

Contributing factors of motorcycle crashes in Barcelona, Spain Factores asociados a los accidentes de motocicleta en Barcelona, España

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Abstract: This study analyzed motorcycle and moped crashes in Barcelona (Spain). 53.190 reports of motorcycle and moped drivers involved in crashes in the years 2006–2011 were extracted from the Directorate General of Traffic database of crashes with victims. These data were analysed in terms of gender, age groups, trip purpose, day of the week, speed violation, use of helmet and harm caused to study the characteristics of motorcycle/moped crashes in Barcelona and to assess the differences between male and female motorcycle drivers in these crashes. The severity of motorcycle crashes suffered by male drivers is higher than that of women. Significant differences were found in all the variables considered in the study, which implies gender differences in the profile of the injured motorcycle/moped driver.

Key words: traffic accidents, motorcycles, mopeds, risk factors, road safety

Resumen: Este estudio analizó los accidentes de motocicleta y ciclomotor en Barcelona (España). 53.190 informes de conductores de motocicleta y ciclomotor involucrados en accidentes entre los años 2006 y 2011 fueron extraídos de la base de datos de accidentes con víctimas de la Dirección General de Tráfico. Estos datos fueron analizados en términos de sexo, grupos de edad, motivo del desplazamiento, día de la semana, infracciones de velocidad, uso del casco y lesividad, con el objetivo de estudiar las características de los accidentes de motocicleta y ciclomotor en Barcelona y evaluar las diferencias entre conductores varones y mujeres en estos accidentes. La gravedad de los accidentes sufridos por conductores varones es superior a la de las mujeres. Se encontraron diferencias significativas en todas las variables consideradas en el estudio, lo que implica diferencias en el perfil del conductor de accidentado.

Palabras clave: accidentes de tráfico, motocicletas, ciclomotores, factores de riesgo, seguridad vial

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Introduction

Thanks to the policies developed by the Directorate General of Traffic (Dirección General de Tráfico, DGT), as well as the effort and research of other public and private entities which work in the road safety field, Spain has achieved a reduction of the mortality rate in traffic crashes by a 75% in the last 20 years (OECD, 2013), placing itself, at present, among the countries with a smaller mortality rate in this kind of crashes, with a total of 3.7 dead per 100,000 inhabitants (World Health Organization, 2015).

This reduction in the severity of traffic crashes in Spain during the last years has not happened uniformly across the occupants of the different kinds of vehicles. While, between the years 2000 and 2016, the mortality rate among drivers and passengers of mopeds and cars was reduced 88.61% and 77.11% respectively, among the drivers and passengers of motorcycles it was only reduced 12.50%, making it the smallest reduction in mortality among all motor vehicles during said period in Spain (Dirección General de Tráfico, 2016).

This higher mortality rate among motorcycle users, at a difference with the other kinds of vehicles, is not exclusive to Spain. It follows a common pattern in the rest of the countries of the European Union where 15% of fatalities of traffic crashes are drivers or passengers of motorcycles, with a total of 11 motorcyclists dead per 100,000 motorcycles; whereas the ratio of deceased car occupants is 5 per 100,000 registered cars (European Commission, 2015).

During the last decades there has been a significant increase in the motorcycle and moped fleets in numerous countries around the world (Blackman & Haworth, 2013; Jamson & Chorlton, 2009). These vehicles have gained popularity as they are considered an attractive alternative to cars for being a cheaper means of transport (with regards to their acquisition as well as their maintenance). It allows for faster journeys in cities that are becoming more and more congested and the ability to find parking space when arriving at destination

(Van Elslande & Elvik, 2012). On the contrary, the higher vulnerability of drivers and passengers of motorcycles and mopeds in case of a crash (even at relatively low speed) implies that their occupants have between 9 and 30 times more probabilities of dying in a traffic crash than car drivers on an equal number of kilometres travelled (Van Elslande et al., 2014).

Among the factors identified as the causes of motorcycle and moped crashes (condition of the vehicle, condition of the road, adverse weather,...) it is the human factor which has been identified with higher frequency as the cause of traffic crashes (Evans, 1996; Petridou & Moustaki, 2000).

Some of the variables identified as risk factors in numerous studies carried out in the field of Traffic Psychology and Road Safety in the specific case of motorcycle and moped crashes have been gender, age, alcohol consumption, lack of experience or speed (Allen et al., 2017; Bjørnskau, Nævestad & Akhtar, 2012; Christophersen & Gjerde, 2015; Hidalgo-Fuentes & Sospedra-Baeza 2018; Huang & Lai, 2011; Kim, Brunner & Yamashita, 2008; Lin & Kraus, 2009; Marković, Pešić, Antić & Vujanić, 2016; Sospedra-Baeza, Hidalgo-Fuentes & Cuñado-Pérez, 2017; Wu, Hours & Martin, 2018).

Male drivers see themselves involved in more fatal crashes than women (Martin, Lafont, Chiron, Gadegbeku & Laumon, 2004; Roudsari, Sharzei & Zargar, 2004). Ulfarsson y Mannering (2004) pointed out that the differences both at a behavioural and physical level would be behind the differences in the severity of the injuries in a traffic crash between men and women. Gender is a potent predictor of risky driving, being the men, specially the younger ones, more inclined to show risky behaviours while driving than women (Chang & Yeh, 2007; Oltedal y Rundmo, 2006; Rhodes & Pivik, 2011; Santamariña-Rubio et al., 2009). As for the physical side, Evans y Gerrish (2001) found out that, when facing the same impact, the risk of dying was higher among women than among men.

This article presents the results of a descriptive study of the data on traffic crashes of motorcycle and moped drivers in Barcelona, province which has the largest fleet of both vehicles in Spain (Dirección General de Tráfico, 2017). The results are presented both in relation to the frequency and the severity of the crashes, and also as an analysis of the differences according to the gender of the driver involved in the crash.

Materials and Methods

The aim of the present research is to analyse the factors associated to motorcycle (engine size bigger than 50 cm³) and moped (engine size smaller than 50 cm³) crashes that have taken place in the province of Barcelona between 2006 and 2011, in relation to their frequency and their severity.

The data used comes from the DGT database of crashes with victims (obtained following a formal request to this organization). The information of the entries included in this database is collected directly by the agents in charge of the vigilance and control of traffic at the time of the crash through a statistical questionnaire in which the specific details of the crash, of the vehicles and the people involved are registered.

After filtering and selecting the crashes that had taken place in the province of Barcelona, the database included a total of 53.190 motorcycle and moped drivers involved in traffic crashes during the studied period.

The variables studied were gender, type of vehicle, age, trip purpose, day of the week, speed infractions, helmet use and severity.

Descriptive analysis of the motorcycle crashes were carried out for the whole sample as well as the Pearson's chi-squared test or Fisher's exact test, to analyse the differences based on the gender of the driver. Also, a fatality index frequently used by the DGT was calculated as indicator of the severity of the crash based on the different variables. This index is defined as the number of fatalities per hundred traffic crash victims.

Results

Descriptive analyses

During the analysed period, 53.190 motorcycle and moped drivers were involved in traffic crashes of varying severity in the province of Barcelona (table 1). The drivers involved in crashes were 78.12% men and 21.12% women. The mean age of the males involved in traffic crashes was 34.08 ($DT=11.93$), while the women's mean age was 31.33 ($DT=9.69$). 82.4% of drivers involved in crashes during this period were under 44 years of age, highlighting the 25 to 34 age group which represented 33.25% of the total of drivers involved in traffic crashes. 66.6% of drivers involved in a crash were riding a motorcycle. The journeys within working hours were the most common trip purpose identified at the time of the crash with a total of 8.99%. In most of the crashes (90.52%) the driver of the motorcycle or moped did not commit any speed infractions and was using a helmet when the crash occurred (86.61%). 81.78% of the crashes took place on working days.

Table 1.
Frequency and percentage distributions in motorcycle and moped crashes

	Frequency	%
Gender		
Men	41.552	78.12
Women	11.235	21.12
Unknown	403	0.76
Type of vehicle		
Moped	17.750	33.4
Motorcycle	35.440	66.6
Age groups		
16-24	12.262	23.05
25-34	17.688	33.25
35-44	11.929	22.43
45-54	6.206	11.67
55-64	2.187	4.11
>65	549	1.03
Unknown	2.369	4.45
Trip purpose		
During the work day	4.781	8.99
Going to or returning from work	550	1.03
Leaving for or returning from holidays	24	0.05
Emergencies	34	0.06
Leisure	1.505	2.83
Other	255	0.48
Unknown	46.041	86.56
Weekdays/weekend		
Weekdays	43.498	81.78
Weekend	9.692	18.22
Speed violation		
Inappropriate speed for existing conditions	1.444	2.71
Exceeding the established speed	114	0.21
Slow speed slowing down circulation	1	0.00
None	48.146	90.52
Unknown	3.485	6.55
Use of helmet		
Yes	46.066	86.61
No	379	0.71
Unknown	6.745	12.68
Harm caused		
Death	291	0.55
Seriously injured (hospitalised for more than 24 hours)	2.968	5.58
Slightly injured (hospitalised for less than 24 hours)	44.967	84.54
Unscathed	1.225	2.30
Unknown	3.739	7.03

Comparison analysis

Significant differences have been found based on the gender of the driver in all the analysed variables (table 2). In relation to age, both in men and women, the age group that concentrated a higher number of victims was the 25-34 year old group, although in a higher percentage in the case of women. Meanwhile, in the case of men, there is a much higher percentage of motorcycle drivers than moped drivers who have suffered a crash (71% vs. 29%). In women we find practically the same percentage for both types of vehicles.

The main difference observed as to the trip purpose is that the men suffered practically double the crashes in leisure trips. Also, men are involved in crashes at the weekend in a higher proportion than women.

Another important difference is that the percentage of drivers who have been involved in a crash having committed a speed infraction (both for driving at an inadequate speed or for speeding) is three times higher in the case of men.

The drivers involved in a crash that resulted in deaths or serious injures (hospitalised for more than 24 hours) was also higher in the case of the male drivers.

The use of helmet is high for both genders, although higher among women.

Table 2.
Comparisons of percentage distribution in motorcycle and moped crashes by gender

	Men	Women	P
Age groups			<0.001 ^a
16-24	9.300 (23.3%)	2.941 (27%)	
25-34	13.352 (33.5%)	4.322 (39.7%)	
35-44	9.495 (23.8%)	2.421 (22.2%)	
45-54	5.191 (13%)	1.014 (9.3%)	
55-64	2.012 (5%)	173 (1.6%)	
>65	522 (1.3%)	26 (0.2%)	
Type of vehicle			<0.001 ^b
Moped	12.040 (29%)	5.525 (49.2%)	
Motorcycle	29.482 (71%)	5.710 (50.8%)	
Trip purpose			<0.001 ^a
During the work day	3.744 (64.1%)	878 (77%)	
Going to or returning from work	474 (8.1%)	72 (6.3%)	
Leaving for or returning from holidays	22 (0.4%)	1 (0.1%)	
Emergencies	32 (0.5%)	2 (0.2%)	
Leisure	1.347 (23.1%)	153 (13.4%)	
Other	219 (3.8%)	35 (3.1%)	
Weekdays/weekend			<0.001 ^b
Weekdays	33.529 (80.7%)	9.648 (85.9%)	
Weekend	8.023 (19.3%)	1.587 (14.1%)	
Speed violation			<0.001 ^a
Inappropriate speed for existing conditions	1.324 (3.4%)	110 (1%)	
Exceeding the established speed	110 (0.3%)	4 (<0.1%)	
Slow speed slowing down circulation	1 (<0.1%)	0 (0%)	
None	37.095 (96.3%)	10.695 (98.9%)	
Use of helmet			0.028 ^b
Yes	36.134 (99.1%)	9.847 (99.3%)	
No	312 (0.9%)	65 (0.7%)	
Harm caused			<0.001 ^a
Death	271 (0.7%)	20 (0.2%)	
Seriously injured (hospitalised for more than 24 hours)	2.623 (6.8%)	333 (3.1%)	
Slightly injured (hospitalised for less than 24 hours)	34.523 (90%)	10.337 (95.5%)	
Unscathed	953 (2.5%)	133 (1.2%)	

^aPearson's chi-squared
^bFisher's exact statistic

Analysis of severity

The fatality index of male drivers is 0.72 dead per 100 victims, while the women's is 0.19 dead per 100 victims (table 3). As to the age of the drivers involved in crashes, the group of over 65 years of age (1.01) is the one which represents the highest mortality, while the group of 16 to 24 years of age (0.38) is the one with the lowest fatality index.

In regards to the type of vehicle, motorcycles reach a higher fatality index (0.77) than mopeds (0.26).

As to the trip purpose at the time of the crash, those crashes which took place for leisure reasons are the ones that present a higher fatality index (7.69). In turn, crashes that took place at the weekend (1.12) present a higher mortality than those which took place during workdays (0.49).

With regards to speed infractions, the one that presents a higher fatality index (13.64) is breaking the speed limit. In those crashes where there was no speed infractions the fatality index is lower than 0.01.

Finally, in regards to the use of helmet among drivers involved in crashes, the fatality index is higher among those drivers who were not using this security measure (10.37) versus those who were (0.52).

Table 3.
Fatality index in motorcycle and moped crashes

	Fatality Index
Gender	
Men	0.72
Women	0.19
Type of vehicle	
Motorcycle	0.77
Moped	0.26
Age groups	
16-24	0.38
25-34	0.58
35-44	0.83
45-54	0.67
55-64	0.91
>65	1.01
Trip purpose	
During the work day	0.72
Going to or returning from work	4.21
Leaving for or returning from holidays	4.76
Emergencies	6.67
Leisure	7.69
Other	0
Weekdays/weekend	
Weekdays	0.49
Weekend	1.12
Speed violation	
Inappropriate speed for existing conditions	4.02
Exceeding the established speed	13.64
Slow speed slowing down circulation	0.00
None	<0.01
Use of helmet	
Yes	0.52
No	10.37

Discussion

The aim of this research was to study the characteristics of motorcycle and moped crashes in the province of Barcelona, in relation to their frequency and their severity as well as to assess the differences between men and women drivers of both types of vehicles, victims of these crashes.

The average age of the motorcycle and moped driver involved in a crash during this period is 34.08 years old in the men and 31.33 years old in the case of the women. This data, in theory, does not match the scientific literature analysed which identifies older age drivers and the younger ones as those with a higher risk of finding themselves involved in a traffic crash at a general level (Kim, Ulfarsson, Kim & Shankar, 2013; Newgard, 2008) as well as in the specific case of motorcycle drivers (Mullin, Jackson, Langley & Norton, 2000; Yeh & Chang, 2009). With regards to severity based on the age, it has been found by this research that the fatality index is higher as the age of the driver increases in motorcycle drivers. This correlates with the findings of other research which point out that older age motorcycle drivers are involved with a higher frequency in severe or fatal crashes (Nunn, 2011; Savolainen & Mannering, 2007).

As for sex, most motorcycle and moped drivers involved in crashes during the years object of this research are men (78.12%), which correlates with the higher risk found in male motorcycle drivers by other research (Lin, Chang, Pai & Keyl, 2003; Zambon & Hasselberg, 2006b). However, as it happens with the age variable, it is not possible to analyse the number of victims according to sex in relation to the number of motorcycle and moped drivers. Therefore, even though men have been involved in a higher number of traffic crashes during this period, we cannot conclude that their risk level is higher than that of the women. The higher fatality index found in male drivers could be due to their higher tendency to carry out risky behaviours which could have as a result more severe crashes (Chang & Yeh, 2007; Rhodes & Pivik, 2011).

The higher fatality index given in crashes occurred during leisure journeys as opposed to the ones occurred during working hours or while commuting, could be related to a higher alcohol consumption in the first ones. This is a factor associated to a higher risk of fatal crashes among motorcycle drivers (Lin & Kraus, 2009; Kasantikul, Ouellet, Smith, Sirathranont & Panichabhongse, 2005; Zambon & Hasselberg, 2006a). Another explanatory hypothesis could be that these journeys take place at night, when it has been proven that there is a higher risk of crashes of powered two-wheeled vehicles (De Lapparent, 2006; Haque, Chin y Huang, 2009). A similar explanation can be given to the higher fatality index presented by crashes that took place during the weekend, as some studies have found a higher incidence of driving under the influence of alcohol or other drugs during the weekend (Christophersen & Gjerde, 2015).

The higher fatality reached by motorcycle drivers as opposed to moped drivers is to be expected as the higher power of the motorcycles has been proven to be a risk factor in several studies (De Lapparent, 2006; Savolainen & Mannering, 2007).

Speed is one of the most important risks in relation to road safety in general (Ellison & Greaves, 2015) and specifically in motorcycle crashes (Savolainen & Mannering, 2007; Lardelli-Claret et al., 2005). The results found in this study agree with the scientific literature in that the mortality rate when driving with excess speed or an inadequate speed for the driving conditions is higher than in the crashes that took place without speed infractions.

The higher fatality index found among drivers that were not using a helmet at the time of the crash correlates with the findings of numerous other studies that point out the reduction of risk of head and face injuries as well as death in case of a crash when using a helmet (Ha et al., 2018; Moskal, Martin & Laumon, 2008; Rice et al., 2016).

The main strength of this study stems from the completeness of the data analysed since the database used covers the whole of the crashes registered by the agents in charge of

the vigilance and control of traffic during the analysed period in the province of Barcelona. On the other hand, said database has, in some of its variables, an important number of unknown or missing data (specially in the variable trip purpose) as in many occasions the agents in charge of registering the crash do not have the necessary data. Moreover, some authors have pointed out that the data obtained from police sources could be biased as the crashes without fatalities tend to be under represented in comparison to crashes with fatalities (Amoros, Martin & Laumon, 2006; Yamamoto, Hashiji & Shankar, 2008).

Conclusions

Motorcycle and moped drivers are among the most vulnerable road users in case of a crash. In recent years there has been an important increase in the motorcycle and moped fleets in Barcelona, it being the Spanish province with the highest number of registered vehicles of both kinds. The lesser reduction in fatalities of motorcycle users compared to the reduction in fatalities observed in other means of transport, make it necessary to make an investigative effort on the circumstances that contribute to this type of crashes as well as their extreme severity.

This study has analysed all crashes with injuries in the province of Barcelona in which motorcycle and moped drivers were involved and that were registered by the DGT during a period of six years. It has identified factors associated to this type of vehicle depending on both their frequency and their severity. Significant differences have been found in all variables studied based on the gender of the driver, which implies a different profile of the driver involved in a crash, pointing to the need to design specific prevention measures to each vehicle based on the particular characteristics associated to their accident rate.

Authors' participation:

a) Conception and design of the work; b) Data acquisition; c) Analysis and interpretation of data; d) Writing of the manuscript; e) Critical review of the manuscript.

S.H.F. has contributed in a,b, c,d, e; M.J.S.B. in a,b,c,d,e

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