JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, May 2011, Vol. 56, No. 3
doi: 10.1111/j.1556-4029.2010.01674.x
Available online at: onlinelibrary.wiley.com

PAPER

GENERAL; PATHOLOGY/BIOLOGY

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Fatal Traffic Injuries Among Children and Adolescents in Three Cities (Capital Budapest, Vilnius, and Tallinn)*

ABSTRACT: Motor vehicle accidental injuries are a frequent cause of death among young children and adolescents. The goal of this study was to compare patterns of injury between three capitals (Budapest, Vilnius, and Tallinn). Information on 190 fatal traffic accidents (69 pedestrians, 14 bicyclists, and 107 motor vehicle occupants) between 2002 and 2006 was collected from databases of medico-legal autopsies. The role of victims in accidents, the location of injuries, cause of death, survival period, and blood alcohol levels were evaluated. One-hundred and forty-one (74%) victims had a passive role in traffic as pedestrians, passengers in cars, or public transport. In victims who died at the scene, the rate of head injury was higher than in cases who received medical treatment (odds ratio = 2.58, CI = 1.2–5.55, $p = 0.0127$). These results underline the importance of postmortem studies to examine the pathomechanism of fatal traffic accidental injuries and to provide information for the prevention of road traffic accidents against children and adolescents.

KEYWORDS: forensic sciences, road traffic accidents, children, adolescents, fatal outcome, medico-legal autopsy

Traffic accidents represent a major urban health problem. Injuries resulting from traffic collisions are a major cause of childhood death, hospitalization, and disability throughout the world. For older children and teenagers, motor vehicle crash is one of the leading causes of death in the industrialized countries (1,2). Road traffic injury cases had the highest percentage of projected long-term disability and required emergency surgery (3). The epidemiological data, the potential socio-economic risks, and the pathomechanism of accidental death among children and adolescents are frequently investigated factors (2,4,5).

The mortality of road traffic accidents represents a serious public health problem with high economic and social costs. In urban areas, children are at increased risk especially for pedestrian injuries. Assessment of multiple risk factors for death among children and adolescents may support the development of risk profiles in road traffic accidents and provides information about the passenger safety interventions directed at child and adolescent and their parents (1). Clinical studies investigate the diagnostic possibilities and research the most effective therapy; however, forensic pathologists face the most severe damages in fatal cases when death frequently happens at the scene without any chance for survival period. International investigation of injury patterns in fatal cases would allow a better understanding of the pathomechanism of accidental damages and may help inform prevention strategies as well. In this study, we compare data from three European countries, where the socio-economic conditions are very similar. In Estonia and Lithuania, the Traffic Code was introduced in 2001, and in Hungary, it was introduced in 1975 and modified in 2007. In all the three countries, the protective helmets for motorcyclists, moped drivers, and their passengers are required. In Estonia, the Traffic Code is expected to change in 2010 and helmets for bicyclists will be suggested. Car seats are required for children in Estonia and Lithuania from 2001, and in Hungary from 2007. In Hungary, the seats are required under 3 years or under or under 135 cm of height. In Estonia, the requirement of safety equipment does not depend on the age of child but his/her height. If the height of a child does not enable him or her to be fastened with a safety belt, a child-restraint seat, a carry-cot, or other safety equipment shall be used.

Our aim was to investigate the characteristics of fatal traffic accident among children and adolescents in three different countries, to examine the mortality data of pedestrians, bicyclists, and motor vehicle occupants, and to compare injury patterns between victims with active and passive role in traffic.

Material and Methods

The survey target groups included child and adolescent victims (age 0–19 years) of fatal road traffic accidents in three different capitals. Information was collected from the forensic autopsy

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*Supported by the Estonian Science Foundation (Grant No. 6592).

Received 9 Sept. 2009; and in revised form 2 Feb. 2010; accepted 13 Feb. 2010.

reports and police scene investigation. Data were analyzed according to the place of capitals, age, gender, roles of traffic participants (pedestrian, bicyclist, motorcyclists, car driver or passenger, other occupants in public transport), type of suffered injuries, duration of hospitalization, cause of death, and blood alcohol concentrations (BACs).

Injury patterns were investigated in two groups of victims: (i) passive role in traffic—pedestrians, passengers in car, and passengers in public transport; and (ii) active role in traffic—bicyclist, motorcyclist, and car driver. We compared the rate of head, chest, abdominal, and extremities injuries in these two groups.

Forensic autopsy reports had a conclusion about the relationship between accidental injuries and cause of death. We excluded cases from the study material when no connection was defined between injuries and death.

We recorded the rate of alcohol-impaired drivers and analyzed the levels of alcohol intoxication. BACs were used only, if death occurred on the same day as the injury. Influence of alcohol was categorized as: (i) not influenced by alcohol: under 49 mg/100 mL; (ii) mild degree with BAC: 50–149 mg/100 mL; (iii) moderate BAC: 150–249 mg/100 mL; (iv) severe BAC: 250–349 mg/100 mL; and (v) very severe above 350 mg/100 mL.

Blood samples were taken from femoral veins. BACs were determined by UNICAM ProGC headspace gas-chromatograph with flame ionization detector (UNICAM Magyarország Kft., Budapest, Hungary), using a Restek BAC-2 column (Restek Corporation, Bellefonte, PA). Data were analyzed according to the manner-of-death, age, gender, and BACs. Alcohol-involved deaths were defined as those with detectable BAC of more than 50 mg/100 mL. In Hungary, the legal limit is 0, in Estonia, the legal limit is 20 mg/100 mL, and in Lithuania, the legal limit is 20 mg/100 mL for drivers with <2 years of experience and 40 mg/100 mL for those with more than 2 years of experience.

The risk of fatal injuries in different body regions was estimated statistically by odds ratio (OR) with 95% confidence interval (CI) by a conditional logistic regression with the statistical significance with p-value < 0.05.

Results

There were 190 cases (126 men, 64 women) such cases medico-legally autopsied in Budapest ($n = 67$), Vilnius ($n = 76$), and Tallinn ($n = 47$) among children and adolescents from 2002 to 2006. In the investigated period, the traffic accidental mortality among the 0- to 19-year-old population was 2.22 deaths/100,000 citizens in Hungary, 2.26 deaths/100,000 citizens in Lithuania, and 2.87 deaths/100,000 citizens in Estonia.

Numbers of death for each year in the study capitals are presented in Table 1. The age distribution is demonstrated in Table 2. The highest number of cases was in the age groups of 15–19 years (63%) and the number of male victims exceeded females in every age group. The material included subsets of 69 (36.3%) pedestrians, 14 (7.3%) bicyclists, 13 (6.8%) motorcyclists, 22 (11.6%) car drivers, 65 (34.2%) car passengers, and 7 (3.6%) others as van passengers and passengers on public transport facilities.

TABLE 1—*Number of deaths for each year for each capitals.*

Year	Budapest	Vilnius	Tallinn	All
2002	18	17	16	51
2003	10	17	9	36
2004	12	13	11	36
2005	17	15	3	35
2006	10	14	8	32
All	67	76	47	190

TABLE 2—*Number of victims in different age groups died in traffic accidents in three capitals.*

	Budapest		Vilnius		Tallinn		
Age group	Male	Female	Male	Female	Male	Female	All
0–6 years	1	6	5	4	3	6	25
7–10 years	7	1	2	2	4	2	18
11–14 years	7	4	5	1	7	4	28
15–19 years	27	14	41	16	17	4	119
All	42	25	53	23	31	16	190

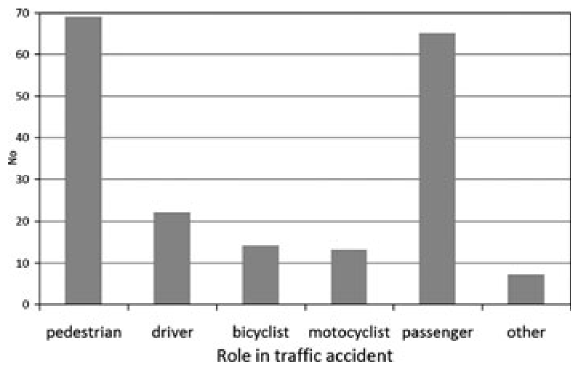

FIG. 1—*The role of victims in fatal road traffic accidents.*

Figure 1 shows the role of victims. One-hundred and forty-one (74.2%) victims had passive role in traffic as pedestrians, passengers in cars, or public transport, and 49 (25.8%) victims had active role as bicyclist, motorcyclist, or car driver. There was no statistical difference in injury patterns between victims with active and passive role in road traffic accidents ($p > 0.05$). Head injuries, such as skull fractures, subarachnoidal hemorrhage, epidural hemorrhage, subdural hemorrhage (SDH), and brain contusion, were the most frequent cause of death in victims, and there was no statistically significant difference between victims with active and passive roles (Table 3). Thoracic damages, like traumatic aortic rupture, and abdominal damages, such as liver rupture, were dominant in motor vehicle occupants.

Head injuries frequently occurred in fatal trauma victims in all the three cities (Fig. 2); however, multiple injuries—included head trauma—were detected in the vast majority of autopsied cases. Numbers of fatal head injuries were 57 (85%) in Budapest, 59 (78%) in Vilnius, and 44 (93%) in Tallinn. We did not find significant differences in injury patterns in the three capitals.

Among pedestrians and bicyclists, the most frequent traumas were head injuries and contusion of lower limbs. They suffered skull fracture, SDH, brain contusion, and damage of the lower extremities. Motorcyclists, car occupants, and passengers suffered head, thoracic, and abdominal injuries, such as traumatic rupture of the aorta, laceration of the liver, and contusion of the bowels.

Postmortem blood alcohol tests were performed in 136 (71%) cases. The results were negative in 96 (50.5%). BACs were evaluated as slight or mild degree in 22 (11.6%), moderate degree in 12 (6.3%), and severe degree in 6 (3.1%) cases of intoxication. No case with positive drug test was found.

Occurrence of traffic accidents by seasons showed that fatal accidents were most frequent in summer and autumn time (Fig. 3); however, there was no significant differences between seasons. The number of motor vehicle accidents was higher at weekends compared to the number of accidents of pedestrians and bicyclists.

In the majority of cases—131 (69%)—death occurred at the scene. During transportation to hospital, 14 (7.3%) persons died.

TABLE 3—*Distribution of injuries of victims with passive and active role in road traffic accidents.*

Injuries	Passive Role *n*	Active Role *n*	OR	CI	*p*-Value
Bleeding (SAH, SDH, EDH), contusion in the head	102	39	0.67	0.28–1.56	>0.05
Skull fracture	95	37	0.67	0.3–1.48	>0.05
Neck injury	19	5	1.37	0.45–4.48	>0.05
Heart or thoracic-aorta injury	20	7	0.99	0.36–2.8	>0.05
Lung injury	44	14	1.13	0.53–2.47	>0.05
Rib, sternum, thoracic column fractures	47	21	0.67	0.33–1.37	>0.05
Abdominal injuries	46	16	1.00	0.47–2.12	>0.05
Upper extremities severe contusion and/or fractures	20	12	0.51	0.21–1.23	>0.05
Pelvic or lower extremities severe contusion and/or fractures	51	13	1.57	0.72–3.44	>0.05

CI, confidence interval; EDH, epidural hemorrhage; OR, odds ratio; SAH, subarachnoidal hemorrhage; SDH, subdural hemorrhage.

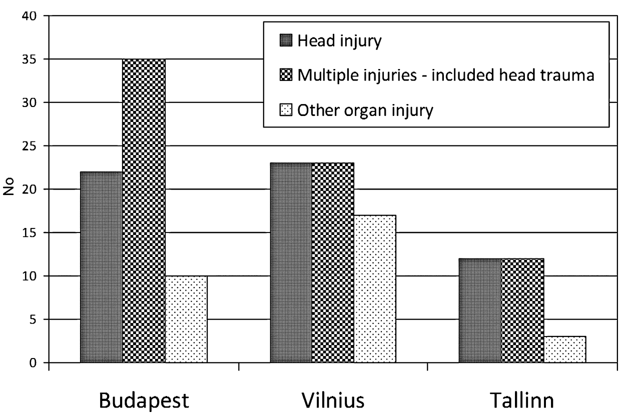

FIG. 2—*Injury patterns among children and adolescents in Budapest, Vilnius, and Tallinn.*

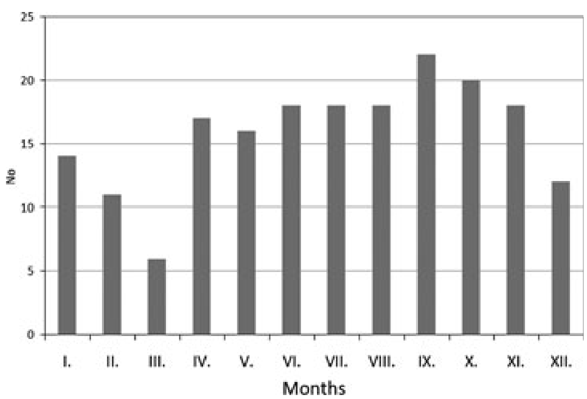

FIG. 3—*Seasonal distribution in traffic accidents.*

Hospital treatment was received by 45 (23%) persons prior to death. In the first week, 11 persons died in Budapest, 10 persons died in Vilnius, and seven persons in Tallinn. The survival period was 8–30 days in three cases in Budapest, in four cases in Vilnius, and in two cases in Tallinn (Fig. 4). There were eight cases in Budapest with a survival period longer than 1 month. The longest survival period was 6 months. The average survival period was 4.4 days in Budapest, 4.0 days in Vilnius, and 4.0 days in Tallinn. Head injury was found in 112 cases amid victims who died at the scene and in 48 cases with survival period. In victims died at the scene, the rate of head injury was higher than in cases received medical treatment (OR = 2.58, CI = 1.2–5.55, $p = 0.0127$).

Discussion

In this study, we compared trends and characteristics of injury patterns in fatal traffic accidents among children and adolescents in three capitals. Statistical differences were detected between injuries of victims with active and passive role in road traffic accidents. The mortality rate was between 2.22 and 2.87 per 100,000 age matched citizens in Budapest, Vilnius, and Tallinn urban regions.

Traffic crashes are the leading health threat to children in many countries (6–9). The high mortality rate of traffic accidents emphasizes the necessity of developing prevention strategies. The mortality rates are higher in the passive pedestrian subset and passengers than for active motor vehicle victims as motorcyclist or drivers (9,10). It is supposed that the passive victims pay less attention to traffic than active ones.

Clinical investigations demonstrate that the percentage of children with major or minor head trauma was reported to be higher among those injured in traffic than among those injured by all other means, respectively (7,11,12). We confirmed study results (7,13,14) that head injuries represent the most frequent cause of death in connection with traffic accidents. In our material, the overall incidence of head injuries in traffic accidents was similar to that reported in the literature (15). We found that 84% of cases had head injuries, and the rate of intracranial damages was higher in victims who died at the scene compared to cases who died in hospital. In our material, head trauma was the most frequent in Estonia and less common in Lithuania. These results suggest that head injuries have a prior importance in fatal traffic accidents in children and adolescents. There are helmet laws for motorcyclists in all the three investigated cities; however, there is no requirement of helmets for bicyclists. There is no difference in child safety restraint laws between the investigated cities in the three countries, and there was no change in legislation during the investigated period.

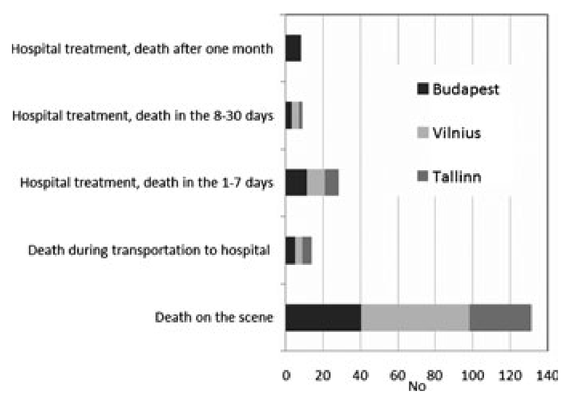

FIG. 4—*The number of death cases happen at the accidental scene, in ambulance, or in hospital.*

Multiple contusions or contusion of lower limbs among pedestrians are common injuries (15,16). In our study, multiple injuries were suffered in the highest rate in Estonia and less frequently in Lithuania. A study (13) reports that in traffic accidents, children most often had femur fractures compared to adults, who suffered more chest and pelvic injuries. The majority of children with lumbar spine injuries were injured in motor vehicle crashes, and most of them were restrained by lap-styled safety belts (17). The outcome from blunt cardiac arrest in children is rapidly and nearly uniformly fatal despite resuscitation. Ninety-four percent of these children died within the first 24 h of blunt cardiac arrest (18). Blunt splenic trauma in motor vehicle crash was reported less number than in elderly age groups (19).

In our material, most of the victims were between 15 and 19 years old, and in every age group, male predominance was observed. Age-specific rates were reported with a peak incidence of child pedestrian injuries among 6- to 10-year-olds, of bicyclist injuries among 9- to 15-year-old children, and of motor vehicle occupant injuries among adolescents between the ages of 12 and 16 years (7,20). Young school-age children between the ages of 5 and 9 years for pedestrian injuries are at particular risk (21,22). The majority of victims of traffic accidents are males (19,20,23).

Risk of injury for child pedestrians has been strongly associated with traffic volume (24). In our material, there were no certain locations where pedestrian deaths were more common, for example, as on more crowded roads or locations near to schools. Motor vehicle crashes are a leading cause of death despite the fact that child safety seats and seat belts can provide effective protection against serious injuries. Studies have generally indicated that daytime running lights use is associated with small to moderate reductions in multiple-vehicle daytime crashes, especially those involving vehicles approaching from the front or side (25). There are several countries—including Hungary, Lithuania and Estonia—where it is mandatory for motor vehicles to have lights on even in daytime.

The most severe and life-threatening injuries have usually caused fatal outcome at the scene, when there is no chance to survive and receive medical treatment. Among these victims, the rate of head injuries and intracranial damages was higher than that in a victim who had a survival period. Our results suggest that forensic postmortem studies may explore the pathophysiology of the most severe and fatal injuries as these victims have not been treated by medical teams at all.

The high rate of severe head injuries in the investigated cities suggests that the protection against head injury can be useful in fatal traffic accidents prevention. Head injuries appear to be a substantial factor affecting the outcome on injured victims. Most of the fatal cases were associated with intracranial bleeding, skull fractures, and brain damages. More emphasis should be placed on injury prevention and public education to prevent traffic injuries in young, vulnerable children. Based on the similar rate of fatal traffic accidents in the three capitals, we emphasize the importance of epidemiological international studies in urban regions.

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