

SPECIFICITIES OF REAR OCCUPANT PROTECTION: ANALYSIS OF FRENCH ACCIDENT DATA

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ABSTRACT

Using French national police crash data and Rhône trauma registry between 1996 and 2006, this study shows that among belted occupants, the number of fatally injured rear passengers is the highest in frontal impact, while the proportion of fatalities is the highest in near side impact, followed by rear impact. This study confirms that improvements in car occupant protection have been focused on front occupants, while less was done for rear passenger protection. This study also suggests that the risk of sustaining a moderate or severe abdomen injury is higher for rear passengers compared to front occupants.

Keywords: Accident analysis, safety belts, injury, abdomen

MAIN CHANGES have improved car passive safety during the last few decades (Hobbs, 2004): Car structure has been particularly optimized in case of frontal impact, and to a lesser extent in case of side impact for the vast majority of cars. Advanced restraint systems combining seat belt load limiters, airbags and pretensioners have been proposed for drivers and for front occupants some time after, whereas little was done during the same period for rear passengers. These passive safety changes have been shown effective in real world accidents by measuring their effect on driver outcome (Martin, 2008), or more generally to all car occupants (Newstead, 2004). Except for children in CRS, less research has been conducted for adolescents and adults seating in the rear. This was due both to the fact that rear seats have a lower occupancy rate and that rear occupants have been generally considered less at risk than front ones (Evans, 1988, Smith, 2004, Smith, 2006). For the same reason, current European regulations and consumer tests do not assess adult rear occupant protection. Recently, US studies (Kuppa, 2005, Kent, 2007, Sahraei, 2009a) have highlighted a relative decrease of the effectiveness of the rear seats in mitigating casualties with car model year. They even reported a reverse trend in the case older occupants sit in the rear. This latest conclusion was somewhat reconsidered by Sahraei (2009b) who had a closer look at driver control group characteristics.

The present study has then been focused on belted car occupants aged 10 years and over, with the objective of studying differences in main characteristics, severity and injury pattern between rear passengers and other car occupants. A secondary objective was to estimate if similar trend for recent cars is observed in France as in the US.

MATERIAL AND METHOD

The first data set comes from the systematic reports of road injury crashes made by the police between 1996 and 2006 for the whole of France. Data include characteristics of crashes, vehicles and occupants, but with no injury description. The second data set comes from the Rhône road trauma registry which covers all road casualties which occurred in the “Département du Rhône” (1.6M inhabitants) who seek medical care. Injuries are coded using the Abbreviated Injury Scale, 1990 revision (AAAM, 1994).

A description of car occupants with regard to their seat position, age, gender and seat belt wearing is first taken from the police data. Analysis is then focused on belted car occupant casualties aged 10 years and over. Only car occupants involved in single or two-car crashes are considered for making interpretation of results easier, when dealing with car occupant severity according to impact area. Fatality rates and relative risks of being fatally injured are estimated according to occupant characteristics, position in car, location of impact and car registration year.

Rhône trauma registry is then used to describe overall injury severity using the maximum AIS (MAIS) (AAAM, 1994). Detailed descriptions are given for casualties suffering from at least one moderate injury (AIS \geq 2) and serious injury (AIS \geq 3). Injury patterns are compared according to seat position.

Comparisons are made using Chi-square test. Adjusted odds ratios (OR) and corresponding 95% confidence intervals are estimated using logistic regression.

RESULTS

SEAT POSITION, AGE AND GENDER DISTRIBUTIONS - In police reports, about 13% of the 962 773 car occupants are rear passengers. This proportion can be considered as a minimum value, as uninjured passengers are probably more often under recorded, while every car has its driver. Rear passengers more often sit on the right side. The numbers of male and female rear passengers are close, while 70% of drivers are men. More than 85% of children younger than 10 years are rear passengers, but 75% of rear passengers are 10 years old and over

SEAT BELT WEARING- From police reports, rear passengers not wearing seatbelt are 19%, compared with 7% for front passengers. These proportions are much higher coming from the Rhône Registry where rear passengers are more than 40%, compared with 11% for front passengers for the same period 1996-2006. Whatever the seat position, the proportion of unbelted casualties is the highest for occupants aged 18 to 29, and regularly decreasing for older ones. Male rear passengers wear seatbelt less often than female ones, but this is also observed for other car occupants.

FATALITY RISK - The highest number of fatally injured rear passengers is observed for frontal impacts (Figure 1), while the proportion of fatalities is the highest in near side impact, followed by rear impact (Figure 2). In other words, even if near side impact is the most dangerous crash configuration for rear passengers as well as for other car occupants, the highest number of fatalities for rear passengers is observed in frontal impact because it is markedly the most common crash condition.

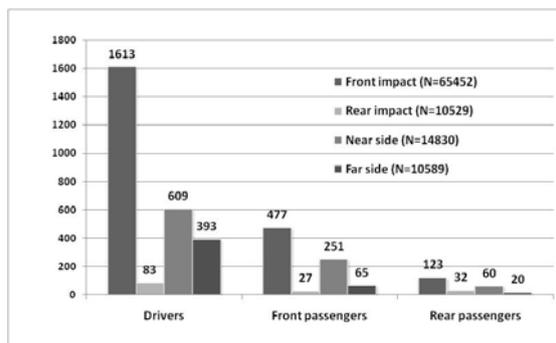


Figure 1: Number of fatalities according to seat position and impact location, Police Data 1996-2006

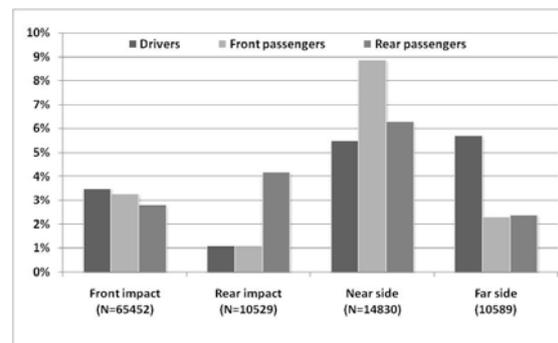


Figure 2: Proportion of fatalities according to impact location and seat position, Police Data 1996-2006

CAR PROTECTION CHANGE – Concerning the possible change in car protection as regards the registration year, used as a proxy for estimating how recent a car design is, rear passengers are significantly less at risk of being fatally injured than drivers or front passengers with cars designed before 1991, and even before 1997, while this difference is no longer found significant for cars designed in 1997 and over. This phenomenon is observed in frontal impact (Figure 3) and also in side impact. In rear impact, rear passengers are twice as likely to be fatally injured as drivers or front passengers, but this is no more dependent on the car registration year. These results take account of the different characteristics of front and rear occupants in terms of sex and age (10 years aged and over), as well as crash location and crash year, and have been obtained from injury accidents, considering only belted and injured occupants. They then suggest that, as expected, improvements in car occupant protection have been more focused on drivers and, to a lesser extent, on front passengers, while in the meantime less was done for rear passenger protection.

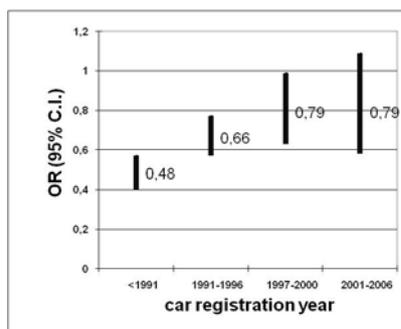


Figure 3: Risk to be fatally injured for rear passengers compared to drivers according to car registration year (N=212 463), OR and 95% C.I., Police Data 1996-2006

INJURY PATTERN – Estimated from Rhône Registry, 17% of the 1655 rear passengers sustain at least one moderate injury (MAIS 2+), and 4.5% one serious injury (MAIS 3+). These figures are very close to the ones concerning other car occupants. Concerning car occupants sustaining at least one serious injury (N=1219), 30% of the 74 rear passengers have chest injuries, which is the most frequently injured body region, but less often than for drivers and front passengers (around 44%). 16% suffer significantly more often from abdomen injuries than drivers (7%). Head, lower and upper extremity injuries are observed in similar proportion, around 21% (Figure 4).

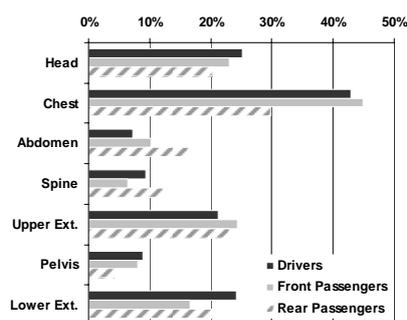


Figure 4: Car occupants with AIS 3+ injury (N=1219)

Table 1: Relative risk of AIS3+ per body region for rear passengers vs drivers and front passengers - OR and 95% CI

	Rear passenger vs Drivers		Rear passenger vs Front passengers	
	OR	(95% CI)	OR	(95% CI)
Head, face and neck	0.89	(0.70-1.14)	1.20	(0.91-1.57)
Chest	0.86	(0.65-1.15)	0.54	(0.39-0.73)
Abdomen	1.90	(1.20-3.01)	1.53	(0.92-2.53)
Spine	1.30	(0.90-1.89)	1.10	(0.73-1.64)
Upper extremity	1.19	(0.91-1.56)	1.00	(0.75-1.34)
Pelvis	0.56	(0.27-1.15)	0.53	(0.25-1.11)
Lower extremity	0.85	(0.61-1.17)	1.19	(0.83-1.71)

Table 1 suggests that rear passengers suffer more often from moderate or serious abdomen injuries, and less often from moderate chest injuries than front occupants, while no difference is shown for the other body regions. This finding is confirmed even once adjusted for age and sex by logistic regression.

DISCUSSION

Concerning seat belt wearing, estimates coming from French surveys are available: the share of car occupants running by day and not wearing a seat belt were estimated at 23% in 2005 and 18% in 2006 for rear passengers, and from 11% in 1999 to 3% in 2006 for front passengers (ONISR, 2008). An underreporting to police of not wearing a seat belt is possible due to fearing some potential insurance or legal issues. Anyway, probably because enforcement has changed during the years of observation, the seat belt rate has been regularly increasing to reach a high level for front passengers, but is still to improve for rear passengers.

The analysis on relative risk of rear occupants over the car model years was conducted comparing all rear passengers to all front occupants. An additional analysis was carried out comparing only occupants in a same car but a sufficient sample could only be obtained for frontal impacts. The results were similar to the unmatched analysis which comforts our analysis for the other impact directions where a matched pair analysis could not be performed.

Belted occupants generally sustain less often and less severe abdominal injuries than unbelted ones (Huelke, 1993, Klinich, 2008). In case of belted rear occupants, Kuppa (2005) found the seat belt as the major source of injuries to the thorax and the abdomen. Concerning the higher risk of abdomen injury for rear belted passengers, a possible mechanism explaining such an over risk for abdomen injuries could be a higher risk of submarining due to rear seat structure geometry and/or belt anchorage locations, or could also be partly due to some two point belts, or a higher misuse rate than for front passengers. This last result must be interpreted with caution, as numbers observed when considering serious belted rear passengers are quite low in our data. However, it seems to correlate with Lamielle's (2006) conclusions.

CONCLUSIONS

This study suggests that, as expected, improvements in car occupant protection have been focused on drivers and, to a lesser extent, on front passengers, while in the meantime less was done for rear passenger protection.

As the number of fatally injured rear passengers is the highest in frontal impact, rear passenger secondary safety should be especially improved for this accident configuration, in particular efforts should be made in order to decrease rear passenger risk of sustaining abdominal injuries. This might require modifying existing crash test dummies to allow a proper assessment of such risk.

While safety belt effectiveness has largely been demonstrated, much prevention work has still to be done to convince all rear passengers to fasten their seat belts. This is all the more relevant considering that unrestrained rear-seat passengers have been shown to place themselves and their front occupant at greater risk of fatal injury in the event of a crash.

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