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Factors associated with severity and hospital admission of motor-vehicle injury cases in a southern European urban area

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Abstract. *Objectives*: To describe the characteristics of motor-vehicle (MV) injury cases admitted to Emergency departments (ED), and to assess factors related to injury severity and hospital admission. *Setting*: Subjects were MV injury patients, aged 16 or more, admitted to four EDs in the city of Barcelona (Spain), from July 1995 to June 1996. *Methods*: Cross-sectional design. The data analyzed were obtained from the information routinely transmitted from the EDs to the Municipal Institute of Health, based on the processing of ED logs. Severity was assessed with the Abbreviated Injury Scale and the Injury Severity Score. Univariate and bivariate descriptive statistical analyses were performed, as well as multiple logistic regressions. *Results*: For the 3791 MV-injury cases included in the study period, a larger contribution of cases was noted for males (63.1%), for cases younger than 30 years (55.3%) and for motorcycle or moped occupants (47.1%). After adjusting for age, sex and the presence of multiple injuries, pedestrians, followed by moped and motorcycle occupants were at a higher risk of a more severe injury (OR: 1.77, 1.61 and 1.50 respectively). Correspondingly, these user groups also showed a higher likelihood of a hospital admission (OR: 2.03, 1.92 and 2.00 respectively), when attended to in an ED. Injury cases attended to in the ED during night hours (OR: 2.06) were also at a higher risk of a hospital admission. *Conclusions*: In Barcelona, pedestrians and two-wheel MV occupants, besides accounting for two-thirds of MV injury cases, are the user groups with a greater risk of a more severe injury, as well as a higher chance of a hospital admission, independently of demographic and health care factors.

Key words: Hospital admission, Injury severity, Motor-vehicle injuries

Abbreviations: AIS = Abbreviated Injury Scale; CI = confidence interval; DUHAT = Dades d'Urgències Hospitalaries per Accident de Trànsit; ED = emergency department; ISS = Injury Severity Score; MV = motor vehicle; OR = odds ratio; ROC = receiver operating characteristic

Background

In industrialized countries, motor-vehicle (MV) injuries are a major public health problem, with an increasing contribution to morbidity and disability, most notably among highly vulnerable population groups such as children [1], young people [2], and the elderly [3]. In the last three decades, Spain, together with Portugal and Greece, ranked among the European Union countries where consequences of MV crashes relative to the number of registered vehicles has been highest [4]. In Spain, MV injuries are the primary cause of death among those 15–24 years [5], with a remarkable negative influence on recent trends in life expectancy in the 1980's [6].

Little attention has been paid to the fact that a large share of MV crashes take place increasingly in urban settings. The case of the city of Barcelona (1.5 million inhabitants), located in the northeastern part of the Spanish Mediterranean coast, and one of the largest cities in Europe, provides some insight into the public health impact of MV crashes in such settings. MV injuries account for 4.4% of potential years of life lost [7], 10% of hospital admissions, and 8% of disabilities [8]. The availability of population-based emergency department data for MV injuries occurring within the city boundaries has allowed the identification of the incidence and severity of such injuries, as well as their distribution by MV user categories. A notable observation has been the striking contribution of motorcycle and moped occupants to the burden of MV injuries and disabilities [9].

Knowledge of the severity and body region of injuries resulting from MV crashes is a key element in

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identifying and evaluating preventive actions. Not all sources of MV crash information collect valid and useful information to allow the assessment of severity [10]. In general, severity measurement is most feasible in hospital-related sources (discharges or emergency services). However, depending on the population under study, it may be necessary to weigh up the advantages and disadvantages of each of the information sources. Hospital discharge information tends to be more precise than that from emergency departments (EDs) [11], but is subject to two limitations. On one hand, only a small percentage of MV crash victims attended by emergency services require a hospital admission. On the other hand, hospitalized cases generally involve more severe injuries than those not admitted, leading to a bias in the estimation of severity towards values higher than that for the totality of MV victims.

A previous study in Barcelona showed that the information collected by EDs is valid for monitoring trends in the magnitude and distribution of severity of injuries among victims not requiring hospitalization [11], as measured by the Abbreviated Injury Scale (AIS) [12], and the Injury Severity Score (ISS) [13]. A preliminary study using 1990–1991 ED data showed that in MV crashes occurring in Barcelona, pedestrians and motorcyclists have a higher risk of a severe injury [9]. Nevertheless, these results did not take into account the potential confounding role of demographic and health care variables – since variables such as gender and age can be associated both with user type and injury severity – and did not examine the consistency of the differences among user categories as regards the risk of hospitalization.

The present study is an attempt to respond to these questions in the same urban setting, using information routinely collected by the EDs of four Barcelona hospitals in recent years, during which a substantial reduction in the impact of MV injuries has been observed [14].

Subjects and methods

Subjects

Subjects were individuals, aged 16 or more, attended to by the EDs of four Barcelona hospitals for injuries due to a MV crash from July 1995 to June 1996. Individuals dying while in the ED were excluded.

Sources of information

Data analyzed were transmitted from four EDs participating in the *Dades d'Urgències Hospitalàries per Accident de Trànsit* (DUHAT) project, coordinated by the Municipal Institute of Health. Initiated in 1994, DUHAT systematically collects information on MV crash victims seen in EDs of the Barcelona public hospitals network (seven centers), including demographic and diagnostic data, as well as user type. The four participating hospitals sampled for this study account for 46% of all MV injury cases attending an ED in Barcelona [15], and the population of their catchment areas is heterogeneous from a socioeconomic standpoint. The selection of these four EDs was made on the grounds of better data completeness regarding injury severity for the study period for these hospitals. Nevertheless, previous analyses of this data set indicate that there are no significant differences in demographic and socioeconomic variables, as well as in user type and severity of injury cases, among the study hospitals and the remaining DUHAT centers.

Methods

For the period under study the data base comprised 3791 cases. The variables transmitted from the participating centers were: hospital identification code, record number, date and time of the visit, date of birth, sex, postal code of residence, type of vehicle and position of the injured case (driver, passenger or pedestrian), as well as discharge status and diagnoses. The coding of these diagnoses, according to ICD-9-CM [16] criteria, was carried out either by coders at each hospital, or by coders of the Municipal Institute of Health.

Severity was measured using the computer program ICDMAP [17]. This program assigns the associated AIS severity score to each ICD-9-CM diagnosis code, as well as an overall severity score per patient according to the ISS, and a maximum severity for each of the following anatomical regions: head, neck, thorax, abdomen, spine, lower limbs, upper limbs, face, and external injuries. Severity was further categorized in two different ways depending on the objective. In order to describe factors associated with severity as a dependent variable, two categories were created: slight ($ISS \leqslant 3$) and moderate or severe ($ISS \geqslant 4$). When used as an adjustment variable in the study of hospital admission, three categories were used: slight ($ISS \leqslant 3$), moderate ($4 \leqslant ISS \leqslant 8$) and severe ($ISS \geqslant 9$). The variable 'admission' was created based on the coding of discharge status into two categories: patients were considered to have been 'admitted' if discharge status was either admission or referral to another hospital.

With regard to independent variables, time and day of visit were categorized as follows: morning: 06–14 hours; afternoon/evening: 14–22 hours; night: 22–06 hours; as well as weekday: from 07 hours Monday to 19 hours Friday evening; weekend: 19 hours Friday evening to 07 hours Monday morning. Cases of multiple injuries were defined as those with more than one diagnosis in at least two different anatomical regions. The most severe anatomical region was defined as the one with the largest AIS score; when

regional scores were similar, the most severe region was chosen, based on criteria used by other authors [18], which give more importance to regions such as head, neck, thorax and/or abdomen. Finally, based on the position and type of vehicle information, a new variable, user type, was defined with five categories: car occupant, motorcycle occupant, moped occupant, pedestrian and others (e.g., bicycle, truck and bus occupants).

Besides a descriptive analysis of the main study variables, multivariate logistic regression methods were used for the construction of models involving factors associated with severity and hospital admission. Assessment of the performance of the models was done using the Hosmer–Lemeshow goodness-of-fit test [19]. This test evaluates the degree of correspondence between the model's estimated probabilities of a more severe injury or of a hospital admission and the actual severity or hospital admission experience of patients over groups spanning the entire range of probabilities. Discrimination was assessed using the area under the receiver operating characteristic (ROC) curve [20] to evaluate how well the model distinguished patients not severely injured or not admitted from those severely injured or admitted. All analyses were performed using the SPSS [21] and the STATA [22] statistical packages.

Results

As presented in Table 1, of the 3791 MV injury cases, 63.1% were men. People aged from 20 to 29 years were the age group with the largest contribution to all MV injuries (41.8%). In all age groups, the percentage of men was higher than that of women (over 66%), except among the elderly, where the percentage was higher among women (57.2%).

Table 1. Distribution of the main characteristics of MV crash injury cases by age group

Age (years)	16–19	20–29	30–49	≥50	Total
Cases	514	1583	1014	680	3791
Sex (%)					
Males	69.84	66.65	67.65	42.79	63.07
Females	30.16	33.35	32.35	57.22	36.93
User (%)					
Car occupant (occ.)	17.90	30.07	41.22	33.09	31.94
Motorcycle occ.	27.63	37.97	28.99	4.56	28.17
Moped occ.	44.55	23.88	9.47	2.21	18.94
Pedestrian	8.75	6.95	17.26	47.79	17.28
Other	1.17	1.14	3.06	12.35	3.67
Weekend (%)					
No	67.51	66.65	72.09	73.24	69.40
Yes	32.49	33.35	27.91	26.76	30.60
Time (%)					
Morning	22.18	31.52	33.63	40.15	32.37
After./even.[a]	52.92	44.54	46.06	49.12	46.90
Night	24.90	23.94	20.32	10.74	20.73
Multiple injuries (%)					
No	94.16	92.36	92.41	92.06	92.56
Yes	5.84	7.64	7.59	7.94	7.44
Anatomic region[b] (%)					
Head	4.28	5.50	5.42	6.32	5.46
Face/neck	0.58	0.69	0.69	1.18	0.76
Thorax/abdomen	0.00	0.32	0.79	2.65	0.82
Spine	4.86	10.23	16.37	8.38	10.82
Lower limbs	8.17	9.98	7.30	13.82	9.71
Upper limbs	7.39	7.58	8.38	7.65	7.78
External injuries	74.71	65.70	61.05	60.00	64.65
Severity (%)					
Slight	81.52	77.51	79.88	71.32	77.58
Moderate	14.20	17.31	14.99	21.03	16.93
Severe	4.28	5.18	5.13	7.65	5.49
Admission (%)					
Yes	5.06	6.25	7.10	11.47	7.25
No	94.94	93.75	92.90	88.63	92.75

[a] After. = afternoon; Even. = evening.
[b] Anatomical region with the most severe injury.

Motorcycle and moped occupants together accounted for the largest share of MV injury cases (47.1%), followed by car occupants (31.9%) and pedestrians (17.3%). The load of two-wheel MV injuries was even higher in the 16–19 year age group (72.2%) – were almost one in two cases involved a moped occupant – while car occupant injury cases predominated in the 30–49 year age group (41.2%), and pedestrians were the leading injured user category in the elderly (47.8%).

About two-thirds of MV injury cases took place on weekdays, and half of them in the afternoon and evening hours. Weekend injuries had a higher contribution in the population below 29 years, while night injuries were slightly more frequent in the 16–19 year age group and were lowest among the older than 50 years.

About one out of every five cases had an injury of moderate or high severity. The relative contribution of these two severity categories was higher among the elderly (28.7%). Almost 90% of cases had only one recorded injury, the younger being the subgroup with the largest proportion of single injuries. External injuries (cuts and bruises) accounted for more than half of all injuries, followed by injuries to the spine (including whiplash), injuries to the head and injuries to the lower and upper limbs. Nevertheless, this relative distribution varied substantially by age group, with a much larger contribution of external injuries among teenagers, of spine injuries in the middle-aged population, and of lower limbs in the elderly. Close to 7% of MV injury cases attended to in EDs were finally admitted to the hospital, with a proportion of admissions rising with age.

As shown in Table 2, bivariate comparisons indicate that males and the elderly, as well as pedestrians, suffered more often injuries of moderate to high severity. Injuries resulting from weekend and night crashes also were of higher severity, while injuries to the head, to the thorax and the abdomen and to both extremities were also of higher severity. Admission proportions followed an overall pattern of distribution among each of the variables rather similar to the one described for severity, except for face and neck injuries, for which, despite a majority of cases of minor severity, about 21% of cases were finally admitted to the hospital.

Tables 3 and 4 show the results of the multivariate logistic regression models for factors associated with severity and hospital admission, respectively. Males (OR: 1.27), cases older than 50 years (OR: 2.00), multiple injury cases (OR: 10.41), motorcycle occupants (OR: 1.50), moped occupants (OR: 1.61) and pedestrians (OR: 1.77) showed a higher and statistically significant adjusted risk of suffering more severe injuries. In the case of the risk of hospital admission, after adjusting for injury severity, males (OR: 1.39), cases older than 50 years (OR: 2.48), motorcycle occupants (OR: 2.00), moped occupants (OR: 1.92) and pedestrians (OR: 2.03) had a higher and statistically significant independent risk of being admitted to the hospital. Individuals seen during night hours had also a higher independent risk of being admitted to the hospital (OR: 2.06), as also did those attended to in hospitals C and D in comparison with those attended to in hospital A (OR: 4.56 and 4.27, respectively). The interaction between age and mode of transportation was not found statistically significant, and was therefore not included in the final model.

Discussion

This study contributes to the knowledge of the main groups of road users injured in MV crashes in a southern European urban area, and particularly to the identification of factors associated with severity and risk of admission. It is based on information sources that represent a more complete coverage of the population involved than that of earlier studies mainly based on hospital discharge data.

While age and sex patterns of MV injury distribution are similar to those of previous studies in the same context and also similar to other countries, it is important to draw attention to the much higher relative contribution of motorcycle, moped users, and of pedestrians in comparison to other countries, as well as to the higher percentage of pedestrians involved in comparison to other urban areas [23–27]. These types of users present, among themselves, different patterns of age and sex. Thus, in the present study, two main subgroups must be underlined in terms of their relative contribution to the magnitude of MV injuries: young male motorcycle and moped users, and elderly pedestrians, the latter with a higher percentage of women. These results also stress that, in the case of the city of Barcelona, despite an important reduction in the total number of MV fatalities and injuries in recent years, age, sex and road user patterns remain essentially unchanged, and must continue to be considered as priority targets for local prevention policies.

Moreover, our results also point out that males, two-wheel MV riders and pedestrians have a higher risk of suffering a more severe injury, even after adjusting for potentially confounding variables such as age, sex, and type and location of the injury, an issue which needed to be explored as a result of an earlier study in the same population [9], similarly to what has been shown for New Zealand [24]. It must be underlined that in the case of motorcycle and moped users, in spite of the fact that in Barcelona a clearly favorable impact of the helmet law has been recently documented – with a substantial decrease in mortality and a lesser involvement of the head in fatal cases [28] – two-wheel MV riders continue to be a user group with a higher risk of a more severe injury. This conclusion remains true for the risk of hospital admis-

Table 2. Distribution by severity and admission for selected demographic, injury and health care variables. Bivariate analysis

Factor	N	Severity			Admission (%)
		% slight	% moderate	% severe	
Sex					
Males	2391	76.83	17.82	5.35	7.95
Females	1400	78.86	15.43	5.71	6.07
Age (years)					
16–19	514	81.52	14.20	4.28	5.06
20–29	1583	77.51	17.31	5.18	6.25
30–49	1014	79.88	14.99	5.13	7.10
≥50	680	71.32	21.03	7.65	11.47
User					
Car occupant (occ.)	1211	80.76	13.05	6.19	4.38
Motorcycle occ.	1068	78.18	17.42	4.40	7.68
Moped occ.	718	76.46	18.52	5.01	7.10
Pedestrian	655	71.30	21.98	6.72	12.67
Other	139	80.58	15.11	4.32	4.32
Weekend					
No	2631	78.49	16.31	5.21	7.11
Yes	1160	75.52	18.36	6.12	7.59
Time					
Morning	1227	78.81	16.54	4.65	6.28
After./even.[a]	1778	77.84	16.59	5.57	6.81
Night	786	75.06	18.32	6.62	9.80
Anatomic region [b]					
Head	207	0.00	46.86	53.14	7.73
Face/neck	29	86.21	13.79	0.00	20.69
Thorax/abdomen	31	64.52	32.26	3.23	29.03
Spine	410	95.12	1.71	3.17	3.41
Lower limbs	368	23.10	58.42	18.48	32.07
Upper limbs	295	28.14	66.44	5.42	18.64
External injuries	2451	95.39	4.61	0.00	2.33
Multiple injuries					
No	3509	81.28	15.50	3.11	7.07
Yes	282	31.56	34.75	33.69	9.57
Severity					
Slight	–	–	–	–	2.45
Moderate	–	–	–	–	23.68
Severe	–	–	–	–	24.52

[a] After. = afternoon; Even. = evening.
[b] Anatomical region with the most severe injury.

sion, since once the effects of age, sex and injury severity are controlled for, motorcycle and moped riders, together with pedestrians, show the highest risks of being admitted. Hospital admission risk, after adjusting for injury severity was lower for multiple injury cases, indicating that ISS measurements seem to adequately capture the influence of severity in the chance of admission, when considered jointly with other independent variables. On the other hand, the observation that patterns of hospital care, as measured by time of ED attendance and specific source of hospital care, may influence the likelihood of admission, even after taking into account differences in age, gender and injury severity, deserves further attention. Although a greater availability of hospital beds and/or a lesser availability of diagnostic procedures during night shifts may account for a greater chance of a hospital admission if the patient is seen at those times, no straightforward explanation can be provided to explain the differences among hospitals in the chance of admission. Because no differences were observed in the relative contribution of referred patients among these hospitals, greater attention must be paid to potential differences in admission criteria among them.

For purposes of severity discrimination among the study population, where most MV injury cases were of minor severity, our definition of moderate/severe injuries was based on a low cut-off point (ISS of four or greater). As a result, a large proportion of the

Table 3. Factors associated with injury severity (ISS ≥ 4). Multivariate logistic regression model (n = 3791)

Factor	N	OR adj.	95% CI	
Age (years)				
16–19	514	1		
20–29	1583	1.33	1.02	1.74
30–49	1014	1.18	0.88	1.59
≥50	680	2.00	1.43	2.78
Sex				
Females	1400	1		
Males	2391	1.27	1.06	1.51
Multiple injuries				
No	3509	1		
Yes	282	10.41	7.93	13.67
User				
Car occupant (occ.)	1211	1		
Motorcycle occ.	1068	1.50	1.20	1.89
Moped occ.	718	1.61	1.25	2.08
Pedestrian	655	1.77	1.37	2.27
Other	139	1.06	0.66	1.71

p-Value goodness of fit 0.6412. Area under ROC curve 0.6627. Adj. = adjusted.

Table 4. Factors associated with admission to hospital. Multivariate logistic regression model (n = 3791)

Factor	N	OR adj.	95% CI	
Age (years)				
16–19	514	1		
20–29	1583	1.18	0.72	1.91
30–49	1014	1.15	0.90	2.54
≥50	680	2.48	1.39	4.42
Sex				
Females	1400	1		
Males	2391	1.39	1.02	1.88
User				
Car occupant (occ.)	1211	1		
Motorcycle occ.	1068	2.00	1.34	2.99
Moped occ.	718	1.92	1.22	3.03
Pedestrian	655	2.03	1.51	3.51
Other	139	1.00	0.39	2.56
Night attention				
No	3005	1		
Yes	786	2.06	1.50	2.83
Severity				
Slight	2941	1		
Moderate	642	12.72	9.36	17.27
Severe	208	24.42	15.15	39.36
Hospital				
A	332	1		
B	713	2.10	0.78	5.62
C	1953	4.56	1.79	11.59
D	793	4.27	1.64	11.13
Multiple injuries				
No	3509	1		
Yes	282	0.42	0.26	0.68

*p-Value goodness-of-fit 0.2246. Area under ROC curve 0.8507. Adj. = adjusted.

cases in the group with moderate/severe injuries did not have very severe or life-threatening injuries. Still, we believe that our categorization scheme has proven to be useful to pinpoint the road user groups experiencing the most unfavorable consequences of MV crashes.

Although, as described above, there are advantages in using information collected by EDs, attention is drawn to the limitations which this involves. These limitations relate to the use of secondary data, initially collected for other purposes. Caution should be made on the fact that our study used data from a sample of hospitals collecting the information necessary for the study purposes. Nevertheless, the injured population described here is similar to previous studies [9], while we know that the demographic, occupant type and injury distribution and severity of the cases attended to in the remaining hospitals do not differ substantially from the ones in the participating hospitals. The exclusion of cases below 16 years of age was due to the lack of sufficient data for the pediatric hospitals covering this age group. On the other hand, although MV injury deaths at the scene were not included in the study, we believe that their small relative contribution (0.5% of all MV injury cases) [29] and the similarity of the distribution of the study variables with the one described for ED cases, do not alter our conclusions. Finally, although the use of the automatic conversion from ICD-9-CM to AIS codes may lead to a minor severity assigned to certain injuries when compared to the manual method [30], we believe that this process is not inadequate when applied a large ED database with a broad contribution of minor severity injuries, as is the case in Barcelona.

This study must be considered as an attempt to pinpoint the subgroups drawing the burden of MV injuries in a large urban area, rather than an effort to explain the differences among such groups. This would certainly require information on a whole range of other important factors not routinely collected in ED reports, such as speed at the time of the crash, use of protective devices such as helmets or safety belts, or presence of other acute or chronic diseases at the time of the injury.

In conclusion, the results obtained have allowed the identification of two groups of the road-user population, namely young riders of two wheeled vehicles, and elderly pedestrians, important in terms of their higher risk of a severe injury and of being admitted to the hospital. This adds to the previous reports on the relatively high volume of cases which they represent within the total of MV crash victim [9]. For these reasons, local injury prevention programs should be designed with these two groups specifically in mind. Focusing on these two subgroups, rather than applying broadly unspecific injury prevention policies, should contribute to an important reduction in MV crash rates, as well as in the severity of inju-

ries. Additionally, the observation of potentially differing admission criteria between the participating centers deserves a more in-depth research from a quality of care approach.

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