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Gender differences in road traffic injury rate using time travelled as a measure of exposure

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ABSTRACT

There is no consensus on whether the risk of road traffic injury is higher among men or among women. Comparison between studies is difficult mainly due to the different exposure measures used to estimate the risk. The measures of exposure to the risk of road traffic injury should be people's mobility measures, but frequently authors use other measures such population or vehicles mobility. We compare road traffic injury risk in men and women, by age, mode of transport and severity, using the time people spend travelling as the exposure measure, in Catalonia for the period 2004–2008. This is a cross-sectional study including all residents aged over 3 years. The road traffic injury rate was calculated using the number of people injured, from the Register of Accidents and Victims of the National Traffic Authority as numerator, and the person-hours travelled, from the 2006 Daily Mobility Survey carried out by the Catalan regional government, as denominator. Sex and age specific rates by mode of transport and severity were calculated, and Poisson regression models were fitted. Among child pedestrians and young drivers, males present higher risk of slight and severe injury, and in the oldest groups women present higher risk. The death rate is always higher in men. There exists interaction between sex and age in road traffic injury risk. Therefore, injury risk is higher among men in some age groups, and among women in other groups, but these age groups vary depending on mode of transport and severity.

1. Introduction

There is evidence that the risk of road traffic injury varies by gender, but there is no consensus over whether it is higher among men or among women. Comparison between studies is difficult due to the different populations studied, in terms of mode of transport (drivers or users – i.e. drivers or passengers – of cars and or two-wheeled motor vehicles, cyclists, pedestrians, etc), or in terms of injury severity (fatal or non-fatal injury, any injury regardless of severity, being involved in a collision with victims regardless of severity, etc.). But above all, comparison between studies is difficult due to the different exposure measures used to estimate the risk of injury (population, vehicle fleet, census of drivers, vehicle mobility -vehicle-kilometers travelled-, people's mobility distance or time travelled, etc.).

For any event in epidemiology, risk ought to be estimated based on the calculation of rates, in which the denominator should be a measure of the quantity of person-time at risk. In the case of road traffic crashes the measures of exposure to the risk of injury should be defined through the various ways of quantifying people's mobility, whether by vehicle or on foot, and as a function of distance or time travelled (European Traffic Safety Council ETSC, 1999). Various authors have estimated the road traffic injury risk using people's mobility as the exposure. However, the majority of these studies are based on drivers involved in collisions or in collisions with victims, without distinguishing whether the driver was injured or not, nor the specific mode of transport. Moreover, in spite of the fact that some of these studies have used the time people spent travelling (Chipman et al., 1992, 1993; Keall, 1995; Lee and Abdel-Aty, 2005; Rodgers, 1995) and others have used the number of trips made (Beck et al., 2007), the majority use the distance travelled as driver of a vehicle as the exposure (Chipman et al., 1992, 1993; Kweon and Kockelman, 2003; Lardelli-Claret et al., 2011; Keall and Newstead, 2009; Harrison and Christie, 2005; Massie et al., 1995, 1997; Al-Balbissi, 2003), meaning non-motorized modes of transport cannot be studied.

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According to the findings of those studies, there are contradictions in relation to differences in road traffic injury risk between men and women. Some studies report higher rates in men than in women in all age groups except the elderly, these differences being more marked in the youngest groups and decreasing as age increases (Al-Balbissi, 2003; Chipman et al., 1993; Massie et al., 1995, 1997). Another study reported higher rates in men than in women, in the youngest and the oldest age groups (Williams, 2003). In contrast, other authors reported similar rates for male and female drivers of the same age, and some others even report higher rates of non-fatal injuries among women over 25 years than among men of the same age (Kweon and Kockelman, 2003; Massie et al., 1995). Beck et al., (2007) estimated the injury rate by sex and by mode of transport including non-motorized modes and using the number of trips people made as the exposure measure. They reported higher risk in men than in women for all users except motorcycle drivers, regardless of age (Beck et al., 2007).

In order to estimate exposure to road traffic injury risk, mobility and transport surveys constitute a useful tool for measuring people's mobility. The 2006 Catalonian Daily Mobility Survey (EMQ2006) was a transport survey representative of the Catalan population which collected information about individuals and about all their trips during one day. This provides an opportunity to obtain measures of people's mobility taking into account their individual characteristics. Thus, the objective of the present study is to compare the risk of road traffic injury in men and women, by age, mode of transport and injury severity, using the time people spend travelling as the exposure measure, in Catalonia for the period 2004–2008.

2. Materials and methods

2.1. Design and study population

This is a cross-sectional study and the study population includes all residents of Catalonia aged over 3 years, in the period 2004–2008. Catalonia is a region located in the North–east of Spain, with approximately seven million inhabitants.

2.2. Information sources

The Register of Accidents and Victims of the National Traffic Authority provides information about people injured in traffic collisions in Spain.

The 2006 Catalonian Daily Mobility Survey (EMQ2006) carried out by the Catalan regional government (Departament de Política Territorial i Obres Públiques de la Generalitat de Catalunya, and Autoritat del Transport Metropolità), provides information about mobility of the population aged over 3 years in Catalonia in 2006. This survey employed a computer-assisted telephone interviewing (CATI) technique to interview a representative sample of the population of Catalonia. Data were collected using multistage stratified sampling, firstly selecting territory (counties and towns of over 50,000 inhabitants) and then selecting the individuals to be interviewed, applying quotas for age and sex, covering the whole of Catalonia. A total of 106,091 people were interviewed in 2006 between March and June, and between September and December, and mobility data were collected for 95,644 individuals who made some trip the day before the interview. In general, the survey collects information about participants and the trips they made during the day before the interview, but when the interview took place on a Monday, information was collected referring to the previous Friday, and in the same interview, 50% of partipants were also asked about their mobility on the Saturday, and 50% about their mobility on the Sunday. For every trip, the day, reason, origin, destination, starting time and duration were collected (Institut d'Estudis Regionals i Metropolitans de Barcelona, 2008).

2.3. Variables

The dependent variable is the number of people aged over 3 years injured in traffic crashes in Catalonia between 2004 and 2008. It includes people suffering both slight and severe injuries (requiring admission to hospital for more than 24 h) as well as people who die (whether at the scene of the accident, on the way to hospital, or in hospital during the 24 h following the accident).

The explanatory variables used are: sex; age group (4–11, 12–13, 14–17, 18–24, 25–34, 35–44, 45–54, 55–64, 65–74, and >74 years), employing groups sufficiently small to permit detecting changes in injury risk taking into account mobility patterns of different population groups, defined for example by ages when people may begin to ride a moped – 14 years – or drive a car – 18 years – retirement age – 65 years, etc.; mode of transport (car driver; motorcycle or moped driver; bicycle; bus; and on foot—pedestrian); and injury severity (slight, serious and fatal).

The exposure variable used is the total time people spent travelling, measured in hours (i.e. person-hours travelled). This variable was estimated based on the number of people who, in responding to the EMQ2006, stated they had made some trip on the day referred to in the interview. Applying post-stratification weights to scale the data to population level, specific for working days and for weekends, we obtain a population estimate for the number of residents of Catalonia travelling on a working day and on a weekend-day, the number of trips they make, and finally the population estimate for the total hours they spend travelling (person-hours travelled). As their mobility is in reference to a single day, to obtain an annual estimation, the estimate of time spent travelling on working days is multiplied by 245, the number of working days in 2006, and the time spent travelling at weekends by 120. A trip is uniquely specified by its origin and destination, and may consist of several stages defined by the different modes of transport used, but the EMQ2006 does not ask about the time spent in each mode of transport in trips involving several different modes. For such multi-stage trips (which represent 5% of all trips) the total trip time is assigned to the main mode of transport (in the order: bus, car-driver, motorcycle-driver, car-passenger, motorcycle-pillion passenger, bicycle, walking trip).

2.4. Statistical analysis

In order to describe the impact of traffic injuries in different population groups in Catalonia during the period 2004–2008, taking their mobility into account, the annual road traffic injury rate was calculated, in each group, using the number of people injured in this period as numerator, and the estimate of person-hours travelled in 2006 multiplied by 5, the length of the study period in years, as denominator. The formula used for calculating the injury rate was:

((number of people injured in the period 2004–2008)/(((number of person-hours travelled on a working day in 2006 × 245 working days in 2006) + (number of person-hours travelled on a weekend-day in 2006 × 120 weekend-days in 2006)) × 5 years in the period 2004–2008)) × 10,000,000

The rate is expressed as people injured per 10 million person-hours travelled and provides an estimate of the road traffic injury risk. Sex- and sex/age-specific rates by mode of transport and severity were calculated. The 95% Confidence Intervals for the rates were calculated using the Poisson distribution (Szclo and Nieto, 2003). Rates for groups with less than 10 people injured are not reported.

In order to compare road traffic injury risks between men and women, the Relative Risk (RR) of suffering a road traffic injury

Table 1
Number and distribution of people-hours travelled (2006), number of road traffic injuries and annualized road traffic injury rate (2004–2008) by sex and mode of transport, and relative risk comparing men to women for each mode of transport. Catalonia, 2004–2008.

	People-hours travelled 2006				Road traffic injuries 2004–2008							
	Men		Women		Men			Women			Men to women	
	N (Million)	%*	N (Million)	%*	N	Rate	95%CI	*N*	Rate	95%CI	RR	95%CI
Pedestrians	410.8	29.2	448.6	35.4	8082	39.4	(38.5, 40.2)	8452	37.7	(36.9, 38.5)	1.03	(1.00, 1.06)
Car drivers	512.4	36.4	227.8	18.0	26,229	102.4	(101.1, 103.6)	12,122	106.4	(104.5, 108.3)	1.02	(0.99, 1.04)
Moped/motorcycle drivers	42.3	3.0	11.2	0.9	42,389	2003.5	(1984.5, 2022.7)	11,298	2010.0	(1973.1, 2047.4)	1.06	(1.04, 1.08)
Cyclists	22.7	1.6	5.7	0.5	2932	258.2	(248.9, 267.7)	776	270.2	(251.5, 289.9)	0.87	(0.80, 0.94)
Bus passengers	92.5	6.6	140.7	11.1	906	19.6	(18. 3, 20.9)	2040	29.0	(27.7, 30.3)	0.73	(0.67, 0.79)
Total*	1406.1	100	1268.6	100	100,569	143.0	(142.2, 143.9)	56,554	89.2	(88.4, 89.9)	1.08	(1.07, 1.09)

Rate: People injured per 10 million person-hours travelled.
RR: Relative Risk from the Poisson regression model, comparing men to women with adjustment for age.
95%CI: 95% confidence interval.
* The different modes of transport do not sum to the given total, nor the percentages to 100% because some modes of transport are not reported (train, metro, etc).

and its 95% CI were estimated by fitting Poisson Regression models. In these models, the dependent variable (Y) was the number of people injured in road traffic crashes, assumed to follow a Poisson distribution. The number of person-hours travelled was used as the exposure variable (t), and sex as explanatory variable (X_i). To obtain the RR in Table 1, a model of each mode of transport were fitted, with adjustment for age (including age in the model as an explanatory variable, X_i). To obtain the RR for Table 2, a model of each mode of transport and severity were fitted, with adjustment for age. And to obtain the RR for Table 3, a model of each mode of transport, severity and age group were fitted. The formulation used for the Poisson regression model was:

$$\ln(E(Y_i)) = \ln(t_i) + X_1\,\beta_1 + \cdots + X_p\beta_p i = 1, 2, \ldots, n$$

where n is the number of observations and p the number of explanatory variables, its maximum value being 2: sex and age.

Statistical analyses were carried out using the STATA v.11 package (Stata Corporation, 2009)

3. Results

In the period 2004–2008, 100,569 men and 56,554 women were injured in road traffic crashes in Catalonia. According to the EMQ2006, it is estimated that in 2006 men spent a total of 1406 million hours travelling, while women spent 1269. Therefore, the annual road traffic injury rate in Catalonia for the period 2004–2008 is 143.0 men injured and 89.2 women injured, per 10 million person-hours travelled.

Among men, car is the mode of transport in which they spend most time travelling, but they are most often injured driving mopeds or motorcycles. Among women, walking is the mode of transport in which they spend most time travelling, but they are most often injured driving cars (Table 1). However, among both men and women, the highest risk of injury, whether slight, severe or fatal, is observed when they travel by motorcycle or moped (Table 2).

Women present significantly higher risk of slight injury than men when travelling by bus, bicycle and car. No differences are observed between men and women as pedestrians, nor as

Table 2
Number of road traffic injuries and annualized road traffic injury rate by sex, injury severity and mode of transport, and relative risk comparing men to women for each mode of transport. Catalonia, 2004–2008.

	Men		Women		Men to women	
	N	Rate	*N*	Rate	RR	95%CI
Slight injuries						
Pedestrians	6557	31.92	7111	31.71	1.00	(0.96, 1.03)
Car drivers	23,303	90.96	11,344	99.59	0.97	(0.96, 0.99)
Moped or motorcycle drivers	37,150	1,755.92	10,641	1,893.14	0.99	(0.97, 1.01)
Cyclists	2546	224.16	714	248.62	0.83	(0.76, 0.90)
Bus passengers	854	18.47	1993	28.32	0.70	(0.64, 0.76)
Total	87,847	125.0	51,793	81.7		
Serious injuries						
Pedestrians	1286	6.26	1226	5.47	1.10	(1.01, 1.19)
Car drivers	2290	8.94	667	5.86	1.53	(1.40, 1.67)
Moped or motorcycle drivers	4695	221.91	633	112.62	2.04	(1.88, 2.22)
Cyclists	333	29.32	60	20.89	1.19	(0.90, 1.59)
Bus passengers	43	0.93	46	0.65	1.73	(1.13, 2.64)
Total	10,793	15,4	4257	6,7	1.57	(1.51, 1.63)
Fatal injuries						
Pedestrians	239	1.16	115	0.51	2.31	(1.84, 2.90)
Car drivers	636	2.48	111	0.97	2.39	(1.95, 2.93)
Moped or motorcycle drivers	544	25.71	24	4.27	6.05	(4.01, 9.11)
Cyclists	53	4.67	2			
Bus passengers	9		1			
Total	1929	2.7	504	0.8	2.59	(2.33, 2.89)

Rate: People injured per 10 million person-hours travelled.
RR: Relative Risk from the Poisson regression model, comparing men to women, with adjustment for age.
95%CI: 95% confidence interval.

Table 3
Number of road traffic injuries and annualized road traffic injury rate by injury severity, sex and age, and relative risk comparing men to women for each age and severity group, in car drivers and motorcycle or moped drivers. Catalonia, 2004–2008.

	Slight injuries						Serious injuries						Fatal injuries					
	Men		Women		Men to women		Men		Women		Men to women		Men		Women		Men to women	
	N	Rate	*N*	Rate	RR	95%CI	*N*	Rate	*N*	Rate	RR	95%CI	*N*	Rate	*N*	Rate	RR	95%CI
Car drivers																		
18–24 years	4340	182.1	1805	142.9	1.3	(1.2, 1.3)	426	17.9	104	8.2	2.2	(1.8, 2.7)	103	4.3	17	1.3	3.2	(1.9, 5.4)
25–34 years	6689	111.9	3587	98.3	1.1	(1.1, 1.2)	591	9.9	173	4.7	2.1	(1.8, 2.5)	152	2.5	28	0.8	3.3	(2.2, 4.9)
35–44 years	4073	54.5	2288	65.5	0.8	(0.8, 0.9)	415	5.6	114	3.3	1.7	(1.4, 2.1)	116	1.6	20	0.6	2.7	(1.7, 4.4)
45–54 years	2685	64.3	1524	86.7	0.7	(0.7, 0.8)	259	6.2	117	6.7	0.9	(0.7, 1.2)	83	2.0	23	1.3	1.5	(0.9, 2.4)
55–64 years	1958	51.9	769	79.9	0.7	(0.6, 0.7)	234	6.2	66	6.9	0.9	(0.7, 1.2)	70	1.9	18	1.9	1.0	(0.6, 1.7)
65–74 years	989	70.8	247	115.2	0.6	(0.5, 0.7)	149	10.7	42	19.6	0.5	(0.4, 0.8)	55	3.9	4			
>74 years	680	154.7	78	155.9	1.0	(0.8, 1.3)	102	23.2	12	24.0	1.0	(0.5, 1.8)	54	12.3	1			
Motorcycle or moped drivers																		
14–17 years	3421	1,863.0	767	1,200.2	1.6	(1.4, 1.7)	664	361.6	91	142.4	2.5	(2.0, 3.2)	37	20.1	4			
18–24 years	8996	2,558.1	3044	2,316.7	1.1	(1.1, 1.2)	950	270.1	174	132.4	2.0	(1.7, 2.4)	89	25.3	5			
25–34 years	11,376	1,879.0	4025	1,984.7	0.9	(0.9, 1.0)	1277	210.9	202	99.6	2.1	(1.8, 2.5)	189	31.2	10	4.9	6.3	(3.4, 11.9)
35–44 years	6873	1,130.2	1777	1,510.0	0.7	(0.7, 0.8)	869	142.9	85	72.2	2.0	(1.6, 2.5)	109	17.9	5			
45–54 years	3402	1,382.1	611	1,838.5	0.8	(0.7, 0.8)	470	190.9	44	132.4	1.4	(1.1, 2.0)	70	28.4	0			
55–64 years	1216	1,384.1	140	1,179.0	1.2	(1.0, 1.4)	167	190.1	14	117.9	1.6	(0.9, 2.8)	30	34.1	0			
65–74 years	302	1,158.1	13	2,511.7	0.5	(0.3, 0.8)	70	268.4	9				10	38.3	0			
>74 years	111	1,645.0	5				37	548.3	1				6		0			
Pedestrians																		
4–11 years	883	58.9	493	31.8	1.9	(1.7, 2.1)	142	9.5	74	4.8	2.0	(1.5, 2.6)	4		4			
12–13 years	190	44.3	141	32.3	1.4	(1.1, 1.7)	34	7.9	24	5.5	1.4	(0.9, 2.4)	0		1			
14–17 years	278	21.3	283	24.6	0.9	(0.7, 1.0)	44	3.4	30	2.6	1.3	(0.8, 2.1)	4		0			
18–24 years	500	40.2	576	45.9	0.9	(0.8, 1.0)	96	7.7	72	5.7	1.3	(1.0, 1.8)	12	1.0	3			
25–34 years	864	48.5	881	31.4	1.5	(1.4, 1.7)	127	7.1	77	2.7	2.6	(2.0, 3.4)	27	1.5	11	0.4	3.9	(1.9, 7.8)
35–44 years	756	32.4	787	21.5	1.5	(1.4, 1.7)	122	5.2	95	2.6	2.0	(1.5, 2.6)	36	1.5	9			
45–54 years	597	31.4	820	31.9	1.0	(0.9, 1.1)	127	6.7	126	4.9	1.4	(1.1, 1.7)	25	1.3	7			
55–64 years	636	17.0	904	25.7	0.7	(0.6, 0.7)	129	3.4	148	4.2	0.8	(0.6, 1.0)	25	0.7	13	0.4	1.8	(0.9, 3.5)
65–74 years	641	16.9	863	29.2	0.6	(0.5, 0.6)	140	3.7	194	6.6	0.6	(0.5, 0.7)	35	0.9	16	0.5	1.7	(0.9, 3.1)
>74 years	801	32.0	1118	44.0	0.7	(0.7, 0.8)	259	10.3	353	13.9	0.7	(0.6, 0.9)	67	2.7	49	1.9	1.4	(0.9, 2.0)

RR: Relative risk from the Poisson regression model.
95%CI: 95% confidence interval.

motorcycle or moped drivers. However, the risk of severe or fatal injury is significantly higher among men than among women in any mode of transport, the differences increasing as severity increases (Table 2). These differences in risk between men and women vary depending on age. Only rates for car and motorcycle or moped drivers and for pedestrians are presented, since these are the groups with sufficient numbers of injured to permit calculation of age-specific rates (Table 3).

Among pedestrians, men present significantly higher risk of slight injury than women in groups aged from 4 to 13 years and from 25 to 44 years. In contrast, from age 54 onwards the results are inverted and women present higher risk than men. In relation to severe injuries, men present higher risk than women in the youngest group, and in those aged 18 to 54 years. From age 65 onwards the women present higher risk. Finally, regarding fatal injuries, men present higher risk than women in the group aged 25 to 34 years (Table 3).

Among car drivers, the risk of slight injury is higher in men than in women for those aged 18 to 34 years. Above that age the situation is reversed, the risk being higher in women, while the differences disappear in people aged over 74 years. Regarding the risk of severe injury, a higher risk is observed in men than in women in groups aged up to 35–44 years, after which differences disappear, except in those aged 65–74 where women present higher risk than men. For fatal injuries, higher risk is observed in men than in women for the group aged 18 to 44 years (Table 3 and Fig. 1).

Among motorcycle and moped drivers, the risk of slight injury is higher in men than in women for the two youngest age groups (14 to 24 years), then the situation reverses and the risk is higher in women for the groups aged 25 to 54 years, and 65 to 74 years. In the case of severe injuries, risk is higher among men than among women up to the age of 54 years, the differences decreasing as age increases. The risk of fatal injury is higher in men than in women for the group aged 25–34 years (Table 3 and Fig. 1).

For all modes of transport and severity categories, the magnitude of the differences and the number of age groups in which the risk is higher in men than in women both increase as severity increases (Table 3 and Fig. 1).

4. Discussion

4.1. Main findings

This study demonstrates the existence of interaction between sex and age in the risk of road traffic injury, among car drivers, motorcycle or moped drivers and pedestrians. The stratified analysis shows that injury risk is significantly higher among men than women for some age groups, while for others the risk among women is significantly higher, and that these age groups vary depending on mode of transport and injury severity. Among child pedestrians and young drivers, men present higher risk of both slight and severe injury than women, and as age increases the differences become reversed, such that in the oldest age groups women present higher risk than men. For all modes of transport, the number of age groups in which men present higher risk than women and the magnitude of the differences increase as severity increases. The fatal injury rate is higher among men than among women, in all those groups for which it was possible to calculate it.

4.2. Limitations

The quality of information in the National Traffic Authority Register of Accidents and Victims has improved in recent years,

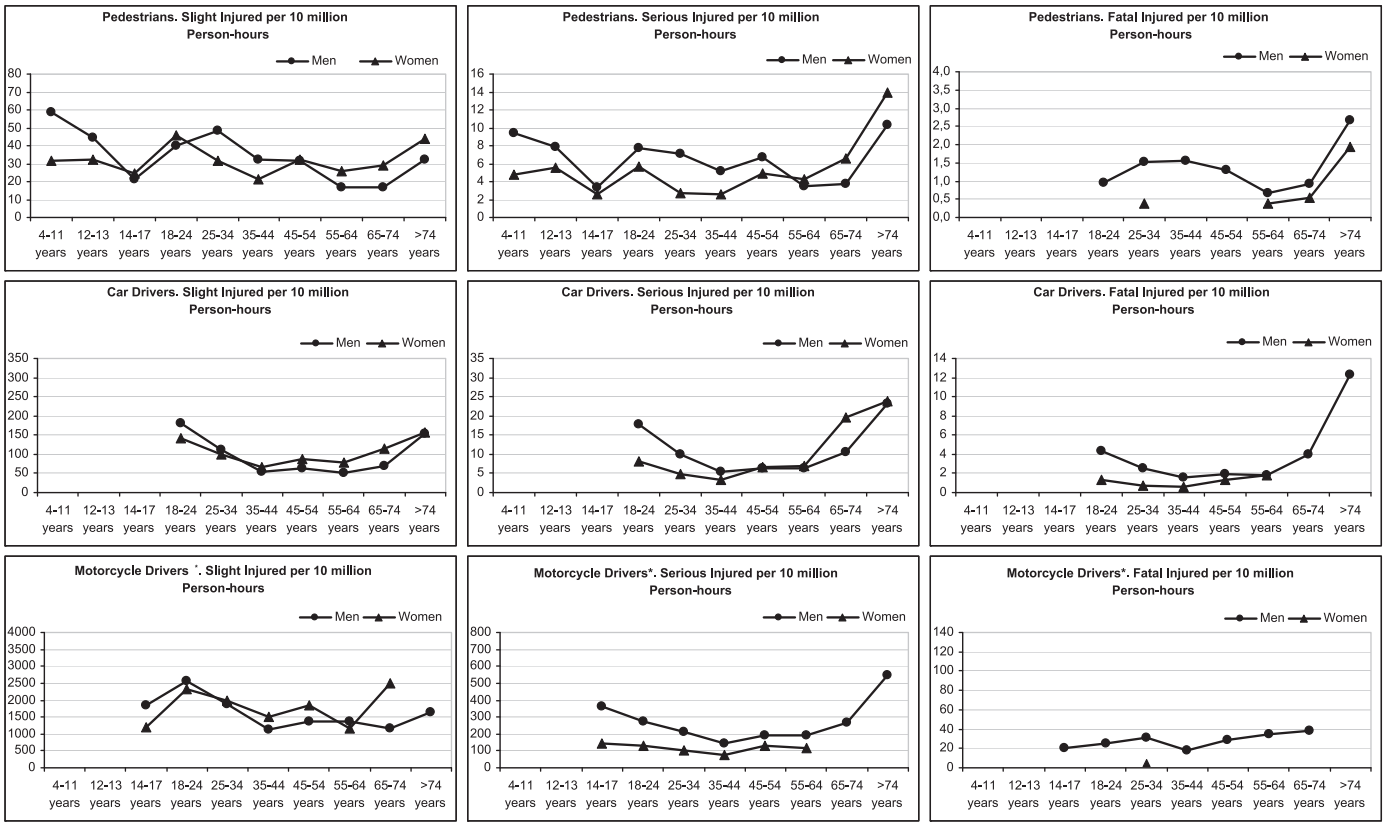

Fig. 1. Annualized road traffic injury rate by injury severity, sex and age, in pedestrians, car drivers and moped or motorcycle drivers. Catalonia, 2004–2008. *Moped drivers included.

however there is still a degree of under-notification of the least severely injured and of people injured in road traffic crashes not involving a motor vehicle (such as cyclists and pedestrians), particularly in urban settings. Therefore, one limitation of the study is the possibility of a reporting bias, which could imply underestimation of the injury risk. On the other hand, overestimation of the injury risk could also occur. The time spent in each trip is self-reported by the interviewee and it could therefore involve a certain degree of memory bias, probably tending to underreport the shortest trips, such as walking trips to make connections between different modes of transport. However, note that mobility reported in the EMQ2006 refers to the day before the interview, unlike other surveys which ask about mobility during the previous week. Also, it must be stressed that the EMQ2006 even collects information about trips on foot of less than 5 min duration.

Despite its completeness, the EMQ2006 does not ask about the time spent in each mode of transport in trips involving several different modes. For such multi-stage trips the total trip time is assigned to the main mode of transport. This probably underestimates the time invested in short trips connecting different modes of transport. This could imply overestimation of the injury risk especially for pedestrians due to the fact that walking trips are the last option in the list of the main modes of transport. However, according to the EMQ2006, these multi-stage trips represented only about 5% of all the trips undertaken in Catalonia in 2006 (6.2% on weekdays and 4.4% at the weekend). Moreover, although the information about minutes spent travelling is referred to only 1 day of the week, these results have been extrapolated to cover the whole year. However, all days of the week are represented and the information is collected in two seasonal periods, March–June, and September–December.

4.3. Strengths

The main strength of this study is that it estimates the road traffic injury rate using people's mobility as the measure of exposure, in terms of time spent travelling, using a representative population survey, the EMQ2006. The EMQ2006 survey provides specific post-stratification weights for working days and weekends, and has the individual as the unit of analysis, not the household as in the majority of mobility surveys. Thus it has been possible to estimate the time people spend travelling, in terms of both individual and trip characteristics, and hence to derive representative population estimates of road traffic injury risk by mode of transport, and specifically by sex and age group.

4.4. Comparison with other studies

The present study found road traffic injury rates per mode of transport which are in agreement with figures reported in the literature, the highest risk of slight, severe and fatal injuries corresponding to men and women motorcycle or moped users (Barret, 2006; Beck et al., 2007; Elvik, 2004; Preusser et al., 1995).

Our results show the existence of interaction between sex and age for the risk of road traffic injury among car and motorcycle or moped drivers and among pedestrians. These findings coincide with another study in Spain (Claret et al., 2003). However, that study only included car drivers involved in collisions, and in which the Odds Ratio of being responsible for the collision was calculated, instead of injury or collision rates. Similar results have been also reported in other countries such as the US (Massie et al., 1995) or Australia (Ryan et al., 1998), although in the latter study using rates based on population census figures rather than on mobility.

In the youngest age groups, men driving cars and motorcycles or mopeds present higher risks of slight and severe injury than women. These results are coherent with reports in the literature about drivers involved in collisions with victims (Al-Balbissi, 2003; Chipman et al., 1993; Massie et al., 1995, 1997) and with specific studies of car and motorcycle or moped drivers involved in collisions (Claret et al., 2003; Kweon and Kockelman, 2003; Lardelli-Claret et al., 2011). Several authors have studied the relationship between this excess of risk in young men and their greater propensity to engage in risky behaviors than women, such as speeding, consumption of alcohol or drugs, etc. (Chen et al., 2000; Clarke et al., 2005, 2006, 2010; Connor et al., 2002; Keall and Frith, 2004; Philip et al., 2001; Santamarina-Rubio et al., 2009; Williams, 2003). This behavior may be related to the ideals of hegemonic masculinity, which encourage the development of a traditional heterosexual masculine identity and the adoption of these kinds of unhealthy behaviors (Borrell and Artazcoz, 2007; Courtenay, 2000).

Adult and elderly women drivers of cars and motorcycles or mopeds present higher rates of slight injury than men. The excess of risk of non-fatal injury among women drivers has been also reported in the literature in studies using distance driven as a measure of exposure (Massie et al., 1995, 1997). One possible explanation put forward is the low average annual mileage by women drivers compared to men. This is sometimes considered as indicative of their having less experience and hence less driving skills and ability to avoid traffic crashes. Other authors support the idea that the use of distance driven as a measure of exposure overestimates the risk for those drivers with low average annual mileage, such as elderly persons, because they tend to cover these distances using mainly streets in urban settings, where speeds are lower but the opportunity for collision is higher. Conversely, high-mileage drivers tend to use higher speed roads like motorways, driving at higher speeds, with lower risk of collision but greater risk of fatal injury (Hakamies-Blomqvist, 1998; Janke, 1991; Keall and Frith, 2006; Langford et al., 2006). In these low annual mileage groups, such as women and older people, time is considered to capture better than distance the differences in risk which may be due to these different patterns of mobility (Chipman et al., 1992, 1993). In urban settings, speed and distance per trip are lower than in motorways but the time spent is greater, due to higher traffic density, existence of intersections, etc. In our study we use time as the exposure measure and observe higher rates of slight injury in women than in men in adult and elderly drivers. Some authors report a higher risk for women of being injured or of suffering more severe injuries than men in a road traffic crash, and that this risk increases with age (Awadzi et al., 2008; Evans, 2001). They discuss aspects such as the greater fragility of women due to physiological differences, in terms of height and weight and the interaction of these factors with vehicle safety design measures (such as positioning and operation of the airbag, seat belt design, among others), as well as differences in resistance of the body to certain forms of impact (Ulfarsson and Mannering, 2004).

An interaction between sex and age in risk of both slight and severe injury is also observed among pedestrians. Among the youngest ages and adults, men present a higher risk of injury than women, however in older age groups women present higher risk than men. These results are consistent with studies in the literature which use measures based on people's mobility (distance, time, number of trips, of intersections or streets crossed, etc.) (Dunbar et al., 2004; Keall, 1995). Several authors suggest, as a possible explanation for the excess of risk among young and adult male pedestrians, that they have a more risky walking behavior, going faster and crossing intersections with lower perception of the risks. (Dunbar et al., 2004; Holland and Hill, 2007; Keall, 1995).

Regarding the excess of risk among older female pedestrians, Holland and Hill (2007, 2010) reported that among older people, the proportion of women who no longer drive or have never driven is higher than among men, and argue that this could mean they have less traffic perception skills, which is directly associated with an increased risk of traffic injury even travelling as pedestrians. They claim that the making of unsafe road decisions increases with age among women (such as crossing unsafely, leaving small safety margins, etc.), but is ameliorated by driving experience.

5. Conclusions

Our results demonstrate the existence of interaction between sex and age in road traffic injury risk. Thus it has been possible to describe how in some age groups men present an excess risk compared to women, while in others women present an excess risk compared to men. Moreover, these relationships vary for each mode of transport and depending on injury severity.

According to these conclusions, it is necessary to calculate specific injury rates by age and by mode of transport in order to estimate road traffic injury risk in men and women, while also taking into account severity of injuries. Moreover, as already highlighted in the discussion of our results, the risk of road traffic injury does not depend on age and sex in themselves, but rather on different factors directly responsible for the variations in injury risk between men and women, which may be: environmental factors such as infrastructures, type of road, day and time of the trip; risk behaviors, such as speed or use of psychoactive substances; experience, etc. Therefore the estimation of injury risk should not only be adjusted for people's mobility, but also for these factors, most of which are related with environmental circumstances under which the trip is made. These factors not only affect the risk of traffic injury, but are also directly related with age and sex (Chipman et al., 1993; Janke, 1991). In this way, it would be possible to study the confounding effect of these factors related with age and sex which may affect the risk of traffic injury, and which ought to be targeted by road safety interventions.

However, this purpose would require a degree of disaggregation of the measures of exposure, which is not possible in most data sources. Thus, we strongly recommend the promotion of systematic and periodic collection of quality information on people's daily mobility, by means of mobility surveys or other technological means. It would be important to guarantee the representativeness of mobility information at the level of the smallest geographical unit possible, including both urban and non-urban settings. Representativeness would also be required of all seasons of the year, of working days and weekends, and of the different road users. This would constitute a potential tool not only for diagnosis and monitoring of road traffic injuries, but also for the comparison between road users and between geographical areas, as well as for the evaluation of road safety interventions at regional and local levels.

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