

# A cluster analysis of road traffic-related childhood knee injuries

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## Abstract

**Background** Knee injuries represent an important category of road traffic injuries among children, and they are heterogeneous in their aetiology. The aims of this study were to estimate the incidence of road traffic childhood knee injuries in Greece by age and gender, point out their time, place and person co-ordinates and identify clusters with distinct characteristics with a view to potential preventive interventions.

**Methods** During a 3-year period, 305 children with knee injuries resulting from a road traffic accident were identified among the 66870 children with injuries recorded in the Emergency Department Injury Surveillance System (EDISS) of Greece. Using previously derived sampling ratios and national data on childhood population, incidence data by age and gender were estimated. Hierarchical analysis was undertaken for cluster identification.

**Results** The incidence of road traffic knee injuries was 97.5 per 100000 children-years. The incidence increased with age and was higher among boys than among girls. Most childhood knee injuries (50.2%) occur among pedestrians, and the majority (90.9%) of the children or their guardians admitted responsibility in crossing the road. Of the 31 children injured as car passengers, the vast majority (87.1%) were unrestrained, and a large fraction (38.7%) were front seat passengers. Two clusters were identified: the first consisted of younger children who resided mostly in the Athens area and suffered less serious knee injuries as pedestrians or car passengers during the colder months; the second consisted of older children, frequently tourists, who suffered more serious injuries as cyclists while vacationing.

**Conclusions** Many of the children who suffered road traffic knee injuries as pedestrians admitted responsibility in road crossing, whereas a large proportion of children who were injured as car passengers were injured while improperly seated in the front and without seatbelt protection. Older children, frequently tourists, were at high risk of knee injuries while using motorcycles and bicycles.

## Keywords

child, knee, injury, road traffic accident, prevention

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## Introduction

Children are vulnerable road users, frequently injured as pedestrians or cyclists (Rome 1995; Kemp & Sibert 1997; DiMaggio & Durkin 2002). The knee joint is a frequently affected body site during the crash event with a relatively high likeli-

hood of residual long-term effects (Brautigian & Johnson 2000). Although there are several studies focusing on knee injuries among adults (Guyer & Ellers 1990), data concerning the risk profile of road traffic knee injuries among children are scant. Data from adults are not easily transferable to children. This is because the bones of children are

characterized by a more extensive harvesian canal system, which makes them more vulnerable to compression rather than tension injuries than the bones of adults (Hodge *et al.* 1991). We have undertaken a study aimed at estimating the incidence of road traffic childhood knee injuries in Greece by age and gender, pointing out their time, place and person co-ordinates and identifying clusters with distinct characteristics with a view to potential preventive interventions.

## Methods

The pattern of road traffic-related knee injuries among children (0–14 years old) was studied using data retrieved from the Emergency Department Injury Surveillance System (EDISS) database developed by the Center for Research and Prevention of Injuries among the Young in collaboration with the Greek Ministry of Health. All types of childhood injuries treated at the Emergency Departments (ED) of a network of four participating hospitals are regularly recorded in this database. Specifically, data are contributed by two hospitals with defined population coverage, namely the district hospital of Volos in the Magnesia region of the Greek mainland and the district hospital of Kerkyra on the island of Corfu. The other two hospitals, namely the Aglaia Kyriakou Children's hospital (one of the two major children's teaching hospitals, which functions on alternate day shifts with 'Agia Sophia' Hospital, the other major children's hospital with the same catchment area) and Asclipeion of Voula Trauma Hospital, are situated in the Greater Athens area and have been estimated to cover about 28.9% of the underlying child-time at risk (Dessypris *et al.* 2002). Specially trained health visitors interviewed in person the injured children who visited the ED as well as their escort. The data are recorded in a precoded questionnaire, which covers sociodemographic variables (gender, age, nationality), event characteristics (place, activity, mechanism, time) and nature of injury (type of injury, injured body part, number of injuries, treatment). The data are subsequently coded in detail under ICD-9, ICD-10 and the European Home and Leisure Accident Surveillance System (EHLASS) coding manuals (Euro-

pean Communities Commission, European Home & Leisure Surveillance System 1996).

During the 3-year period from 1 January 1996 to 31 December 1998, a total of 66 870 children with injuries were recorded in EDISS. Among them, 2367 were involved in road traffic injuries, of whom 305 (13%) suffered knee injuries. Of the knee injuries, 22 were amputations (1), fractures (12) and dislocations–sprains (9) and were considered as serious injuries. The initial analysis was performed using simple tabulations. Incidence rates by age and gender were estimated, using previously derived sampling ratios and national data on the child population. The risk profiles of childhood knee road traffic injury were ascertained through cluster analysis. This procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics, using an algorithm that starts with each case in a separate cluster and progressively combines them (Cluster analysis, SPSS Base 9.0, 1999).

## Results

The two hospitals in Athens cover 28.9% of the childhood person time at risk in the Greater Athens area, and the two district hospitals in Volos and Kerkyra have population-based coverage in the corresponding districts (Dessypris *et al.* 2002). There can be no suitable denominator for tourists, so injuries among tourists are excluded in the assessment of incidence rates. In the Greek population, the incidence of road traffic knee injuries among children is about 97.5 per 100 000 children–years or 97.5 injuries per 100 000 children over a period of 1 year. There is no difference by sex among children 0–4 years old, whereas among older children, the frequency of injuries is higher among boys (Table 1).

Half (153/305) the children with road traffic knee injuries were pedestrians, and the vast majority of them or their guardians (139 or 90.8%) admitted that the children were responsible for suffering a road traffic-related knee injury. Of the injured children, 108 (35.4%) were motorcyclists or bicyclists, confirming the widespread view in Greece that these forms of transportation are hazardous given the traffic pattern in the country.

**Table 1.** Number of children\* with road traffic knee injuries requiring hospital contact and incidence (IR) per 100 000 children-years

Age (years)	Male		Female		Total	
	n	IR	n	IR	n	IR
0-4	26	22.3	18	31.4	44	26.7
5-9	74	119.6	36	76.7	110	98.8
10-14	84	178.9	54	133.3	138	156.7
Total	184	110.9	108	83.3	292	97.5

Data from EDISS during the 3-year period 1996-98 by age and gender.

\*13 tourists were excluded.

Of the children injured as private car passengers, 12 were seated in the front and, of them, nine were unrestrained during the event that led to the injury. All but one of the 19 children who were injured while rear seat passengers were also unrestrained.

Cluster analysis integrates the consequences of person-time at risk and inherent hazard but, nevertheless, it generates meaningful results by highlighting who, when and where knee injuries occur in relation to road accidents rather than other injuries. Table 2 shows two clusters of children who sustained knee injuries. The first cluster consists of younger children, mainly of migrant or of Greek parents, who reside mostly in the Greater Athens area and suffered less serious knee injuries as pedestrians or car passengers during the colder months of the year. The second cluster consists of older children, mainly tourists, who suffered more serious injuries as cyclists during the warm period of the year, while vacationing on an island or in a small town. It is interesting that the second cluster highlights the well-known problem that is also evident in our data, namely that young tourists are at high risk when using motorcycles in Greece. Indeed, seven out of the 13 young tourists, all 10-14 years old, suffered a knee injury while driving a motorcycle.

## Discussion

Busy clinicians cannot prioritize the recording of information concerning the circumstances and the sociodemographic co-ordinates of the event that has led to an injury. Even if the information has

**Table 2.** Distribution of the 305 children (0-14 years) with knee injuries resulting from road traffic accidents into two major clusters derived from hierarchical cluster analysis taking into account injury severity, demographic variables and time, place and person characteristics

Variable	First cluster		Second cluster	
	n	%	n	%
Age (years)				
0-4	46	100	0	0
5-9	111	100	0	0
10-14	83	56.1	65	43.9
Nationality				
Migrants	44	100	0	0
Greek	193	77.8	55	22.2
Tourists	3	23.1	10	76.9
Area of injury				
Greater Athens	202	99	2	1
Volos	20	33.3	40	66.7
Corfu	18	43.9	23	56.1
Role of victim				
Pedestrian	147	96.1	6	3.9
Motorcyclist	39	56.5	30	43.5
Car passenger and related	27	61.4	17	38.6
Bicyclist	27	69.2	12	30.8
Season of injury				
October-March	102	87.2	15	12.8
April-September	138	73.4	50	26.6
Type of injury				
More serious	16	72.7	6	27.3
Less serious	224	79.2	59	20.8

been collected, management and analysis of data is a cumbersome task unless a properly organized and run database is available. Yet, these data are essential for assessment of the magnitude of the problem, identification of risk factors and development of pertinent policies and programmes for injury prevention and control. Emergency department injury surveillance systems allow efficient storage and retrieval of this information, which can subsequently be linked with that available in medical records. In Greece, the EDISS database that was used in this investigation has provided useful information over the years on several injury types and their risk profile (Petridou *et al.* 1998a; Moustaki *et al.* 2001).

A strength of this investigation is the large number of knee-injured children and the ascertainment of person, time, place and mechanism co-ordinates of the event that led to the injury by severity of the latter. Another strength of the investigation is the

ability to calculate population-based incidence rates by gender and age of childhood road traffic-related knee injuries. An important limitation of this study, which is shared by most injury investigations, is that the population at risk, taking into account time spent in each injury-relevant activity, is not available.

Some valuable clinical studies on knee injuries have been undertaken (Atkinson & Atkinson 2000), but the risk profile, as well as the determinants of road traffic knee injuries in childhood, have not previously been systematically investigated. Cluster analysis helps to customize preventive measures by identifying groups of individuals with similar within-groups and distinct between-groups characteristics. The results of this investigation indicate that road traffic-related knee injuries among children belong to two groups requiring different preventive approaches. Although its effectiveness has not been adequately assessed, traffic education could be a priority (DiMaggio & Durkin 2002; Duperrex et al. 2002) for young Greek and migrant children, who are generally at fault as pedestrian victims, whereas older children, including tourists, should be discouraged from using motorcycles in the complex traffic environment of Greek towns and cities.

A substantial fraction of knee injuries was recorded among children who were injured as car passengers and who, as a rule, were travelling unrestrained and frequently in the front seat (Petridou et al. 1998b). In Greece, the use of car restraints is legally mandated and, sadly, usually ignored. It is hoped that the demonstration of the occurrence of a substantial number of knee injuries, common among unrestrained young car passengers involved in an accident, will help to motivate the public as well as the authorities towards a stricter adherence to existing laws.

In conclusion, this study documents that traffic education is a priority for young people, pending documentation of its effectiveness. The incidence of road traffic knee injuries among children could be reduced through enforcement of car restraint laws. The benefits and risks of motorcycle use should be re-examined in view of their involvement in the causation of severe injuries, including serious knee injuries.

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