law year (2000).

RESULTS

As shown in fig 1, the incidence rate per 100,000 persons of TBI admissions to neurosurgery decreased significantly by 31.4% after introduction of the revised law. This reduction is highly significant (p<0.001, χ²=16.99). The change in rate was also seen using the number of registered motorcycles-mopeds in Romagna (n=432,000) as the unit of exposure. The rate pre-law was 63 per 100,000 registered vehicles and the post-law rate was 43 per 100,000 registered vehicles, a decrease of 31.7% (p<0.001, χ²=16.05)

Specific TBI diagnoses also changed as a result of the helmet law (fig 2). For example, we observed a 76% decrease in the diagnosis of traumatic subarachnoid hemorrhage and subdural and epidural hematomas (International Classification of Diseases, 9th revision, clinical modification 852) due to motorcycle-moped crashes. This decrease was statistically significant (p<0.00001, Fisher’s exact test).

The changes in the neurosurgical/neurointensive care unit admissions were almost entirely due to a decrease in numbers of patients admitted with an epidural hematoma after moped crashes. For example, in 1998 there were 37 patients admitted with an epidural hematoma and in 1999 (the year before the new law), 42 patients were admitted. In the year after the introduction of the revised helmet law, only four patients were admitted with this TBI diagnosis. During the same period, the
number of patients with acute subdural hematomas or diffuse intracranial injuries decreased only slightly (17 patients in 1998, 18 patients in the year before the law, and 13 cases in the year after). These two hematoma series differed significantly (p<0.005, \( \chi^2 = 11.25 \)).

A comparison of all TBI incidence shows that there was no significant variation before and after introduction of the revised helmet law, with the exception of TBI admissions because of motorcycle-moped crashes (fig 3) where a 66% decrease (p<0.0001, \( \chi^2 = 22.55 \)) was observed. TBI admissions by age group showed that motorcycle-moped riders aged 18–30 years (p<0.01, \( \chi^2 = 8.64 \)), 31–60 years (p<0.05, \( \chi^2 = 5.88 \)), sustain significantly less TBI (fig 4). Patients aged 14–17 years had also less TBI but had only marginal significance (p=0.052, \( \chi^2 = 3.78 \)).

**DISCUSSION**

**Helmet use before and after the law**

In Italy, before 2000, the motorcycle helmet had not been accepted by motorcycle and especially by moped riders. Aesthetic, fatalistic, and climatic reasons were given for not using helmets. A survey conducted in 1986 before and after the introduction of the earlier law showed an increase in use of helmets (from 15% to 96%) for motorcycle drivers and (from 4% to 53%) for moped drivers. In a recent study done in 1999 before the introduction of the new law, only 22.5% of injured scooter drivers wore a helmet in Rome. In Naples, only 3.4% of injured drivers wore helmets.

Earlier data from Italy have demonstrated that helmet use reduces hospital admissions for head injuries by 28%–37%. Similar results were also published for Taiwan. Our study confirms this effect by showing a 31% decrease in admissions to the neurosurgical unit after the introduction of the new law (fig 1).

Since new guidelines for head injury management and teleradiology image transfer were introduced at the same time as the revised helmet law, we studied in more detail the TBI population to try to separate the effects of helmet law from possible effects from these management changes.

The independent effect of helmet use in the decrease of TBI is highlighted by the fact that admissions for TBI from other external causes (fig 3) such as pedestrian, bicycle, or car crashes did not show any significant change after the national helmet law was introduced. Therefore, it is reasonable to conclude that the differences observed were not due to simultaneous changes in head injury management policy.

We also showed (fig 4) that the effect of helmet law enforcement is observed in almost all rider age groups. The decrease of head injury admissions among those 14–17 years of age after the introduction of the new law shows that the earlier legislation was far from optimal. According to police, enforcement of a new law is much easier when all riders must wear a helmet.

**Specific reduction of intracranial hematomas**

Our findings are in agreement with that reported in a paper from Taiwan that demonstrated a significant decrease in intracranial post-traumatic hematomas after the introduction of a new helmet law. The data collected in this study show that the reduction of intracranial hematomas with the use of helmets in moped drivers is mainly due to the “disappearance” of one type of hematoma: the epidural hematoma. This hematoma is usually associated with the presence of a skull fracture and is considered the “typical” primary impact brain injury. The clinical pattern of this type of hematoma is the so-called “lucid interval”, or a brief post-traumatic loss of consciousness followed by a period of normal consciousness and then followed by a comatose state. Since mortality associated with these hematomas can be zero when the diagnosis is made during the “lucid period” before the coma state, heightened efforts have been dedicated to the management of apparently mild head injured patients with the aim of early diagnosis of intracranial hematomas.

We have shown that, in Italy with a large number of mopeds in use by younger riders, wearing helmets results in a significant decrease of epidural hematomas, whereas subdural or diffuse injuries, which generally occur from high speed impacts, are much less affected by helmet use. Confirmation of our findings in other regions of Europe with high use of mopeds or scooters is suggested.

**Study limitations**

Although national data on helmet use, before and after the new law, were available for all of Italy, detailed information on the impact of the law on TBI was limited to only the Romagna region of Italy. However, informal communications with neurosurgical colleagues (A Andreoli, A Barbenera, 2003) in Bologna (a city with the neurosurgical unit closest to the Romagna region) revealed a similar reduction in the incidence of epidural hematomas in the one year period after introduction of the revised helmet law. In addition, our colleagues report a 63% reduction in TBI hospital admissions because of motorcycle-moped crashes in their city. Nonetheless, an expanded study of the impact of the revised helmet law is...
needed to generalize the effect observed in the Romagna region to all of Italy.

CONCLUSIONS
We have observed that in the year 2000 in Romagna there was significant decrease in neurosurgical hospital admissions for motorcycle-moped TBI because of the adoption of the national compulsory helmet law. This dramatic decrease in TBIs after motorcycle-moped crashes was evident in all age groups. Epidural hematomas have almost disappeared in injured moped drivers after the introduction of the revised law.

It has been confirmed that the mandatory use of helmets, with police enforcement, is an effective measure for traumatic brain injury prevention at any age.

Authors’ affiliations
F Servadei, C Begliomini, E Gardini, WHO Collaborating Centre on Neurotrauma, Maurizio Bufalini Hospital, Cesena, Italy
M Giustini, F Taggi, Italian National Health Institute, Rome, Italy
J Kraus, WHO Collaborating Centre on Neurotrauma, UCLA Southern California Injury Prevention Research Center, Los Angeles, California, USA

REFERENCES