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Driver dependent factors and the risk of causing a collision for two wheeled motor vehicles

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Appendices 1 and 2 can be viewed on our website.

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Objective: To assess the effect of driver dependent factors on the risk of causing a collision for two wheeled motor vehicles (TWMVs).

Design: Case control study.

Setting: Spain, from 1993 to 2002.

Subjects: All drivers of TWMVs involved in the 181 551 collisions between two vehicles recorded in the Spanish registry of traffic crashes which did not involve pedestrians, and in which at least one of the vehicles was a TWMV and only one driver had committed a driving infraction. The infractor and non-infractor drivers constituted the case and control groups, respectively.

Main outcome measures: Logistic regression analyses were used to obtain crude and adjusted odds ratio estimates for each of the driver related factors recorded in the registry (age, sex, nationality, psychophysical factors, and speeding infractions, among others).

Results: Inappropriate speed was the variable with the greatest influence on the risk of causing a collision, followed by excessive speed and driving under the influence of alcohol. Younger and older drivers, foreign drivers, and driving without a valid license were also associated with a higher risk of causing a collision. In contrast, helmet use, female sex, and longer time in possession of a driving license were associated with a lower risk.

Conclusions: Although the main driver dependent factors related to the risk of causing a collision for a TWMV were similar to those documented for four wheeled vehicles, several differences in the pattern of associations support the need to study moped and motorcycle crashes separately from crashes involving other types of vehicles.

One of the determinants of road safety problems posed by two wheeled motor vehicles (TWMVs) is their high risk of involvement in a crash per unit of exposure. Several studies have shown that the risk of crashing TWMVs is several times higher than for four wheeled vehicles.^{1–5} This difference is even greater for the risk of severe and fatal crashes.^{4,6} However, few studies have set out specifically to assess the determinants of the risk of crashes for TWMV, although some findings suggest that they are not the same as for other types of vehicle.^{1,3,7} Most previous studies have not considered the probable effect modification of the type of TWMV (moped: TWMV with an engine capacity not exceeding 50 cc; or motorcycle: TWMV with an engine capacity exceeding 50 cc) on the association between driver dependent factors and the risk of a crash. Moreover, the confounding effects of environmental factors have not usually been considered carefully. In Spain, no studies have appeared concerning the risk factors for TWMV crashes, although the fleet of TWMVs is one of the largest among EU countries, and the rate of TWMV crashes and related disabilities per 1000 inhabitants are also among the highest in the EU.^{8,9}

The purpose of the present study was to assess the effect of the main TWMV driver dependent factors on the risk of causing a collision with victims in Spain from 1993 to 2002.

METHODS

The present study is based on a quasi-induced exposure method¹⁰ which compares responsible and non-responsible drivers involved in collisions, assuming that the latter are a representative sample of all drivers on the road. To enhance

the usefulness of this assumption, the comparison is restricted to so-called clean collisions (CC)—collisions between two vehicles in which only one of the drivers is considered responsible for the crash. In accordance with this approach, we included in the study all collisions between two vehicles recorded in the Spanish database of traffic crashes with victims (maintained by the Spanish Dirección General de Tráfico) from 1993 to 2002 which met the following inclusion criteria: at least one of the vehicles involved was a TWMV; only one of the drivers had committed a driving infraction; and no pedestrians were involved. The characteristics of the Spanish registry of traffic crashes have been described in previous papers.¹¹ We used the commission of an infraction by the driver as a surrogate indicator of responsibility, and classified all drivers as infractors or non-infractors depending on whether they committed any of the infractions listed in Appendix 1 (see <http://www.injuryprevention.com/supplemental>). Speed related infractions were not included in this variable because they are coded in the registry as a separate variable. Therefore, we proposed two definitions of infractor driver, one which excluded and one which included in the group of infractors those drivers who committed only a speed related infraction. In addition, we decided to analyze two groups of collisions depending on the kind of TWMV involved (moped or motorcycle), as we anticipated important differences between them. Therefore, four non-independent groups of CC were analyzed separately: CC involving mopeds in which speed related infractions were excluded as part of the dependent variable (124 134 collisions and 128 273

Abbreviations: CC, clean collisions; cOR, crude odds ratio; aOR, adjusted odds ratio; TWMV, two wheeled motor vehicles

Table 1 Distribution of moped and motorcycle drivers according to each category of the driver related variables analyzed (excluding speed related infractions in the dependent variable)

Variables	Mopeds (n = 128 273)		Motorcycles (n = 62 005)	
	n	%	n	%
Age (years)				
Mopeds				
<15	1784	1.39		
15	4173	3.25	619	1.00
16	11508	8.97		
17	16031	12.50		
18	13885	10.82	5191	8.37
19	10719	8.36		
20	8994	7.01	5377	8.67
21	6989	5.45		
22	5509	4.29	6384	10.30
23	4489	3.50		
24	3766	2.94	6591	10.63
25–29	11801	9.20	6056	9.77
28–29			5360	8.64
30–34	6191	4.83	9689	15.63
35–44	6409	5.00	5712	9.21
40–44			3535	5.70
45–54	3665	2.86	3140	5.06
55–64	3198	2.49	1082	1.75
65–74	2561	2.00	407	0.66
>74	928	0.72		
Unknown	5673	4.42	2862	4.62
Sex				
Male	101923	79.46	55449	89.43
Female	23411	18.25	5327	8.59
Unknown	2939	2.29	1229	1.98
Psychophysical circumstances				
None	110493	86.14	54160	87.35
DUI (no test performed)	602	0.47	194	0.31
DUI (with a positive test)	684	0.53	267	0.43
Others	858	0.67	290	0.47
Unknown	15636	12.19	7094	11.44
Nationality				
Spanish	122778	95.72	59396	95.79
Foreign	2958	2.31	1569	2.53
Unknown	2537	1.98	1040	1.68
Helmet use				
Helmeted	84232	65.67	51744	83.45
Unhelmeted	17015	13.26	2673	4.31
Unknown	27026	21.07	7588	12.24
Physical disabilities				
None	111503	86.93	54861	88.48
Some	1533	1.20	898	1.45
Unknown	15237	11.88	6246	10.07
Hours driving				
<1	91121	71.04	39811	64.21
1–3	900	0.70	1940	3.13
>3–5	64	0.05	305	0.49
>5	170	0.13	165	0.27
Unknown	36018	28.08	19784	31.91
Administrative infractions				
None	76604	59.72	36179	58.35
No valid license	7379	5.75	3466	5.59
Excess passengers or load	3313	2.58	31	0.05
Others	1248	0.97	1195	1.93
Unknown	39729	30.97	21134	34.08
Speed related infractions				
None	72832	56.78	32954	53.15
Inappropriate speed for road or traffic conditions	7532	5.87	3823	6.17
Excessive speed	1032	0.80	1429	2.30
Slow speed	67	0.05	21	0.03
Unknown	46810	36.49	23778	38.35
Years in possession of a driving license				
<1	13612	10.61	3569	5.76
1	24190	18.86	6437	10.38
2	16944	13.21	5077	8.19
3	10789	8.41	4193	6.76
4	6797	5.30	3845	6.20
5–9	13159	10.26	13872	22.37
>9	15026	11.71	14668	23.66
Unknown	27756	21.64	10344	16.68

Table 1 Continued

Variables	Mopeds (n = 128 273)		Motorcycles (n = 62 005)	
	n	%	n	%
Commission of other infractions (excluding speed related)				
No	67144	52.34	38148	61.52
Yes	61129	47.66	23857	38.48

drivers); CC involving motorcycles in which speed related infractions were excluded (60 472 collisions and 62 005 drivers); CC involving mopeds in which speed related infractions were included (122 633 collisions and 126 706 drivers); and CC involving motorcycles in which speed related infractions were included (59 645 collisions and 61 149 drivers). Appendix 2 classifies the drivers in each of these four groups according to whether they committed speed related or other infractions (see <http://www.injury-prevention.com/supplemental>). The sum of CC involving mopeds and motorcycles exceeds the number of collisions initially included in the study because CC between a moped and a motorcycle were considered twice: once in the subgroup of moped collisions, and again in the subgroup of motorcycle collisions. The occurrence of CC between two mopeds or two motorcycles explains why, in each one of the four subgroups, the number of drivers was always higher than the number of collisions.

Study variables

Table 1 displays the categories of each of the driver related variables, along with the distribution of drivers in each category. As potential confounders, the following crash and vehicle related variables were also recorded: hour, day of the week, month, and year in which the crash occurred; type of day (weekday, eve of a holiday, holiday, day after a holiday), zone (open road, through-street, urban area), condition of the road surface (normal, altered), light conditions (daylight, twilight, night with good lighting, night with poor lighting, night with no lighting), weather conditions (good weather, other conditions), visibility conditions (good, restricted), other danger (no, yes), traffic density (light, heavy, traffic jam), presence of a pillion passenger (yes, no, unknown), previous defects in the vehicle (no, yes, unknown).

Analysis

Our analysis was based on the comparison of driver related characteristics between infractor and non-infractor drivers, as in a case control study. In the first step, crude odds ratios (cOR) for each category of driver related variables were obtained. Then multivariate analyses were done with unconditional logistic regression models. In these models the dependent variable was the condition of infractor, and as independent terms in the models we tested all driver, vehicle, and crash related variables. These analyses allowed us to estimate the odds ratios for each category of all driver related variables, adjusted by the confounding effect of the remaining factors included in the model (aOR). When speed related infractions were excluded from the dependent variable, they were considered as another driver dependent risk factor. When speed related infractions were included as part of the dependent variable, a stratified analysis was done separately for two groups of cases: drivers who committed only speed related infractions, and drivers who committed only other types of infractions. All analyses were performed with the Stata statistical package (version 8.0, 2003, Stata Statistical Software, College Station, TX, USA)

Table 2 Odds ratios for the effect of driver related characteristics on the risk of a moped of causing a clean collision

Variables†	Analysis excluding speed related infractions in the dependent variable (n = 128 273 drivers)				Analysis including speed related infractions in the dependent variable (n = 126 706 drivers)	
	Crude analysis		Adjusted analysis*		Adjusted analysis*	
	cOR	95% CI	aOR	95% CI	aOR	95% CI
Age (years)						
<15	2.11	1.89 to 2.35	1.50	1.33 to 1.68	1.62	1.44 to 1.82
15	1.43	1.32 to 1.55	1.12	1.03 to 1.22	1.29	1.19 to 1.41
16	1.29	1.21 to 1.37	1.12	1.04 to 1.20	1.24	1.15 to 1.32
17	1.16	1.09 to 1.23	1.06	0.99 to 1.13	1.17	1.09 to 1.25
18	1.03	0.97 to 1.10	0.98	0.92 to 1.05	1.07	1.00 to 1.14
19	1.06	0.99 to 1.13	1.05	0.97 to 1.12	1.12	1.04 to 1.20
20	1.01	0.94 to 1.07	1.02	0.95 to 1.10	1.07	1.00 to 1.15
21	0.93	0.86 to 0.99	0.96	0.89 to 1.04	1.01	0.94 to 1.08
22	0.96	0.90 to 1.04	1.03	0.95 to 1.11	1.06	0.98 to 1.15
23	0.91	0.84 to 0.98	0.96	0.89 to 1.05	0.99	0.91 to 1.07
24	0.89	0.82 to 0.96	0.96	0.88 to 1.05	0.97	0.89 to 1.06
25–29	0.98	0.92 to 1.04	1.05	0.98 to 1.12	1.06	0.99 to 1.13
30–34	1.00	Referent	1.00	Referent	1.00	Referent
35–44	1.01	0.94 to 1.08	0.99	0.92 to 1.07	0.97	0.90 to 1.05
45–54	1.10	1.01 to 1.19	1.05	0.97 to 1.15	1.00	0.92 to 1.09
55–64	1.34	1.23 to 1.46	1.24	1.13 to 1.35	1.13	1.03 to 1.24
65–74	2.14	1.95 to 2.35	1.90	1.72 to 2.10	1.67	1.51 to 1.84
>74	2.82	2.43 to 3.27	2.43	2.08 to 2.83	2.21	1.89 to 2.58
Unknown	1.23	1.14 to 1.32	1.12	1.01 to 1.23	1.23	1.12 to 1.36
Sex‡						
Female	0.72	0.70 to 0.74	0.85	0.82 to 0.87	0.78	0.76 to 0.80
Unknown	0.95	0.89 to 1.03	0.92	0.80 to 1.07	0.88	0.77 to 1.02
Psychophysical circumstances§						
DUI (no test)	7.32	5.81 to 9.23	5.30	4.17 to 6.75	6.28	4.94 to 8.00
DUI (+ test)	9.37	7.38 to 11.89	8.71	6.82 to 11.11	8.92	6.98 to 11.39
Others	1.87	1.63 to 2.15	1.57	1.35 to 1.82	1.75	1.52 to 2.03
Unknown	1.42	1.38 to 1.47	1.22	1.17 to 1.27	1.27	1.21 to 1.32
Nationality¶						
Foreign	1.41	1.31 to 1.51	1.14	1.06 to 1.24	1.13	1.05 to 1.22
Unknown	0.97	0.90 to 1.05	0.89	0.78 to 1.02	0.92	0.80 to 1.04
Helmet use**						
Helmeted	0.51	0.50 to 0.53	0.66	0.64 to 0.69	0.61	0.59 to 0.64
Unknown	0.45	0.44 to 0.47	0.60	0.58 to 0.63	0.56	0.53 to 0.58
Physical disabilities††						
Some	1.30	1.17 to 1.44	0.99	0.89 to 1.11	1.05	0.94 to 1.17
Unknown	1.20	1.16 to 1.24	0.91	0.87 to 0.96	0.96	0.92 to 1.01
Hours driving‡‡						
1–3	1.06	0.93 to 1.21	0.98	0.85 to 1.13	1.02	0.89 to 1.17
>3–5	1.09	0.67 to 1.78	0.96	0.56 to 1.63	1.08	0.66 to 1.79
>5	1.07	0.79 to 1.44	0.94	0.68 to 1.30	1.02	0.75 to 1.40
Unknown	0.97	0.95 to 1.00	1.00	0.97 to 1.03	1.02	1.00 to 1.05
Administrative infractions§§						
No valid license	2.51	2.38 to 2.64	1.70	1.60 to 1.81	1.80	1.69 to 1.91
Excess passengers/load	1.14	1.07 to 1.23	0.89	0.82 to 0.96	0.89	0.83 to 0.97
Others	1.12	1.00 to 1.26	0.89	0.79 to 1.00	0.98	0.88 to 1.11
Unknown	1.18	1.15 to 1.21	0.98	0.96 to 1.01	1.12	1.09 to 1.15
Speed infractions¶¶						
Inappropriate	10.03	9.34 to 10.76	10.46	9.73 to 11.25		
Excessive	6.55	5.57 to 7.70	6.35	5.39 to 7.48		
Slow speed	5.75	3.14 to 10.53	4.20	2.26 to 7.81		
Unknown	1.34	1.31 to 1.37	1.49	1.45 to 1.53		
Years in possession of valid driving license#						
1	0.83	0.80 to 0.87	0.82	0.78 to 0.86	0.84	0.80 to 0.87
2	0.73	0.70 to 0.76	0.74	0.70 to 0.77	0.76	0.72 to 0.79
3	0.70	0.67 to 0.74	0.73	0.69 to 0.77	0.75	0.71 to 0.79
4	0.69	0.65 to 0.73	0.74	0.69 to 0.79	0.75	0.71 to 0.80
5–9	0.68	0.65 to 0.72	0.73	0.69 to 0.77	0.75	0.71 to 0.79
>9	0.87	0.83 to 0.91	0.76	0.72 to 0.81	0.77	0.73 to 0.82
Unknown	1.23	1.18 to 1.29	0.97	0.93 to 1.02	0.99	0.95 to 1.04

*In the adjusted analysis, in addition to the variables included in the table, the following variables were also included (see categories in the Methods section): time of day, day of the week, month, and year in which the crash occurred; type of day, zone, condition of the road surface, light conditions, weather conditions, visibility conditions, other danger, traffic density, presence of a pillion passenger, previous defects in the vehicle.

†Reference categories: ‡, male sex; §, normal; ¶, Spanish; **, non-helmeted; ††, none; ‡‡, less than 1 hour driving; §§, none; ¶¶, none; #, 0 years.

Table 3 Odds ratios for the effect of driver related characteristics on the risk of a motorcycle of causing a clean collision

Variables†	Analysis excluding speed related infractions in the dependent variable (n = 62 005 drivers)				Analysis including speed related infractions in the dependent variable (n = 61 149)	
	Crude analysis		Adjusted analysis*		Adjusted analysis*	
	cOR	95% CI	aOR	95% CI	aOR	95% CI
Age (years)						
<17	1.98	1.68 to 2.33	1.33	1.11 to 1.60	1.55	1.30 to 1.85
17–19	1.41	1.32 to 1.51	1.14	1.05 to 1.23	1.25	1.16 to 1.36
20–21	1.34	1.25 to 1.44	1.11	1.02 to 1.20	1.24	1.15 to 1.34
22–23	1.18	1.11 to 1.26	1.05	0.97 to 1.13	1.12	1.05 to 1.21
24–25	1.12	1.05 to 1.19	1.03	0.95 to 1.10	1.10	1.02 to 1.18
26–27	1.11	1.04 to 1.19	1.05	0.97 to 1.13	1.11	1.03 to 1.19
28–29	1.07	1.00 to 1.15	1.05	0.98 to 1.13	1.08	1.01 to 1.16
30–34	1.00	Referent	1.00	Referent	1.00	Referent
35–39	0.97	0.91 to 1.03	1.01	0.94 to 1.08	1.00	0.93 to 1.08
40–44	0.92	0.85 to 1.00	0.99	0.91 to 1.08	0.95	0.88 to 1.04
45–54	0.95	0.87 to 1.03	1.03	0.94 to 1.12	0.96	0.88 to 1.05
55–64	0.98	0.86 to 1.12	1.13	0.99 to 1.30	1.01	0.88 to 1.16
>64	1.59	1.30 to 1.94	1.95	1.59 to 2.39	1.56	1.28 to 1.92
Unknown	1.13	1.04 to 1.23	1.06	0.94 to 1.20	1.18	1.06 to 1.33
Sex‡						
Female	0.86	0.81 to 0.91	1.03	0.97 to 1.10	0.92	0.87 to 0.98
Unknown	0.91	0.81 to 1.02	0.86	0.70 to 1.04	0.78	0.64 to 0.94
Psychophysical circumstances§						
DUI (no test)	6.06	4.31 to 8.54	4.05	2.81 to 5.83	5.14	3.60 to 7.35
DUI (+ test)	12.31	8.50 to 17.81	11.56	7.90 to 16.91	13.48	9.12 to 19.93
Others	1.95	1.55 to 2.46	1.51	1.17 to 1.94	1.79	1.40 to 2.29
Unknown	1.28	1.22 to 1.35	1.09	1.02 to 1.17	1.31	1.22 to 1.40
Nationality¶						
Foreign	1.94	1.76 to 2.15	1.59	1.43 to 1.78	1.64	1.47 to 1.82
Unknown	1.01	0.89 to 1.14	1.12	0.93 to 1.35	1.26	1.05 to 1.51
Helmet use**						
Helmeted	0.59	0.55 to 0.64	0.82	0.75 to 0.90	0.70	0.64 to 0.76
Unknown	0.49	0.45 to 0.54	0.73	0.66 to 0.81	0.62	0.56 to 0.68
Physical disabilities††						
Some	1.14	1.00 to 1.30	0.90	0.77 to 1.04	0.97	0.84 to 1.11
Unknown	1.03	0.97 to 1.08	0.81	0.75 to 0.88	0.83	0.77 to 0.90
Hours driving‡‡						
1–3	1.28	1.17 to 1.40	1.04	0.93 to 1.15	1.08	0.98 to 1.19
>3–5	0.82	0.65 to 1.04	0.80	0.62 to 1.03	0.74	0.58 to 0.94
>5	1.22	0.90 to 1.67	1.31	0.94 to 1.81	1.13	0.82 to 1.55
Unknown	0.87	0.84 to 0.90	0.93	0.89 to 0.97	0.92	0.89 to 0.96
Administrative infractions§§						
No valid license	2.54	2.37 to 2.73	1.70	1.55 to 1.86	2.04	1.87 to 2.23
Excess passengers/load	1.03	0.50 to 2.16	0.80	0.35 to 1.83	0.88	0.40 to 1.95
Others	1.28	1.14 to 1.44	1.01	0.89 to 1.15	1.21	1.07 to 1.37
Unknown	1.34	1.30 to 1.39	1.10	1.06 to 1.15	1.32	1.27 to 1.37
Speed infractions¶¶						
Inappropriate	13.98	12.74 to 15.35	13.11	11.90 to 14.45		
Excessive	7.61	6.72 to 8.62	7.04	6.20 to 8.00		
Slow speed	1.44	0.60 to 3.48	1.19	0.48 to 2.98		
Unknown	1.59	1.53 to 1.64	1.60	1.53 to 1.67		
Years in possession of a driving license#						
1	0.85	0.79 to 0.93	0.87	0.79 to 0.95	0.84	0.77 to 0.92
2	0.85	0.78 to 0.93	0.86	0.78 to 0.94	0.85	0.78 to 0.94
3	0.81	0.74 to 0.88	0.84	0.76 to 0.93	0.83	0.76 to 0.92
4	0.80	0.73 to 0.88	0.85	0.76 to 0.94	0.83	0.75 to 0.92
5–9	0.75	0.70 to 0.81	0.81	0.74 to 0.88	0.80	0.74 to 0.87
>9	0.70	0.65 to 0.75	0.79	0.72 to 0.86	0.79	0.72 to 0.86
Unknown	1.16	1.07 to 1.25	0.96	0.88 to 1.06	0.95	0.87 to 1.04

*In the adjusted analysis, apart from the variables included in the table, the following variables were also included (see categories in the Methods section): time of day, day of the week, month, and year in which the crash occurred; type of day, zone, condition of the road surface, light conditions, weather conditions, visibility conditions, other danger, traffic density, presence of a pillion passenger, previous defects in the vehicle.

†Reference categories: ‡, male sex; §, normal; ¶, Spanish; **, non-helmeted; ††, none; ‡‡, less than 1 hour driving; §§, none; ¶¶, none; #, 0 years.

RESULTS

Table 2 shows the results of the analysis for moped drivers. When speed related infractions were excluded from the dependent variable, inappropriate speed for the traffic or road conditions was the factor most strongly related with the risk

of collision (aOR = 10.46). Driving above the speed limit (aOR = 6.35) and slow speed (aOR = 4.20) also showed a strong association. The adjusted risk estimates for each age group showed a J shaped pattern: the highest aOR were obtained for age groups at the ends of the range (aOR = 1.50

for drivers younger than 15 years, and 2.43 for drivers more than 74 years old). Helmet use and female sex were associated with a lower risk of collision. A protective effect was also clear for the number of years in possession of a driving license, with the aOR yielding almost the same values for the five categories from 2 years to >9 years in the adjusted analysis. A large increase in the risk of collision was observed for driving under the influence of alcohol, especially when a positive test result was recorded (aOR = 8.71). Both driving without a valid license, and to a lesser extent, being a foreign driver, were associated with slight increases in the risk of collision in both the crude and adjusted analyses. Excess of passengers or load was also associated with a slight increase in risk in the crude analysis, but this association was reversed in the adjusted analysis.

The results obtained when speed related infractions were included in the dependent variable were almost the same as those obtained when these infractions were excluded. The only remarkable differences were for the effect of age and sex. Risk was slightly higher in association with younger age. The opposite effect was observed for the oldest drivers: their risks were lower than when speed related infractions were excluded from the dependent variable. The protective effect of sex on the risk of causing a collision was slightly higher (aOR = 0.78) than when speed related infractions were excluded (aOR = 0.85). When the analysis was stratified according to the type of infraction (data not shown) some changes were appreciable between the two strata: the increase in risk for the youngest drivers and the protective effect of female sex were stronger when only speed-related infractions were considered in the case group. However, the small sample size of this subgroup of cases (197 drivers) greatly broadened the confidence intervals for all the aOR estimates.

Table 3 shows the estimates for motorcycle drivers. When speed related was excluded from the dependent variable, inappropriate speed was again the factor most strongly related with the risk of collision (aOR = 13.11), followed by the effect of alcohol when a positive test result was recorded (aOR = 11.56). Driving above the speed limit and driving under the influence of alcohol with no documented test result were also strongly associated with the risk of collision. Helmet use and the number of years in possession of a driving license were associated with a lower risk of collision in both the crude and adjusted analyses. For this latter variable, a weak dose-response relation was observed, with aOR ranging from 0.87 for the first year after obtaining a license to 0.79 for the group of most experienced drivers. Regarding the influence of age, the cOR estimates yielded a U shaped pattern with the highest values for drivers less than 17 years old (cOR = 1.98) and more than 64 years old (cOR = 1.59). However, the corresponding adjusted values tended to be lower for young drivers (aOR = 1.33 for the youngest age group) and higher for older drivers (1.95 for the oldest age group). Female sex was associated with a slight decrease in risk in the crude analysis, but this association disappeared in the aOR. Driving without a valid license and being a foreign driver were associated with a significantly higher risk in both the crude and adjusted analyses.

The pattern of associations described above remained practically unchanged when speed related infractions were included as part of the dependent variable. However, some differences in the magnitude of the aOR were observed. The trends for age were similar to those described above for moped drivers, with greater increases in risk associated with younger ages. Smaller increases in risk were associated with older ages. Female sex showed a weak protective effect (aOR = 0.92). The aOR for both psychophysical circumstances and administrative infractions were more than 10%

larger than their corresponding values when speed related infractions were excluded from the dependent variable. The opposite was observed for helmet use, whose protective effect in the present analysis (aOR = 0.70) was greater than when speed related infractions were excluded (aOR = 0.82). Some changes were observed when speed related and other infractors were considered separately (data not shown): for the former group of cases, comprising only 196 drivers, the increase in risk seemed to be higher for younger drivers and to disappear for older drivers, and the protective effect of female sex also increased.

DISCUSSION

The results of our study show that the risk of a TWMV driver being responsible for a collision is strongly influenced by several individual factors, as found previously for car collisions.^{11 12} When speed related infractions were considered as a driver dependent risk factor, our results clearly showed that inappropriate speed for the road or traffic conditions was the best predictor of the risk of causing a collision for both mopeds and motorcycles. To a lesser extent, there was also a substantial relation between excess speed and the risk of causing a collision. The difference in the estimates for the two main categories of speed related infractions is logical, as excess speed refers to driving above the legal speed limit—something moped drivers and, to a lesser extent, motorcycle drivers rarely do. As expected, these associations were stronger for motorcycles than for mopeds and probably reflected the greater engine size in the former. In support of this reasoning, some authors have reported an increase in risk associated with greater engine size.^{4 13} When speed related infractions were considered as part of the dependent variable, the pattern of associations for the remaining variables did not change substantially. This is not surprising, as most of the speed related infractions did not occur alone but in conjunction with another driving infraction.

Driving under the influence of alcohol, especially with a positive test result, was the second factor most strongly related with the risk of causing a collision for moped and motorcycle drivers. This finding is consistent with the strong association found in previous studies.^{13 14} For motorcycle drivers the aOR for the effect of alcohol was higher when speed related infractions were included as part of the dependent variable, indirectly reflecting an association between these two risk factors (alcohol use and speeding).

Regarding the remaining driver related factors, age and sex deserve some discussion. The higher risk found for the youngest TWMV drivers has been reported in several earlier studies.^{2 3 13 15 16} However, in our study this increase in risk was smaller than the increase observed for older drivers. This produced a J shaped pattern of association between risk and age. The increase in risk for older TWMV drivers has not been reported before, probably because most previous studies assessed the increase in risk of young drivers in comparison with a broad reference category (generally those 25 years old or more).^{13 15} Indeed, part of the pattern we found for age in the adjusted analysis was related with the control of the confounding effect of other variables associated with both young age and the risk of causing of collision (that is, speed related infractions or psychophysical circumstances). This was especially true for motorcycle drivers: their cOR estimates showed the U shaped pattern classically described for age related risk of involvement in a crash.¹⁷ When speed related infractions were included in the dependent variable, the risk for young drivers increased and the risk for older drivers decreased for both moped and motorcycle drivers. This shows that part of the excess risk detected for younger drivers was explained by the well known

association between younger age and speeding.^{13–18} Moreover, we note that the dependent variable for our study was the risk of causing a collision, a type of crash typically associated with older ages.^{10–19} The excess risk for young drivers would probably be higher if single vehicle crashes (a type of crash strongly associated with speeding)²⁰ had been included.

Regarding sex, we found a protective effect for female drivers of mopeds in comparison to male drivers, as noted in previous studies.^{2–3} This effect was slightly stronger when speed related infractions were included in the dependent variable. Again, part (but not all) of the increased risk for male drivers can be explained by the association between male sex and speeding.¹⁸ Consistent with this association was our finding that the protective effect of female sex among motorcycle drivers was seen only when speed related infractions were included in the dependent variable.

We have tried to measure the effect of risky driving behaviors through the use of surrogate variables such as helmet use and the commission of administrative infractions. Our results show a higher risk of causing a crash for non-helmeted drivers and for driving without a valid license, in agreement with the results of previous studies.^{13–14–16–21} Driver experience, indirectly measured here as the number of years in possession of a driving license, had a protective effect on the risk of causing a collision. The effect of experience in previous studies was uncertain: this factor was influential in several studies,^{13–16–22} but others found no association.^{15–21} The higher risk for foreign drivers is in agreement with results of earlier studies of car drivers.^{23–25}

Several methodological concerns need to be considered to interpret our results appropriately. The most important limitations are related with the use of a quasi-induced exposure method, which is only an approximation of the true risk estimate (based on a direct measure of exposure). This approach is useful when information is lacking about the intensity of exposure for different kinds of TWMV. As stated in the methods section, what we compare here are the characteristics of infractor and non-infractor drivers involved in CC. Our analysis is consistent with three important assumptions:^{11–26}

1. *The infractions assigned by the police officer to each driver involved in a crash were correct:* No studies in Spain have attempted to verify this assumption. Our hypothesis is that it is generally easier to record a given infraction reliably than it is to assign culpability for an accident to a given driver. Even if we assume that the wrong infraction was recorded, the strength of our method is based on the assumption that this is non-differential—that is, that the infraction recorded by the police officer does not depend on driver characteristics. Any resulting bias would therefore be toward the null.

2. *In the collisions studied here, the drivers who committed the infraction were responsible for the collision:* From an epidemiological viewpoint, most traffic accidents have a multicausal origin and can rarely be imputed to a single factor (such as the driver) as the only cause. Our study is therefore based on the assumption that there exists a particular group of collisions in which one of the drivers involved (the one who committed an infraction) is more likely to be responsible than the other driver. Although the relation between committing an infraction and the risk of being involved in traffic crashes has been well established,^{27–29} the assumption that the infractor is responsible for the collision may not be true. However, the approach we used in the present study makes such an association plausible: in a collision in which only one of the drivers committed an infraction and the other involved drivers did not, the former driver is much more likely to have caused the accident.

3. *Non-infractor drivers are a representative sample of all exposed drivers.* Some authors²⁷ have pointed out that non-responsible

drivers might be at a somewhat higher risk of being involved in collisions than the overall population of drivers. If this hypothesis is true, our odds ratio estimates may be biased to some extent towards the null. In any case, even if this assumption were not entirely valid, it is reasonable to think that the effect for a given variable (such as driving under the influence of alcohol) on the risk of causing a collision correlates well with the effect of this variable on the risk of a driver involved in a crash being responsible for the crash, especially in case of CC, in which only one of the drivers is considered responsible for the crash.

Other limitations are related to the Spanish database of traffic crashes, which probably is affected by the same problems described previously for similar databases in other countries.^{30–33} The sample used in the present study is probably not representative of all CC with victims in which TWMVs were involved, because the degree of underreporting of traffic crashes in urban areas (where most of the crashes involving TWMVs take place) is especially high in Spain. Furthermore, because the degree of underreporting usually correlates inversely with severity of the crash,^{30–31} our sample probably overestimated the proportion of severe crashes involving TWMVs. In addition, inadequate validity may be a particular concern for variables that are highly dependent on subjective criteria, such as psychophysical circumstances.

Regarding the analysis, we included a category of missing values for each variable to keep the whole sample in the multivariate analyses. Some of the odds ratios these categories yielded were significantly different from one. However, it is impossible to interpret these associations because we do not know the reasons for the missing values for any given variable. A somewhat similar situation holds for the category of drivers labeled “other” in some variables. Finally, because we have studied only CC, we cannot extrapolate our results to all crashes (single or multiple), or even to all collisions between vehicles. However, it should be noted that single vehicle crashes represent only 17% of all crashes involving mopeds and 28% of all crashes involving motorcycles. On the other hand, CC represent 78% of all collisions involving TWMVs in the Spanish registry of traffic crashes.

Key points

- Crashes involving two wheeled motor vehicles (TWMVs) are a health problem in all countries, because of their growing frequency and the severity of the resulting injuries.
- Some evidence suggests that the risk of crashing for these vehicles is higher than for cars, and that the determinants of these crashes are not the same as for other types of vehicle.
- Information about the effect of driver related factors on the risk of causing a collision for TWMVs is scarce and somewhat contradictory, because very few studies have assessed this issue.
- Inappropriate or excessive speed and driving under the influence of alcohol are, by far, the two factors related most strongly with the risk of causing a TWMV collision.
- Male drivers and those drivers in the youngest and oldest age groups are also at increased risk of causing a collision.
- Inexperience of the TWMV driver, measured as the number of years in possession of a driving license, is also a risk factor for causing a collision.

In summary, our results show a strong relation between several TWMV driver related factors and the risk of causing a collision. Some of these factors influence this risk in the same way as for car crashes, but others are specifically related with the risk of crashes involving TWMVs. Furthermore, the effect of some of these factors differs depending on whether mopeds or motorcycles are involved. These findings should be taken into account for further research as well as for implementing road safety programs. Inappropriate or excessive speed and driving under the influence of alcohol are, by far, the two factors related most strongly with the risk of causing a TWMV collision. Efforts aimed at decreasing this risk should thus consider measures targeted at controlling these two factors.

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LACUNAE

Driving in America

This morning on the freeway, I looked over to my left and there was a woman in a brand new Cadillac doing 65 mph with her face up next to her rear view mirror putting on her eyeliner. I looked away for a couple seconds and when I looked back she was halfway over in my lane, still working on that makeup. I don't scare easily, but she scared me so much I dropped my electric shaver, which knocked the donut out of my other hand. In all the confusion of trying to straighten out the car using my knees against the steering wheel, it knocked my cell phone away from my ear which fell into the coffee between my legs, splashed, and burned Big Jim and the Twins, ruined the damn phone, soaked my trousers, and disconnected an important call. Damn driver!

Multiple sources—one of which may or may not be true! Contributed by Peter Jacobsen.