Linking Emergency Medical Department and Road Traffic Police casualty data: a tool in assessing the burden of injuries in less resourced countries

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Abstract

The study aimed to (1) assess the magnitude of road traffic injuries in a country missing a formal linkage system of police with hospital data, (2) quantify the under-reporting, and (3) produce a convenient algorithm exploring its constituent components. Linkage of disaggregate (individual) data collected by the Road Traffic Police (RTP) with those by the Emergency Department Injury Surveillance System (EDISS) on the Greek island of Corfu and coded with different classification systems was carried out. The applied four-step methodology, also comprising the calculation of under-reporting coefficients of the variation by basic demographic variables, mode of transport and injury outcome, led to the identification of the overall under-reporting from either registry. RTP data captured 96.6% (coefficient: 1.035), whereas EDISS only 54.4% of total fatalities (overall concordance: 51.1%). On the contrary, EDISS captured 94.6% of non fatal injuries, whereas RTP only 16% (coefficient: 6.238), resulting in a low overall concordance (10.6%). Considering severity of injury assessed by EDISS, by using the ISS, as the gold standard, RTP data misclassified 20.3% of severe injuries as less severe, whereas a statistically significant difference in the under-reporting by gender was also noted. In conclusion, relatively simple methodologies can provide essential coefficients to assess the actual numbers, severity and components of road casualties by complementing routinely collected RTP with sentinel Emergency Department reporting systems.

Keywords: Linkage; Burden of injury; Road accident data; Underreporting; Police files; Medical files

1. Introduction

Road traffic injuries account for a vast proportion of fatal injuries. Worldwide, the estimated annual toll amounts over a million, namely ~25% of all fatal injuries (Murray and Lopez, 1997). Despite recent developments in road crash prevention, according to the World Health Organization, an equivalent of more than 3000 people die and over 30 000 are seriously injured every day in road crashes. WHO derives the fatal road traffic figures on the basis of deaths registered by the health sector in each country; these figures have been found to be significantly higher than those estimated by the official Police statistics (Jacobs et al., 2000).

The discrepancies of non-fatal road traffic injuries provided by different data sources are even bigger. There is evidence that Police does not report a considerable proportion of accidents, whereas the level of reporting differs among different road user groups. Indeed, a French study that sought to compare Hospital with Road Traffic Police (RTP) data found that only 37% of non-fatal hospitalized injuries were recorded by the Police; the likelihood that a hospital recorded case is also included in the Police file was associated with length of stay in the hospital, physician in charge of the first aid, urban place of the crash, type of vehicle involved, day and time of the crash and blood alcohol concentration (Aptel et al., 1999).

Accurate and comprehensive figures on both fatal and non-fatal road traffic injuries, however, are a key measure for the development of any road traffic injury prevention plan. Actual and externally valid figures on road casualties can be assembled by comparing figures routinely reported by Road Traffic Police with those provided by medical and/or other data sources. Several studies have matched Police accident data from a defined geographic area with local hospital records (Keigan et al., 1999; Rosman, 1996), whereas national and regional reporting levels for hospitals and Police have been estimated by extrapolation from local comparisons (Aptel et al., 1999; Simpson, 1996).

Ideal computerised individual matching can be achieved when unique personal identification numbers are provisioned for all citizens, as it is the case in Nordic countries (Hjalgrim et al., 2000). It most cases, however, an ad hoc process has to be devised in order to link anonymised data from alternative data sources. The objective of this study was to quantify the under-reporting of road traffic casualties and explore its constituent components by means of a convenient methodology allowing linkage of disaggregate (individual) data collected by the Emergency Medical Department Injury Surveillance System (EDISS) operated by the Center for Research and Prevention of Injuries (CEREPRI) in Greece with those from Police data files. The study protocol was approved by the Ethics Committee of the Athens University Medical School. Its methodology sought to provide a useful tool for policy makers and injury prevention practitioners wishing to know the exact size of those road casualties, which are severe enough to necessitate emergency medical care.

2. Methods

2.1 Development of the methodological tool

The proposal for the methodological tool was based on the exploitation of previous work, focusing on fatal or hospitalized road accident injury under-reporting. Given that the present study aimed to link data derived from the busy Accident and Emergency Departments environment, it was anticipated that data incompatibility problems would be augmented; therefore, all provisions had been made to maximize the comprehensiveness of the methodology, which comprises a tool of four distinct steps:

1. Definition of an appropriate study area ensuring that no accident casualties reported by the Police within this area, were transferred to any other Hospital than the one under investigation. This study area is referred as the “catchment” area of the Hospital.
2. Selection of appropriate variables to be used for the identification of the matching cases and values, which are present in both databases and share the same definitions, so that transformations and/or aggregations can be foreseen.
3. Data matching procedure, in which the selected variables and values were used for the extraction of a file with records common in both databases (concordant cases). It was provisioned that concordant records can be grouped by any of the selected variables allowing their further processing, whereas discordant (non matching) cases were grouped in a separate file.
4. Calculations from the common records file as well as the non-matching file and extraction of the under-reporting coefficients to be used for the identification of the under-reporting level overall and by mode of transport, road user characteristics (age, gender) and casualty severity.

Within the framework of the present methodology, it was ensured that no threats were imposed to personal identification data. All data processed from both the EDISS and the RTP databases were anonymised and the results of the study are presented tabulated at an aggregate level only; therefore, no road accident casualty can be identified on a personal level.

2.2 Data files

Hospital discharge data for all causes, including injuries, are routinely collected in all EU member states and the quality is satisfactory with regard to the nature of the lesion and the health outcome. As a rule, however, these data cannot be used for the estimation of the burden of road traffic injuries, given that external cause of the injury codification suffers severely both in quantitative and qualitative terms. During the last decade, however, it became evident that detailed information on the external cause of injuries, severe enough to seek care at the Accident and Emergency Departments, should be made available in the EU; consequently, several member states participating in the coordinated EU project EHLASS (Europena Home and Leisure Injury Surveillance System) (Belechri et al., 2002) expanded their surveillance system to all types of injury, including road traffic crashes. The Greek EDISS was the first “all injury” surveillance system, a sentinel system running in the Emergency Department of four hospitals throughout the ten million-inhabitant country, while covering the total number of injuries contacting the Emergency Departments of the participating hospitals. One of the collaborating centres is located in the Regional (District) Hospital of the island of Corfu in the Ionian sea serving a 100 000 population (Dessypris et al., 2002). Specially trained registered nurses interview those suffering from any type of injury or their relatives on the basis of a pre-coded standardized questionnaire covering socio-demographic variables, event/injury characteristics and treatment of the injured individual. The three most serious injuries are recorded based on information provided by the physicians and the Injury Severity Score (ISS) is calculated. The cut-off point for a severe injury was set to be 5, representing at least one serious injury or a combination of moderate injuries. Subsequently, the recorded information is entered in a computerised database running under continuous data quality control. Injured patients who were transferred for treatment outside the island are normally recorded in the hospital database, as they are primarily admitted to the hospital of Corfu; yet, the number of patients who sought treatment outside the island and never contacted the Corfu hospital is unknown. Moreover, the outcome of the hospitalized patients is recorded at the time of hospital discharge, irrespectively of the duration of hospitalization.

Road Traffic Police Departments (RTP) have been collecting data on the external cause of road traffic casualties in all European Union (EU) countries, but operational definitions, collection methods, reporting systems and quality standards may vary across member states. Likewise, data collection on road accidents involving casualties (injury or death) in Greece has been reported by RTP at national level since 1963 on the basis of the results of an investigation carried out whenever an injury or death occurs in a road accident. The Police records all road accidents occurring on a public or private road that have been called upon. No special crash characteristics are required for the Police to report a road accident. The report is filled in on the accident site by the policeman. Data collected by the Police in the detailed form of the National Statistical Service of Greece are computerised and were made available for further analyses.

The compatibility between the EDISS and the RTP data was examined in order to ensure that a common set of variables could be exploited for the linkage process. Variables were compared in terms of value sets as well as variable definitions and a common variable set to be used in the linkage process was established. Minor transformations were adopted in specific variables in order to ensure comparability between the two data sets.

3. Application of the Methodology

3.1 Selection of the study area

Patient flow to the Regional Hospital of Corfu meets the clearly defined catchment area requirements; all road traffic casualties occurring on the island who sought medical treatment at the Emergency Hospital Department are initially assessed, including the most severe cases, which might be subsequently transferred elsewhere for specialized care. During the study period 1996 - 2003, the linkage methodology developed in this context was applied on data derived from an ad hoc Injury Surveillance System, which registers all cases visiting the Emergency Hospital Department in comparison to those routinely registered by the Road Traffic Police for the island of Corfu.

The road environment in the island of Corfu consists mainly of lower class rural roads. The number of vehicles in use in the island, in 2003, was 38210 passenger cars, 12181 HGV’s, 390 buses and 18763 motorcycles. In 2003, 754 drink-driving infringements as well as 3689 speed infringements were recorded by the police. The use of safety equipment (seat belt and helmet) is mandatory for all motor vehicles and all drivers and passengers. The infringements for not using seat belt and helmet in 2003 were 1300 and 5173 respectively. The island population does not seem to differ from the mainland population in ways that would affect the frequency and characteristics of road accidents. Population fluctuations as well as potential changes in driving behaviour during the summer months are expected to be equally observed in the mainland population. Therefore, it is estimated that the island population represents a microcosm of the mainland population.

3.2 Selection of variables

Road user type (driver, passenger, pedestrian, bicyclist); time of occurrence (year, month, day); age of the road user (in single years); gender of the road user; nationality of the road user; and mode of transport were selected as the most reliable common subset of variables to identify the cases included in the two databases. Given that the definition of the "mode of transport" variable is somehow different in EDISS than in RTP data collection, necessary transformations were adopted. Specifically, the value "pedestrian" is included in EDISS while it is not included in the RTP "mode of transport" variable (for pedestrian casualties, the motor vehicle which collided with the pedestrian is recorded as the mode of transport and the value "pedestrian" is recorded in the "person class" variable). In order to obtain a compatible value set, the value "pedestrian" in EDISS was replaced with that of the vehicle which collided with the pedestrian, the latter obtained by an extra variable in EDISS. Therefore, the values included in the variable were: passenger car, motorcycle, moped, bicycle, small truck, large truck and bus.

3.3 Linkage of data files

A deterministic linkage technique was adopted in order to identify the concordant cases. Several previous studies (Rosman 1996, Alsop et. al. 2001) used probabilistic methods for linking road accident injury data files. However when interpreting relatively small data files (as was the case for the selected study area) the use of a deterministic linkage technique can also provide reliable and accurate results like a more sophisticated probabilistic method. The data sets were also checked for duplicate cases within a record file containing both RTP and hospital records. The linkage process was repeated several times by using slightly different matching criteria, while several manual checks on the linked records were performed maximizing thus the accuracy of the linkage.

The linkage principle used in this study was to identify the matching cases between the two datasets, based on the common set of variables. During the linkage process, however, some values of the common set variables used for the cross-checking did not match for several cases in both datasets although they seemed to refer to the same casualty. Inconsistencies between the recorded values could be attributed either to incorrect reporting on the part of the patient (in the case of the hospital data) or to misjudgment on the part of the person completing the collection form (in the case of RTP data). Otherwise, they could simply be explained as a result of an error while processing the data. In order to identify concordant cases which could not be included to the linking data file due to these small discrepancies, one of the following two approaches was adopted: (1) repeating the linkage process using each time a different subset of less common variables as the criterion for linkage in order to examine a broader range of possible matches. For example, when the nationality of the road user was unknown in the police database and known in EDISS, excluding the nationality variable from the matching subset of variables would allow inclusion of the case in the possible matching groups, based on the matching results of the remaining variables and (2) adopting less strict criteria in the linkage process and allowing a tolerance interval for the values of certain variables. Thus, despite slight differences on the values of the linking variables, some cases could be matched; for example, when a difference of one or two years in the age of the road user was observed, the cases could be considered as referring to the same casualty (concordant), taking into account the values of the other common variables. The above process was performed only for a limited number of cases and all results were manually cross-checked in order to prevent false record matches.

After completing the linkage of the two data files, the matching dataset became available. The under-reporting coefficient *c* for Police derived data was calculated by dividing the sum of the cases included plus the missing cases from the Police database, by the number of the cases included in the Police database (SafetyNet, 2005). Therefore, an improved estimate of the real number of road accident casualties was extracted by multiplying the number of cases included in the Police database with the coefficient *c*. An even better estimation of the real number of road accident casualties might also take into account casualties that have been reported neither by the police nor by the hospitals. Previous studies have attempted this through capture-recapture techniques (Morrison and Stone, 2000); however, this was not the case in the present study.

Additionally, under-reporting coefficients for the Police data were calculated by age and gender, as well as mode of transport and injury outcome. The Z statistical test was used to assess the statistical significance of the difference observed between the reporting levels in each category. The reporting levels were calculated as the rate between the number of cases reported by the RTP and the total number of cases. For non-fatal injuries, the statistical significance of the difference in the reporting levels by gender in each age group was assessed, whereas for fatal injuries, due to small numbers in each subcategory, the statistical significance of the difference was calculated only between males and females, irrespectively of age group. The statistical package SPSS, version 13, was used for all analyses.

4. Results

During the 8-year study period, 11 915 individuals injured in a road crash were transferred to the Corfu Hospital and were registered by EDISS, out of whom 97 (0.8%) died upon arrival or within a 30-day hospitalization interval. For the same period, 2082 casualties were reported by the RTP, out of which 172 (8.3%) were declared as deaths.

Table 1 summarizes the results of data linkage between EDISS and RTP databases, while Figure 1 further depicts the relative proportions of concordant and discordant cases by fatal or non-fatal outcome. As expected, RTP data capture 96.6% whereas EDISS 54.4% of total fatalities, and the overall concordance is 51.1%. On the contrary, EDISS captures 94.6% of total non-fatal injuries, whereas RTP only 16% resulting in a low overall concordance (10.6%). The estimated under-reporting coefficient for fatal injuries in the RTP database is just 1.035, whereas the respective figure for non-fatal ones is over six times higher (6.238). Respectively, the under-reporting coefficients in EDISS data are 1.84 for fatal and 1.06 for non-fatal injuries.

Table1

Figure 1

The EDISS data show that 4.5% of the casualties who suffered non-fatal injuries did not contact the hospital immediately. More specifically, 1.5% went to the hospital the next day while 3% went to the hospital after 2 or more days. The ISS of the casualties that did not contact the hospital immediately show that these people suffered from less severe injuries. More specifically, the average ISS of all casualties is 2.13 while the respective average for the casualties that did not contact the hospital on the same day is 1.52. A t-test shows that these two averages differ, in a 95% level of significance.

Normally, all injuries which occurred while driving a motor vehicle should be reported by the police irrespectively whether the vehicle was damaged or not. It could be assumed that underreporting might be higher for less severe injuries such as abrasions without reportable damage to the vehicle as it is more likely that the parties involved in the accident might not call the police.

The high degree of inconsistency in assessing severity of non-fatal injuries between the two systems is shown in Table 2.Considering the EDISS assessment as a gold standard, it can be estimated that >20% of severe injuries are misclassified as less severe by the policemen, whereas another 10% of the less severe injuries are misclassified as severe. Given that Police data rely solely on the judgment of the policeman who completes the casualty form following the police guidelines, the findings are in the expected direction. The poor agreement of the injury classification in the two databases is also evident by the low kappa value (k=0.17).

Table 2

As shown in Table 3, overall there is no significant variation in the reporting levels of fatal injuries by gender (p-value 0.79). Regarding non-fatal injuries, overall the RTP under-reporting appears to be higher in women. The difference is statistically significant (p-value=0.01) and generated principally by considerable deviation in the values of the under-reporting coefficients by gender in the age group 18-24 years (p-value=0.0001).

Further analyses by type of road user (driver, passenger, pedestrian) showed that under-reporting is higher in female car passengers and female drivers (data not shown; p-values: 0.004 and 0.0001 respectively).

Table 3

The analysis of data in the same age group (18-24 years) by mode of transport was restricted only to the sizeable categories of car passengers and motorized two wheelers and a significant gender difference was found in both categories (p-values: 0.01). Additionally, a further analysis within age groups by road user type and gender revealed that in specific age groups, the difference of the reporting levels between males and females is not always of the same sign (i.e. male drivers might be more under-reported than females while female passengers may be more under-reported than males), resulting the overall difference between males and females for these age groups to be non significant. More specifically, this was the case for the age group 15-17, where female drivers are less reported than males while male passengers and pedestrians are less reported than females. Similar trends are also observed for the age groups 25-44 and 65+ resulting in an overall non-significant difference in the reporting levels of males and females.

Lastly, Table 4 presents overall inconsistencies in the reporting systems by mode of transport. RTP data seldom report non-fatal injuries involving non-motorized two wheelers, which are in general rare in this country and meager proportions of injuries involving motorized cyclists (~10%) and cars (~15%). The finding is in line with current practices, namely that police are called upon when more serious injuries occur.

Increased discrepancies in the reporting between RTP and EDISS were noted in the case of powered two wheels and car injuries. Within these categories, the highest differences were observed in the age group of 35-44 (68%), followed by the age groups of 45-54 and 15-17 (63% and 62%, respectively); the high proportion of injuries of unknown mode of transport in EDISS, however, precludes any further speculations.

Table 4

5. Discussion

The application of the four-step methodology developed in the context of this study seems to be a useful tool for assessing the real burden of fatal and non fatal road traffic injuries, needed for the prioritarization of preventive efforts in less resourced countries not availing a formal linkage system of Police with Hospital data. The process relies on already available disaggregate data, respects confidentiality and personal data protection issues, is relatively simple, can be cost-effectively employed by bone fide institutions, and provides the mostly needed reliable information on injury rates and severity outcomes.

The study highlights the potential to quantify road casualty under-reporting on the basis of an algorithm incorporating already available disaggregate level data. Both the overall low proportion (3.5%) of fatal road injury under-reporting and the extremely high proportion (almost 85%) of non-fatal road injury under-reporting findings in the Greek setting are in line with previous reports (Derriks and Mak, 2007; DfT, 2006). In the present investigation, the data are further, comprehensively analyzed by gender and age of the victim, as well as by mode of transport, providing a useful insight into the characteristics of the casualty underreporting.

The application of the proposed methodology in a well-delineated area, such as the island of Corfu, yielded a significant difference in under-reporting levels depending on the source of data. More precisely, Police data miss 3.5% of the total road accident fatalities, probably due to late road injury deaths occurring in the hospital, whereas the respective figure for missing fatalities in the hospital database mounts to a high 46%, most likely due to differential flow of on-site fatalities, as these never reach the hospital.

The most striking result of the present study is that the Greek Police system registered only 16% of the total non fatal injuries, an extremely low proportion compared to the Police reporting rate reported in other studies (Amoros et al., 2006; Aptel et al., 1999; Harris, 1990; Lopez et al., 2000), underlining the need for substantive policy changes in the country. An additional 4.5% of the cases in the total set reported to hospital at least one day after the crash and these would not be expected to be present in the Police data. This leaves the RTP data missing 79.5% of the total number of road traffic injuries. As expected, this huge under-reporting has various implications, as it impacts on current estimates of the economic burden of road traffic injuries and possibly results in misguided prioritization of preventative initiatives.

The Police under-reporting level of non-fatal injuries seems to be higher among the younger (0-17) age and lower in the older (55+ years) age groups in accordance with previous findings indicating that the younger the victim is, the lower the probability to be reported by the Police system (Amoros et al., 2006). Both for males and females, the highest level of Police under-reporting is observed at the younger (15 -17 years) age group. As expected, casualties sustained by two-wheeler tend to be more frequently under-reported than by any other type of road user (Loo and Tsui, 2007; Rosman, 2001; Rossi et al., 2005). Indeed, the actual number of two-wheeler casualties is about ten times higher than that reported by the Police. In particular, injuries sustained by cyclists suffer the lowest probability of being reported. It is intriguing that bicycles, in most countries, constitute a marginal mode of transport and bicycle crashes are not perceived by both the Police and the individuals involved as "road traffic crashes" (Amoros et al., 2006).

Road casualty reporting by various road user characteristics (driver, passenger, pedestrian) and gender seems to show diverse patterns among younger compared older ages. In the age group of 15-17 year old, for example, female drivers are less reported than males, while male passengers and pedestrians are less reported than females. On the contrary, in the age group of 65+ year old, male drivers are less reported than females, while female passengers and pedestrians are less reported than males. Finally, in the age group of 25-34, it is worth noting that female drivers and pedestrians are less frequently reported than males and male passengers less frequently reported than their female counterparts. However, overall females seem to be less reported by the police than males. An explanation might be that even though all people involved in the crash should be reported, it is very likely that injured drivers are better police-reported than injured passengers, since the crash report should always identify the driver of each vehicle involved. Given the fact that in Greece (including Corfu) the percentage of male drivers is much higher than females (NTUA - DTPE, 2005, 2008), it can be assumed that this factor might partly explain the higher under-reporting in females.

Police data tends more often to underestimate than overestimate the severity of the injuries. Actually, one out of five casualties is recorded by the Police as less severe, whereas they are recorded as serious injuries in the hospital data files, a finding also previously reported (DfT, 2006). On the contrary, as expected, 10% of the total casualties recorded by the Police as serious injuries are eventually found to be recorded as less severe by the hospital system.

Deterministic record linkage appeared to be inappropriate for linking emergency hospital department with road traffic police data files coded under different classification systems. To this end, we opted to develop and use a more flexible methodology, according to which a highly iterative process allowed for the extraction of complete and disaggregate results. Injuries sustained in the relatively “captive” population of an island were used to construct this prototype. The disaggregate nature of the proposed methodology facilitates its application in a variety of available data sets, allowing for multiple consistency controls. The manual iterative controls can be considered as both strong and weak points of the proposed methodology: indeed, whereas cases with a linkage potential are exploited to a maximum, the expansion to a much wider scale is severely limited by the high calculation time.

In conclusion, relatively simple methodologies provide essential coefficients that are needed in order to assess the actual figures, severity and components of road casualties by complementing routinely collected RTP with sentinel Emergency Department reporting systems. Sentinel emergency department surveillance systems comprising minimum injury datasets are, therefore, a prerequisite enabling less resourced countries not only to monitor time trends and epidemiological patterns of injuries, but also to employ ad hoc linkage processes required to accurately estimate the burden of injury and properly allocate resources.

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Table 1: Concordance of injury cases provided by the Emergency Department Injury Surveillance System (EDISS, N=11,364) and the Hellenic Road Traffic Police (RTP, N=2,082) by fatal or non-fatal outcome

Injury cases	Fatal	Non Fatal	Total
Concordant cases	91	1262	1353
Extras in EDISS	6	10005	10011
Extras in RTP	81	648	729
Grand Total	178	11915	12093

Table 2: Discrepancies in the severity of outcome among the 1262 concordant non fatal injury cases provided by the Emergency Department Injury Surveillance System (EDISS) and the Road Traffic Police (RTP)

Injury Severity	N	%
Concordant cases: same level of injury severity	877	69.5%
Discordant cases: severe (EDISS) - less severe (RTP)	256	20.3%
Discordant cases: less severe (EDISS) - severe in (RTP)	129	10.2%
Total N of cases	1262	100.0%

Table 3: Under-reporting coefficients for the Road Traffic Police under-reporting by gender as well as by age group among non fatal cases only

Fatal/non fatal outcome	Age group	Gender		p-value*
		Male	Female	
Fatal	All ages	1.023	1.073	0.79
Non fatal	All ages	6.001	6.803	**0.01**
	0-14	7.304	5.829	0.33
	15-17	9.205	9.364	0.9
	18-24	5.781	7.968	**0.0001**
	25-34	5.799	6.547	0.22
	35-44	6.018	7.500	0.12
	45-54	6.000	5.630	0.70
	55-64	5.133	4.600	0.54
	65+	5.210	5.619	0.67

* P-value derived from z-test comparing the under-reporting coefficients of the two genders in each age group

Table 4: Discrepancies in the reporting of the 11,915 non fatal cases provided by the Emergency Department Injury Surveillance System (EDISS) and the Road Traffic Police (RTP) by mode of transport along with associated under-reporting coefficients

Vehicle type	Concordant	Discordant		Total		Under-reporting coefficient
		EDISS	RTP	N	%	
Bicycle	8	120	5	133	1.1	10.231
Motorized two wheels	727	6311	322	7360	61.8	7.016
Car	452	1545	286	2283	19.2	3.093
Truck	56	52	28	136	1.1	1.619
Bus	9	16	3	28	0.2	2.333
Other-Unknown	10	1961	4	1975	16.6	141.071
Total	1262	10005	648	11915	100.0	6.238

Figure 1: Concordant cases (N and %) resulting from data linkage of fatal and non fatal injuries provided by the Emergency Department Injury Surveillance System (EDISS) and the Road Traffic Police (RTP) in Corfu

Fatal injuries | Non fatal injuries