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Individual factors affecting the risk of death for rear-seated passengers in road crashes

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Abstract

We studied the effect of age, gender, use of restraint systems and seat position on the risk of death for rear-seated passengers of cars involved in road crashes. The data source was the Spanish register of traffic crashes with victims compiled by the Government's General Traffic Directorate. Data for crashes recorded from 1993 to 2002, inclusive, were studied. We used a matched cohort design to analyze all 5260 rear-seated passengers in vehicles occupied by two or three rear-seated passengers for accidents in which at least one of these passengers was killed. Conditional Poisson regression with death as the dependent variable was used. An increased risk of death was observed for females and children aged <3 years. For passengers aged 25 years and older, the risk increased with age. The use of restraint systems and central and right-side seats was associated with a lower risk. These results should be considered in research focused on passenger fragility and strategies to prevent injury and death.

Keywords: Traffic crashes; Death; Age; Sex; Restraint systems; Position; Poisson regression

1. Introduction

Many studies have assessed the effect of individual variables, such as age, sex, safety belt use and seating position in the vehicle on the risk of death or severe injury to the driver or passengers of vehicles involved in road crashes (Bédard et al., 2002; Braver et al., 1998; Cummings et al., 2003b; Evans, 2001a,b; Huelke and Compton, 1995; Li et al., 2003; O'Donnell and Connor, 1996; Smith and Cummings, 2004; Yau, 2004; Zhang et al., 2000). To control for the confounding effect of crash severity (for example, the protective effect of the driver's safety belt may be overestimated if unbelted drivers tend to be involved in more severe crashes), some researchers have applied matched-by-vehicle analyses, either with the double pair comparison method proposed by Evans (1986) or with the more efficient regression matched-pair analysis methods (Cummings et al., 2003a). All these methods make it possible to control the main factors associated with crash severity (i.e., type and speed of the vehicle). However, regression matched-pair analyses have usually been applied for driver and front-seated passenger pairs, but not to assess the effect of individual factors upon the risk of death for rear-seated passengers. This is a matter of concern, as seat position (driver, front- or rear-passenger) may modify the effect of some of these individual-level risk factors (Cummings et al., 2003a,b).

The present study assessed, through a matched cohort design, the effect of age, gender, use of restraint systems and seat position on the risk of death for rear-seated passengers in cars involved in road crashes.

2. Methods

2.1. Design, data source and study sample

We used a matched-by-vehicle cohort design with two or three subjects in each matching group. Data were obtained from the register of traffic crashes with victims maintained by the Spanish Dirección General de Tráfico. This register contains information recorded by the police at the scene of the crash (for a more detailed description, see the article of Lardelli-Claret et

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Table 1
Distribution of cars, passengers and deaths according to the number of rear-seated passengers and the number of deaths in each group

Passengers in the rear seat	Deaths in each group of passengers	Number of cars	Number of passengers	Number of deaths
2	1	1212	2424	1212
2	2	326	652	652
3	1	535	1605	535
3	2	127	381	254
3	3	66	198	198
Total		2266	5260	2851

al. (2003)). From this source we selected our study population, consisting of all 5260 rear-seated passengers in cars involved in road crashes with victims in Spain from 1993 to 2002, who met the following inclusion criteria:

- The vehicle was a passenger car, and the rear seat was occupied at the time of the crash by two or three passengers.
- At least one of the rear-seated passengers in each car was killed (groups of rear-seated passengers in which no deaths occurred were noninformative for the conditional Poisson regression analysis we used).
- The severity of the injury (death, severe injury requiring hospitalization, minor injury not requiring hospitalization or uninjured) was known for all the rear-seated passengers in each car.

2.2. Study variables

Table 1 shows the distribution of cars, passengers and deaths according to the number of rear-seated passengers (two or three) and the number of deaths in each group (one, two or three).

Death of the rear-seated passenger within the first 24 h after the crash (yes/no) was the dependent variable. The matching variable was the identifier code for each car. As independent variables we considered age (0–2, 3–5, 6–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, >64 years old, unknown), gender (male, female, unknown), use of restraint systems (none, yes – including both seat belts or child restraint systems – or unknown), and rear-seat position (left, central, right).

2.3. Data analysis

A conditional Poisson regression model was fitted to the matched data sets of rear-seated passengers (Hardin and Hilbe, 2001). This is an extension of the classic Poisson regression analysis for paired data, as used in the present study (groups of two or three passengers seated in the same vehicle, which is the matching unit). Conditional Poisson regression makes it possible to estimate relative risk for matched-pair cohort data, conditioned by the number of deaths in each matched group of passengers in which at least one of them died. The advantages

Table 2
Distribution of passengers and adjusted relative risk of death for each category of the independent variables

Variable	Categories	*N*	%	RR*	95% confidence interval	
Sex	Male	2580	49.1	1	Reference	
	Female	2567	48.8	1.28	1.13	1.46
	Unknown	113	2.1	1.08	0.41	2.85
Age	0–2	185	3.52	1.70	1.18	2.43
	3–5	200	3.80	1.11	0.78	1.59
	6–9	228	4.33	1.18	0.83	1.68
	10–14	317	6.03	1.09	0.81	1.47
	15–19	1158	22.02	1	Reference	
	20–24	936	17.79	0.98	0.81	1.20
	25–34	581	11.05	1.23	0.96	1.58
	35–44	339	6.44	1.73	1.30	2.32
	45–54	310	5.89	2.07	1.52	2.81
	55–64	308	5.86	2.84	2.06	3.91
	>64	496	9.43	5.07	3.68	6.97
	Unknown	202	3.84	1.19	0.62	2.30
Use of restraint system	No	3984	75.74	1	Reference	
	Yes	562	10.68	0.56	0.38	0.82
	Unknown	714	13.57	0.67	0.38	1.16
Seat position	Left-side	2219	42.19	1	Reference	
	Right-side	2190	41.63	0.82	0.76	0.89
	Central	851	16.18	0.75	0.65	0.86

* RR: relative risk of death.

of conditional Poisson regression compared to conditional logistic regression in traffic crash research have been described by Cummings et al. (2003a).

All independent variables described above were included as categorical terms in the model. Adjusted relative risks of death and 95% confidence intervals were obtained for each category, in relation to a reference category defined for each variable. Interaction terms were tested for each pair of independent variables with the likelihood ratio test (for a significant *P* value of 0.05). The Stata Statistical Software package (Version 8.0) (2003) was used for all analyses.

3. Results

Table 2 shows the distribution of passengers according to study variables, and the relative risk of death estimates for each category of the independent variables included in the model. Female sex was associated with a slight increase in the risk of death. Age less than 3 years was associated with an increased risk in comparison to passengers aged 3–24 years old. In passengers aged 25 years or older, the risk increased with age up to 64 years or more (the oldest age group considered in this study). Restraint systems in rear seats were associated with a great reduction in the risk of death. Finally, the risk of death was lower for passengers in the central or right-side seat in comparison to those seated on the left-side. We detected no significant interactions between any of the variables included in the model.

4. Discussion

The present study shows that among rear-seated passengers, female sex and extreme young or old age were associated with a higher risk of death as a result of a crash. An increased risk for the youngest passengers (less than 3 years old in this study) has also been observed in previous studies (Braver et al., 1998; Evans, 2001a; Petridou et al., 1998). Our results are also in agreement with the vast majority of studies which detected an increase in the risk of death related with advanced age (Bédard et al., 2002; Dellinger et al., 2002; Evans, 2001a; O'Donnell and Connor, 1996). The excess risk for women in comparison to male passengers has also been described in previous studies (Bédard et al., 2002; Evans, 2001b; Kweon and Kockelman, 2003; O'Donnell and Connor, 1996; Zhang et al., 2000). It is important to emphasize that in our study these age- and gender-related differences do not depend on differences in the severity of the crash between these groups of passengers, as the matched cohort design completely controlled for this confounder. Therefore, alternative explanations should consider the possibility of less resistance to impact associated with female sex and younger and older ages. Concurrent adverse medical or physical conditions in older passengers may be a factor associated with their greater fragility.

The 44% reduction in the risk of death for restrained rear-seated passengers in our study is identical to that previously reported in a study based on the double pair method that assessed the effectiveness of back seat outboard lap/shoulder belts (Morgan, 1999). Although many previous studies detected a decreased risk of death or severe injury for rear-seated passengers in comparison to front-seated ones (Evans and Frick, 1988; Huelke and Compton, 1995; Smith and Cummings, 2004), particularly in the case of children (Automotive Coalition for Traffic Safety, 2003; Berg et al., 2000; Braver et al., 1998; Durbin et al., 2005; Glass et al., 2000; Petridou et al., 1998; Williams and Zador, 1977), few studies have examined the differences between specific rear-seat positions (Braver et al., 1998; Evans and Frick, 1988; Lund, 2005). Although the present study is not directly comparable with them, our results are in partial agreement with studies that detected a lower risk for the central rear position in comparison to either of the outboard positions (Braver et al., 1998; Evans and Frick, 1988) and also with the higher risk related with the left-rear seating position described by O'Donnell and Connor (1996). The differences in risk between left and right rear seats cannot be attributed to the type of seat belt associated with each seat (lap belt or lap/shoulder belt).

From a methodological point of view, the main limitation of our study lies in the validity of the data source. Although Cummings (2002) found an acceptable degree of validity for the estimates of safety belt efficacy obtained from police data in the USA, this may not be the case for data recorded by the Spanish police, for which no validity studies have been done to date. Therefore, the data on the use of restraint systems may be less reliable than other data recorded for traffic crashes, as the legal and economic consequences of nonuse of a restraint system may compromise the validity of the information recorded by the police after the crash. Furthermore, overreporting of seat belt use may be less frequent in fatal crashes (such as those analyzed here) than in nonfatal crashes (Cummings et al., 2003b).

In conclusion, we found clear differences in the risk of death for rear-seated passengers involved in a crash depending on age, sex, seat position and use of restraint systems. These differences are dependent mainly on factors that affect the fragility of the passenger, and are not related with severity of the crash. Therefore, our results should be taken into account in further research focused on the study of passenger fragility, and in efforts to implement preventive strategies to reduce the risk of death of passengers involved in a road crash.

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