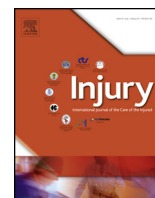




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# Driver's education may reduce annual incidence and severity of moped and scooter accidents. A population-based study

Silja Kosola<sup>a,b,\*</sup>, Päivi Salminen<sup>b</sup>, Pentti Kallio<sup>b</sup><sup>a</sup> School and Student Health Care, City of Helsinki, Finland<sup>b</sup> Department of Pediatric Surgery, Helsinki Children's Hospital, Helsinki University Central Hospital and University of Helsinki, Finland

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## ABSTRACT

**Background and aims:** In our previous study, the annual number of adolescents treated at Helsinki Children's Hospital and Töölö Trauma Centre for injuries from moped and scooter accidents increased five-fold between 2002 and 2007. In June 2011, the requirements for a moped/scooter license changed to include driver's education and a vehicle handling evaluation. The aim of this retrospective study was to assess the influence of legislative changes on moped and scooter related serious injuries in adolescents. **Patients and methods:** Data from 520 patients (age 15–16) treated for trauma from moped and scooter accidents at our institutions between January 2008 and December 2013 were included. Case numbers were compared with population data from national databases. Overall incidence, trauma mechanism, injury profile, and proportion of patients requiring hospital admission were calculated for time periods before and after the law amendment.

**Results:** After the law change in 2011, the annual incidence of moped/scooter injuries among 15-year-olds in our area decreased from 0.8% in 2011 to 0.3% in 2013 ( $p < 0.001$ ), and estimated incidence of injuries per new moped/scooter license declined from 1.8% in 2011 to 1.0% in 2013 ( $p = 0.001$ ). Simultaneously, proportions of patients injured in collisions, diagnosed with multiple trauma or requiring in-patient care reduced.

**Conclusions:** A change in moped/scooter license requirements may have a causal relationship with both reduced number and severity of moped/scooter related injuries in adolescents.

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## Introduction

Two-wheeled motorised mopeds and scooters provide an easy means of transport both in urban and rural settings and have become highly popular among teens in Europe. Moped and scooter sales are increasing also in Australia, Canada, and the United States [1–3]. In Europe, road traffic injuries account for 20% of injury deaths among 0–18-year-olds [4], and half of these deaths are due to motorised two-wheelers [5]. In addition to mortality, moped and scooter riders face a 20–45-fold risk of injury in comparison to car drivers [1,6], and moped crash rates per distance travelled may also be nearly four-fold in comparison to motorcycles [7].

According to Finnish law, a 15-year old is allowed to drive a moped or scooter (maximum velocity of 45 km/h and maximum motor capacity of 50 cm<sup>3</sup>). Until June 2011, a written permit from a

legal guardian, a health certificate, and passing a written examination were required to obtain a moped or scooter driver's license. Between 2002 and 2007, the number of new moped/scooter licenses issued in Finland doubled, as did the proportion of 15–17-year old road traffic victims [8]. Our previous study covered the same time period in Finland's largest tertiary hospitals treating adolescents, and found a five-fold increase in annual patient numbers treated for trauma sustained in moped and scooter accidents [9]. In June 2011 the law was changed. Since then, moped/scooter driver's license applicants are required to participate in theoretical instruction and practical driving lessons (minimum six and three hours, respectively), followed by both a theoretical written exam and a vehicle handling test [10].

Minimum four hours of theoretical instruction must be on moped-related topics, and driving lessons must include at least an hour of vehicle handling and two hours of driving in traffic. The exam consists of ten verbal multiple choice questions including traffic signs (one false answer allowed) and 15 photographs of traffic situations with an attached true/false sentence (e.g. I am allowed to continue driving straight in this lane). The legal right to

\* Corresponding author at: Helsinki Children's Hospital, Biomedicum 2 C, Room# 609, PO Box 705, 00029 HUS, Finland. Tel.: +358 9 427 5725.

E-mail address: [silja.kosola@hus.fi](mailto:silja.kosola@hus.fi) (S. Kosola).

ride a moped or scooter with a pillion passenger remained unchanged, and helmets are required for both drivers and passengers.

Our aim was to evaluate the influence of the legislative change in reducing trauma from adolescents' moped and scooter accidents and to discuss further means of improving road traffic safety of adolescents.

## Patients and methods

### Patients

We gathered patient records of all children aged 7–16 years treated for trauma at the Helsinki Children's Hospital and Töölö Trauma Centre, Helsinki, Finland, or Jorvi Hospital, Espoo, Finland, between January 2008 and December 2013. For this study, inclusion criteria were: trauma from moped/scooter accidents (excluding motocross injuries), legal moped/scooter driving age (15 or 16 years) and living in the six cities or municipalities for which our centres serve as the primary source of specialist care (Helsinki, Espoo, Vantaa, Kirkkonummi, Kerava, and Kauniainen). Altogether 520 patients fulfilling inclusion criteria were identified and included in the study.

We collected the following information from patient records: date of birth, date of admission, gender, accident details, helmet use, patients' self-reported speed, diagnoses, hospitalisation days, and surgical procedures under general anesthesia.

Trauma were grouped into four categories of head trauma, fractures, internal injuries, and multiple trauma. Multiple trauma were defined as severe injury of two or more body parts (head trauma, trauma of internal organs, and fractures).

Because the law change came into effect mid-year 2011 that year was excluded from comparisons in accident features and clinical data before and after the new law.

### Data for incidence estimates

Helsinki Children's Hospital is the only paediatric hospital in Helsinki and has the only paediatric ICU in the province of Uusimaa (population 1.4 million). Töölö Trauma Centre provides treatment for neurosurgical trauma, and Jorvi Hospital is the primary surgical unit for children and adolescents from Espoo, Vantaa, Kauniainen and Kirkkonummi.

Statistics on population demographics and issued moped/scooter licenses were available via Statistics Finland and the Finnish Road Safety Council [8,10]. From the annual census, we derived the population of 15-year-olds in the six cities or municipalities for which our centres serve as the primary source of specialist care (Helsinki, Espoo, Vantaa, Kirkkonummi, Kerava, and Kauniainen). These figures were used to estimate the annual incidence of hospital-treated injuries sustained from moped and scooter accidents in the population of 15-year-olds in our study area. We also obtained the national population size of 15-year-olds and nation-wide figures on new moped/scooter driver's licenses issued to 15-year-olds to estimate changes in popularity of moped/scooter licenses. Assuming a similar popularity of moped/scooter licenses in our study area, we derived an annual incidence estimate for hospital-treated injuries per license among 15-year-olds.

### Statistics

Statistical analyses were performed using SPSS 19.0 statistics software (IBM, Somers, NY). Descriptive statistics include frequencies, percentages, and means (with standard deviation, SD), and in case of skewed distributions, medians (with range). Fisher's exact test was used for dichotomous variables. For continuous variables,

the chi-square test and the Mann–Whitney *U*-test were used according to distribution, as appropriate. Correlations were calculated using the Pearson two-tailed test. A *p* value <0.05 was considered statistically significant.

## Results

Patient demographics are presented in Table 1.

### Accident details

In the full patient cohort, 426 patients (82%) were injured in accidents when they were driving alone, and 271 patients (52%) were injured in collisions. Self-reported speed was recorded for 334 patients (64%), and sixteen of them (5%) reported velocities exceeding 60 km/h (up to 90 km/h), thus suggesting illegal tuning of the vehicle. Data on helmet use was available for 309 patients (59%). Eight of these patients (3%) had been driving without a helmet, and in 16 cases (5%) helmets fell off.

Data on driver status, self-reported speed, accident type, and helmet use in patients before (2008–2010) and after (2012–2013) the law change are summarised in Table 2. Significant changes were noted in rates of collisions (57% before and 45% after the law change; *p* = 0.034) and for retaining an intact helmet (83% before and 92% after the law change; *p* = 0.047).

### Trauma and treatment

None of the patients admitted for trauma from moped or scooter accidents died during the study period. In the complete patient cohort, fractures were the most common injury type found in 257 (49%) patients. Ninety patients (17%) were diagnosed with head trauma and 30 patients (6%) with internal trauma. Altogether

**Table 1**  
Demographics of 520 patients according to year admitted.

	2008	2009	2010	2011	2012	2013
Patients, <i>n</i>	114	87	107	102	68	42
Boys, <i>n</i> (%)	79 (69)	61 (70)	69 (64)	74 (73)	48 (71)	29 (69)
Age 15, <i>n</i> (%)	86 (75)	68 (78)	79 (74)	94 (92)	59 (87)	36 (86)

**Table 2**  
Accident details of patients before (2008–2010, *n* = 308) and after (2012–2013, *n* = 110) drivers' education became mandatory.

	Before, <i>n</i> (%)	After, <i>n</i> (%)
Driver status		
Driving alone	247 (80)	95 (86)
With passenger	32 (10)	8 (7)
As passenger	29 (9)	7 (6)
Speed <sup>a</sup>		
<20 km/h	11 (6)	6 (8)
20–45 km/h	132 (70)	56 (77)
>45 km/h	45 (24)	11 (15)
Accident type		
Fall	122 (40)	55 (50)
Collision	<b>175 (57)</b>	<b>49 (45)</b>
Undefined	11 (4)	6 (5)
Helmet status <sup>b</sup>		
Intact	<b>152 (83)</b>	<b>61 (92)</b>
Broken	13 (7)	2 (3)
Fell off	12 (7)	2 (3)
Not in use	6 (3)	1 (2)

<sup>a</sup> Data on self-reported speed available for 188 (61%) and 73 (66%) patients in before and after groups, respectively.

<sup>b</sup> Data on helmet status available for 183 (59%) and 66 (60%) patients in before and after groups, respectively. Significant differences in bold (Fisher's exact test, *p* < 0.05).

**Table 3**

Clinical data of patients before (2008–2010,  $n = 308$ ) and after (2012–2013,  $n = 110$ ) drivers' education became mandatory.

	Before, $n$ (%)	After, $n$ (%)	$p$ -value
Trauma type			
Head	62 (20)	15 (14)	0.153
Fracture	154 (53)	58 (53)	1.000
Internal	18 (6)	1 (1)	<b>0.032</b>
Multiple	43 (14)	7 (6)	<b>0.039</b>
Hospitalised	179 (58)	47 (43)	<b>0.007</b>
Surgical operation	101 (33)	28 (25)	0.186

Significant  $p$ -values (Fisher's exact test) in bold.

63 patients (12%) had multiple injuries involving at least two body parts. More than half of patients ( $n = 285$ , 55%) were hospitalised and the median length of stay was one day. Forty-three patients (8%) were hospitalised for longer than seven days (up to 162 days). A third of patients ( $n = 156$ , 30%) underwent at least one operation under general anesthesia.

Trauma types, hospitalisation rates and surgical operations before and after the law change are presented in Table 3. A significantly smaller proportion of patients presented with trauma of internal organs (1% vs. 6%;  $p = 0.032$ ) and multiple trauma (6% vs. 14%;  $p = 0.039$ ) or required hospital admittance (43% vs. 58%;  $p = 0.007$ ) after the law change than before it.

#### Correlations of accident details, trauma and treatment

In the whole patient population, patients injured in collisions had more hospital admissions (67% vs. 39%;  $p < 0.001$ ) and required longer in-patient care (median 1 day, range 0–162) than did those hurt after falling down (median no hospitalisation, range 0–71;  $p < 0.001$  for difference between groups). Head injuries were diagnosed in 49 patients (18%) despite helmet use in comparison to 28 (67%) patients without a helmet (including those whose helmets fell off;  $p < 0.001$ ).

#### Changes in incidence estimates

During our study period, annually 33–48% of 15-year-olds Finns acquired a moped/scooter driver's license (Table 4). Roughly 19% of these adolescents live in our study area (Table 5). The incidence of moped or scooter related injuries among 15-year-olds within the study area reached its peak, 0.8%, in 2011 and declined to 0.3% in 2013 ( $p < 0.001$ ). Assuming a similar prevalence of moped/scooter

**Table 4**

Population of 15-year-olds and frequency of new moped/scooter licenses per year in Finland.

	2008	2009	2010	2011	2012	2013
Population age 15 ( $n$ )	65,805	66,119	64,212	61,962	60,618	58,526
New licenses for age 15 ( $n$ )	28,636	31,794	30,032	26,928	22,008	19,113
Licenses/population 15 (%)	43.5	48.1	46.8	43.5	36.3	32.7

Data sources: Statistics Finland and the Finnish Road Safety Council.

**Table 5**

Accident incidence estimates for greater Helsinki area.<sup>\*</sup>

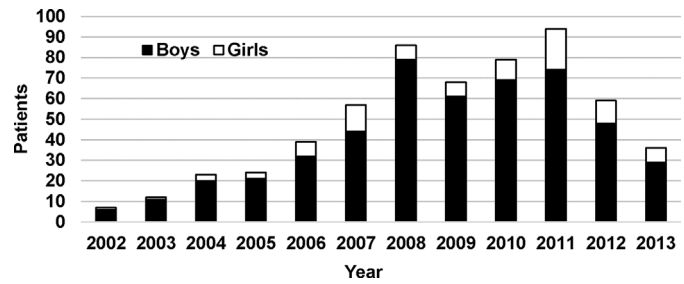
	2008	2009	2010	2011	2012	2013
Population age 15 ( $n$ )	12,579	12,472	12,153	11,735	11,659	11,188
New licenses ( $n$ ) <sup>**</sup>	5474	5997	5684	5100	4233	3654
Patients age 15 ( $n$ )	86	68	79	94	59	36
Incidence among age 15 (%) <sup>a</sup>	0.7	0.5	0.7	0.8	0.5	0.3
Incidence per new license (%) <sup>b</sup>	1.6	1.1	1.4	1.8	1.4	1.0

<sup>\*</sup> Greater Helsinki area includes the following cities and municipalities: Helsinki, Espoo, Vantaa, Kirkkonummi, Kerava and Kauniainen.

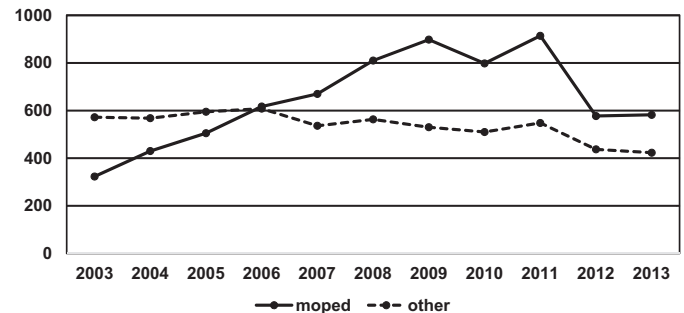
<sup>\*\*</sup> Estimated number of new moped/scooter licenses based on similar prevalence as in national data (Table 4).

<sup>a</sup> Significant difference between years 2011 vs. 2013 (chi square  $p < 0.001$ ).

<sup>b</sup> Significant difference between years 2011 vs. 2013 (chi square  $p = 0.001$ ).



**Fig. 1.** Annual number of 15-year-old patients treated for injuries from moped/scooter accidents at our centre from 2002 to 2013.



**Fig. 2.** Annual number of moped and scooter injuries and other traffic injuries of 15–17-year-olds in Finland from 2003 to 2013.

licenses as in the national data, the estimated incidence of moped and scooter related injuries in 15-year-olds per new license also peaked in 2011 (1.8%) and decreased to 1.0% in 2013 ( $p = 0.001$ ). Combining data from our two studies, annual cases of 15-year-old patients treated for injuries from moped and scooter accidents at our centres are depicted in Fig. 1. On a national level, moped and scooter injuries still outnumber all other traffic injuries among 15–17-year-olds (Fig. 2), and in 2013, 15-year-old moped/scooter drivers were involved in more traffic accidents than 18-year-old car drivers (Fig. 3).

#### Discussion

In this population-based retrospective study, our aim was to evaluate the influence of legislative change including enhanced driver's education on reducing trauma from adolescents' moped

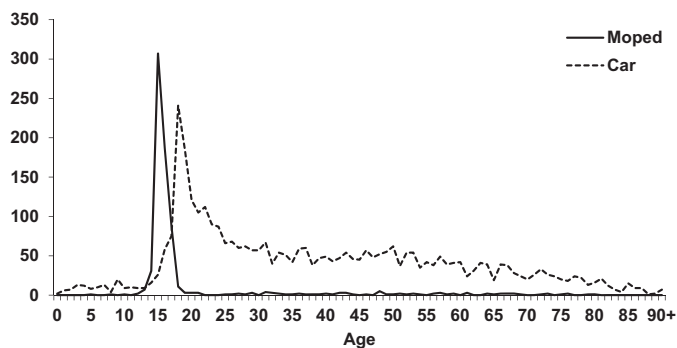


Fig. 3. Injuries from moped/scooter accidents and car accidents according to patient age in Finland in 2013.

and scooter accidents. Our major findings are that the increased moped/scooter license requirements associated with positive changes in accident patterns, helmet use, need for in-patient care and diagnosed trauma. A positive change was also noted in estimated injury incidence per moped/scooter license.

Our patient population comprises a large, comprehensive cohort of adolescents injured in traffic. Although primary health care and private services also treat some patients, our data covers at least the most severely injured patients in the metropolitan Helsinki area. To the best of our knowledge, our study is the first one attempting to estimate changes in incidence per moped/scooter license. Our meticulous clinical data collection and combining it with national register data provide credibility to our findings. Our study demonstrates, however, some typical limitations of retrospective studies. Data on helmet use and velocities were often missing. Even in the cases with speed at the time of the accident reported, all estimates were subjective. Speed estimates may be biased in both directions, since teens tend to exaggerate speed but underestimating may have occurred to affect traffic insurance coverage. Despite our best efforts, incidence figures per driver's license are only estimates and should be interpreted cautiously. These estimates are, however, based on circa a fifth of the population of appropriate age in Finland.

A recent Cochrane review [11] summarised the limited evidence on motorcycle rider training for the prevention of road traffic crashes including mopeds and motorised scooters. Most studies were more than two decades old, only a few were published in peer-reviewed journals, data were often gathered as self-reports or from police files and no conclusions could be drawn. Especially falls are underreported in the official traffic accident statistics gathered by the police, which highlights the importance of clinicians participating in studies on road traffic injuries [12].

The addition of theoretical instruction and practical driving lessons as well as a vehicle handling evaluation led to a six-fold increase in the cost of a moped/scooter license (from 90€ to 550€). Consequently, the nation-wide annual number of passed written examinations declined by 27% [10]. It may be argued that the decrease in estimated incidence of hospital-treated moped/scooter injuries is only a consequence of the decline in moped/scooter license popularity. It seems unlikely, however, that coincidence alone would explain all the positive changes associated with the new license requirements. Based on our findings, mandatory driver's education seems an effective means to improve moped and scooter driver safety to some extent. Most patients in our study were age 15 implying a fast learning curve that is also evident in the national data (Fig. 3). No driver's education can completely replace the value of experience.

Helmet use has been compulsory for moped and scooter drivers and passengers in Finland already since 1982. Helmet use should

be strongly advocated, since head trauma account for 67% of injury-related deaths in Finnish children and adolescents [13]. Despite the decreasing trend in head trauma (before vs. after law change), these figures failed to reach statistical significance. In our complete patient cohort, however, helmet use was associated with fewer head trauma, a finding in line with international reports [14–16]. In general, injury types were similar to our previous publication and also resembled those reported in recent studies on moped and scooter accidents from Australia, Sweden and the Netherlands [1,6,9,17]. Fractures remained common but the rates of internal and multiple trauma in our patients after the law change are lower than in other studies.

Risk-taking behaviour in adolescents is a common finding and may be explained by the late maturation of the prefrontal cortex [18,19]. Due to the retrospective nature of this study, we were unable to assess motivations among the patients in this study. In general, public transport in the metropolitan Helsinki area has good coverage and is fairly affordable. Mopeds are mostly used to travel short distances where riding a bike is another practical alternative, and for sensation-seeking purposes. In more sparsely populated areas of Finland and Scandinavia, mopeds may have a greater impact on the social life of adolescents. We remain somewhat worried about the consequences risk-taking may have in traffic. Health certificates for moped/scooter license applicants in Finland are most often provided by school physicians and we suggest they should receive information on the applicant's attitudes and behaviour in school to evaluate their competence as drivers of motorised vehicles. Based on extensive interviews of adolescents, The Finnish Road Safety Council estimates that a third of all mopeds and scooters have been illegally modified, 70% of parents/guardians know about their child's modified vehicle and have even provided assistance in modification of the vehicle to increase performance despite it being illegal [10]. This may be due to a false assumption that higher speeds increase safety since they enable the moped/scooter driver to follow the flow of traffic. Scientific evidence, however, shows greater speeds increase the chances of severe and lethal injuries [20]. In Australia, the state of Victoria has recently introduced a graduated licensing system for motorcycle riders to tackle the issue of inexperience [21]. Requirements for drivers in the learner phase include wearing a high visibility vest and no pillion passengers which are two further measures worth considering also among adolescent moped/scooter drivers.

In conclusion, enhanced driver's education associated with positive changes in moped and scooter accidents and consequent injuries of adolescents. Further research is required to determine the influence driver's education has on the road traffic safety of adolescents.

### Conflict of interest

The authors of this manuscript (Driver's education may reduce annual incidence and severity of moped and scooter accidents. A population-based study) have no conflicts of interest to declare.

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