FRONT PASSENGER PROTECTION :
WHAT SPECIFIC REQUIREMENTS IN FRONTAL IMPACT ?

C. Thomas, J.Y. Foret-Bruno, G. Brutel, J.Y. Le Coz
Laboratoire d'Accidentologie et de Biomécanique PSA Peugeot-Citroën/RENAULT
Nanterre- France
C. Got, A. Patel
Institut de Recherches Orthopédiques Hôpital Raymond Poincaré
Garches- France

ABSTRACT

Because 30 % of the belted front occupants in frontal impact are passengers, it is important that their specific protection be checked in public experimental tests.
The characteristics of belted front passengers in real-world frontal impact are analyzed, from the statistical viewpoint based on several hundred thousand accidents which occurred in France over a ten-year period, and from the technical viewpoint (car front overlap, delta-V, mean acceleration, intrusion, AIS injury scale) based on the LAB's multi-disciplinary survey.
It is seen that belted front passengers sustain chiefly severe thoracic and abdominal injuries (especially for the most elderly women). These injuries are attributable, above all, to the acceleration forces sustained and not to passenger cell intrusions in frontal impacts with an overlap $\geq 60\%$.
The experimental tests with left front overlap $\leq 40\%$ being carried out at present appear relatively unjustified. In all, they cover only 12 % of M.AIS 3+ belted "drivers and front passengers" considered together, and only 2 % of severely or fatally injured front passengers considered separately.

INTRODUCTION

Can the protection of front passengers be ignored when working out a global frontal impact procedure ?
At present, all attention is focused on driver protection alone, but this should not cause one to overlook the other occupants, and especially the front passengers. This is especially necessary since the risk factors incurred by each of the two belted front occupants in frontal impact are far from being strictly symmetrical.
The factors of differentiating between the situations for drivers and for front passengers are due especially to :
- characteristics specific to each of the two user populations such as sex, age or posture (the driver is in a driving position which imposes specific requirements, while the front passenger is more free to change position) ;
- the car passenger cell, with on the one hand the driver environment (steering wheel, steering column, footwell) and on the other hand the storage areas under the dashboard ;
- finally, the frontal impacts themselves, since intrusions, when they exist, usually occur asymmetrically, and in 85 % of cases on the driver side.

The need to distinguish between drivers and front passengers is emphasized in the conclusion to a paper by Hill, Mackay and Morris (1) on thoracic and abdominal injuries attributable to the seat belt in a sample of front occupants (drivers and front passengers together). The authors consider :
- the difficulty of attributing driver rib fractures to the seat belt or the steering wheel, and
- the extra risk of severe thoracic injuries (AIS 3+) for belted females aged over 70.

Their comments concerning these aspects fully justify their recommendation that drivers and front passengers be considered separately in future studies.
Other authors (2) have clearly shown the higher proportion of thoracic and abdominal injuries sustained by belted front passengers compared with all belted drivers, who more often suffer skull/facial or leg injuries.
A comparison of the overall injury severities of belted "driver and front passenger" occupants on board cars involved in frontal impacts is a very good approach for understanding the differences of risks (3). In the absence of intrusion, the risks of severe or fatal injuries are twice as high for front passengers as for drivers. When intrusion occurs, this greatly aggravates the consequences for the occupant by whom it is sustained.
L. Evans (4) indicates that it is surprising to observe that there is now scarcely 1 % difference between the fatality rates for drivers and front passengers, for all types of impacts together. The author adds that this was not the case earlier, when the front passenger was usually a female and accordingly, due to this simple fact,

the fatality rate for this "front passenger" position (called the "suicide seat") was 25 % higher than for drivers, who were generally of male gender.
The international literature shows clearly that the risks incurred by belted front passengers occupants in frontal impacts differ from those sustained by the drivers, if only in terms of difference of risk per body area. However, the overall injury severities appear to be of a comparable level. There is therefore no reason to limit occupant protection measures to the drivers alone.
It is essential to take into account real-world driving conditions as a guide to effective counter-measures for automotive secondary safety. The analysis of real-world frontal impacts involving front passengers performed here aims at understanding why their present protection is not better than that of the drivers, who are more frequently subjected to the harmful effects of intrusion.
Two complementary approaches must be used for this purpose :
- A quantitative approach, based on a broad statistical data bank, to quantify the relative effects of the various types of car frontal damage or variations in sex and age for drivers and front passengers.
- A qualitative approach, based on detailed medical and technical analysis of frontal impacts involving front passengers. This approach can indicate the severity of injuries as a whole or by body area, while also taking into account the influence of parameters such as front overlap, delta-V, mean acceleration, glance-off and intrusion on the front occupants.

The discussion will cover on the one hand the comparison of results with those obtained by other accident investigation teams and on the other hand the contributions of the various best known experimental tests relating to the passive protection of front passengers.

SAMPLES AND METHOD

Two files of real-world accident data are used below, in succession. It should be specified as of now that :
- both files take into account, without restriction, all car brands and models, whatever their origin, French or foreign, and
- only those cars involved in FRONTAL IMPACT which have on board front occupants who are ALL BELTED are considered in what follows. For the sake of clarity, the front occupants are subdivided into three categories :
  * belted drivers "alone on board" ;
  * belted drivers accompanied by a front passenger who is likewise belted ;
  * belted front passengers.

Sample One Extensive statistical data is processed on the basis of the national file of accidents causing bodily harm reported by the French National Gendarmerie throughout the decade 1983-1992. After sorting (in accordance with the above criteria), the following sample is excerpted:
- 243,155 cars in frontal impact ;
- 347,665 belted front occupants, of which :
  * 138,645 drivers "alone on board" ;
  * 104,510 "driver and front passenger" pairs ;
- 9,656 fatalities and 74,106 severe injuries are counted among all the occupants.

This file provides a relevant documentary basis since it refers to the most severe French accidents.
Sample Two More sophisticated analyses taking into account the measurements performed directly on the accident cars, but also the injury evaluations quantified according to the 1990 version of the AIS injury scale (5) or evaluations of impact violence such as the delta-V or mean acceleration (6,7,8), are performed on the data file from the multi-disciplinary survey of the PSA Peugeot-Citroën/RENAULT Accident Research and Biomechanics Laboratory.
The sample adopted includes :
- 1,438 cars involved in crashes against all types of obstacles ;
- 2,058 belted front occupants, of which :
  * 818 drivers "alone on board" ;
  * 620 "driver and front passenger" pairs ;
- 287 M.AIS 3+ (including fatalities) are counted in total.

This basic sample is used in full to study the influence of front overlap on the breakdown of victims. After that, the influence of intrusion and impact violence is studied in the delta-V range between 36 km/h and 65 km/h. The initial group is thus reduced to 222 lone drivers and 192 pairs of front occupants. In this sub-sample, fatalities which underwent no post-mortem will be excluded to allow analysis of the severity distributions by body area on victims whose injuries are all known.

RESULTS

The statistical data from the National Gendarmerie file is presented first before examining the data from the detailed accident survey.

We shall examine in succession, according to the seat location, questions relating to frontal damage overlap and then the analysis of risks specific to each category of front occupant.

1. STATISTICAL DATA ON THE NATIONAL LEVEL

Out of all belted front occupants in frontal impact, FRONT PASSENGERS represent :

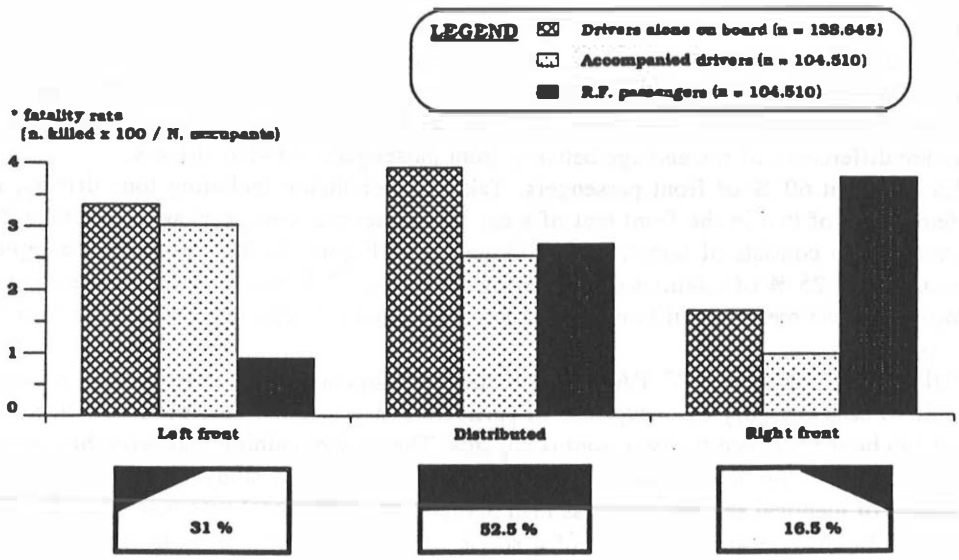
- 30 % of the 347,665 occupants in the sample ;
- 30 % (24,873/83,762) of fatalities and severe injuries ;
- 25 % (2,477/9,656) of fatalities.

Their overall risk exposure is not uniform, varying greatly depending on the typology of the contact between the car front and the obstacle (9).

THE OVERLAPS observed on the 243,155 cars in the sample are divided into three classes (left front, distributed front, right front) in accordance with the national encoding procedure. Impacts distributed over the whole front represent the majority of the cars involved in frontal impacts (52%) as with the fatalities and severe injuries (59% of cases) (Table 1). The fatality rates (fatalities x 100/occupants) vary from 1 to 4 depending on whether the front occupant is located in the deformed area or not (Figure 1).

	Car front damaged areaA(%)			
	left front	distributed front	right front	Total
All front occupants (n = 347,665)	30	53	17	100
Fatalities + sev. injuried (n = 83,762)	27	59	14	100
Fatalities only (n = 9,656)	27	60	13	100

Table 1: **BREAKDOWN (%) OF THE OVERALL INJURY SEVERITY OF BELTED FRONT OCCUPANTS IN FRONTAL IMPACT ACCORDING TO THE AREA DAMAGED** (Source: Gendarmerie file 1983-1992)



Front damage types for 243.155 cars

FIGURE 1

FATALITY RATES* OF THE 347.665 BELTED FRONT OCCUPANTS INVOLVED IN FRONTAL IMPACTS ACCORDING TO DAMAGE TYPES AND OCCUPANT SEAT LOCATION (Source : Gendarmerie 1983 to 1992)

For front passengers, the highest fatality rate (3.74) is observed in "right front" impacts (the least frequent), while the lowest rate (0.92) is observed for left-offset impacts. In impacts of the "distributed over the front" type, where the influence of intrusion is weaker, the fatality rate for front passengers (2.70) is 7 % higher than that for *their* drivers (2.52).

THE COMPARISON OF FATALITY AND SEVERITY RATES for the three groups of front occupants (Figure 2) reveals that the risk of death for the front occupant pairs is more than 40 % lower than for drivers alone on board (2.39 versus 3.37). It seems logical to attribute this difference to the lesser violence of impacts involving drivers having at least one front passenger on board.

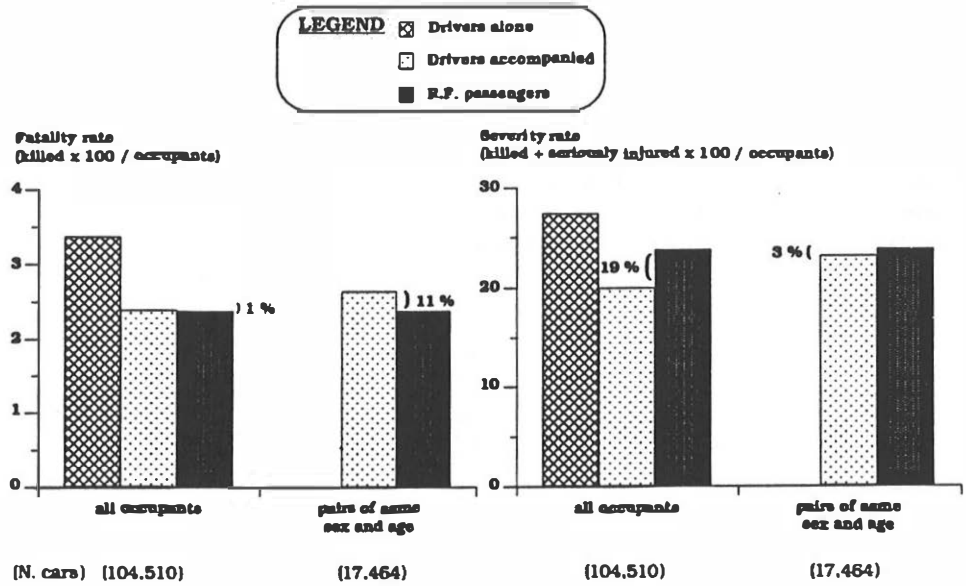


FIGURE 2

FATALITY AND SEVERITY RATES OF BELTED FRONT OCCUPANTS IN FRONTAL IMPACTS

(Source : Gendarmerie 1983 to 1992)

The fatality rates for FRONT PASSENGERS are on the whole identical to those of *their* drivers (non-significant difference of 1 %). On the other hand the same is not true for severity rates (fatalities + severe injuries x 100/occupants) which are 19 % higher for passengers. This major difference cannot here be attributed to differences of delta-V or mean acceleration. The most likely reasons for this higher severity for passengers are differences of sex and age between front passengers and *their* drivers.

FEMALES represent 60 % of front passengers. Taking a population including lone drivers, it can be stated that one female out of two in the front seat of a car is a passenger, compared with less than 20 % for males. The high-risk group consists of females aged 60 and over (Figure 3). This group alone represents 12 % of front passengers but 25 % of fatalities (compared with 4 % and 7 % respectively for the comparable group of males). Moreover, the mean age of female front passengers (40.6 years) is 9 years more than the mean age of male front passengers.

"DRIVER/FRONT PASSENGER" PAIRS form the best population for obtaining an understanding of the risks specific to each category of occupants. In particular, they make it possible to eliminate the influence of the sex and age biases between the two front occupants. The only remaining bias with this method is due to the combined influence of the driver environment and intrusion. For this study, a sub-group of 17,464 pairs of front occupants of identical sex and age (less than 5 years' age difference) was made up, also eliminating cases of overloading due to forward projection of a single unbelted rear occupant. In this perfectly homogeneous sub-group, the fatality rate of the drivers (2.64) is 11 % higher than for their front passengers of identical sex and age (see Figure 2).

It is verified here that intrusion (more frequent on the driver side) has an aggravating influence on the risk of death of drivers compared with their passengers. But the trend is reversed if the injury severity rate criterion is adopted (front passengers 23.8 ; *their* drivers 23.1). This means that when the crash violence is lower, the

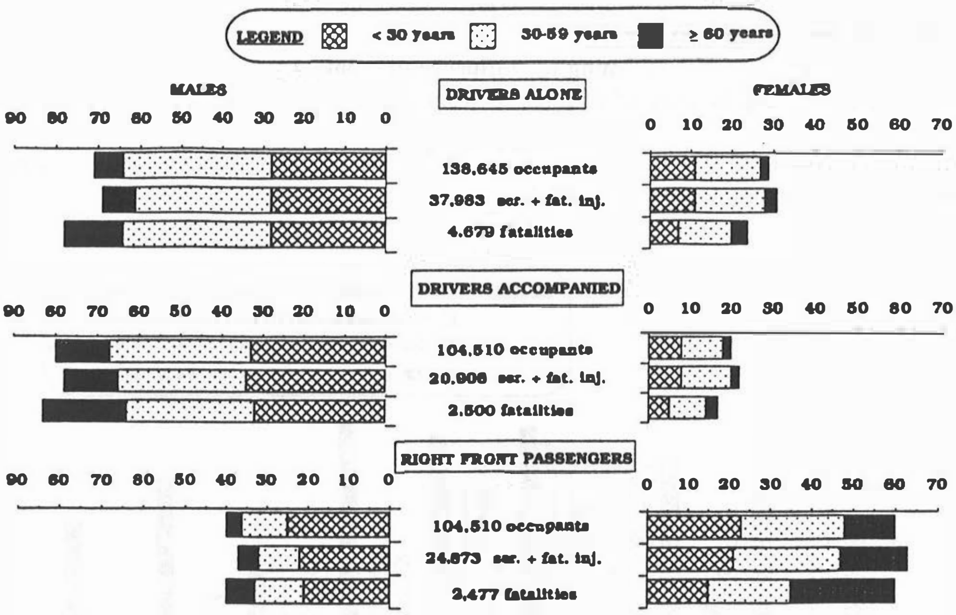


FIGURE 3
BREAKDOWN (%), IN TERMS OF SEX AND AGE, OF THE 347,665 BELTED FRONT OCCUPANTS INVOLVED IN FRONTAL IMPACTS ACCORDING TO THE OCCUPANT SEAT LOCATION AND THE DEGREE OF INJURY (Source : Gendarmerie file 1983 to 1992)

effect of intrusion is less significant. In these circumstances, it appears that the influence of the driver environment alone generates no extra risk for drivers compared with their passengers of identical sex and age.

THE COMPOSITION of the front occupant pairs of identical age partly explains the fatality rates observed. Figure 4 shows that the lowest risks of death are recorded when the two front occupants are two women of identical age, while the highest risks are recorded when two males are in the front seats. In general, when a male is driving, the risk level increases for both the front occupants.

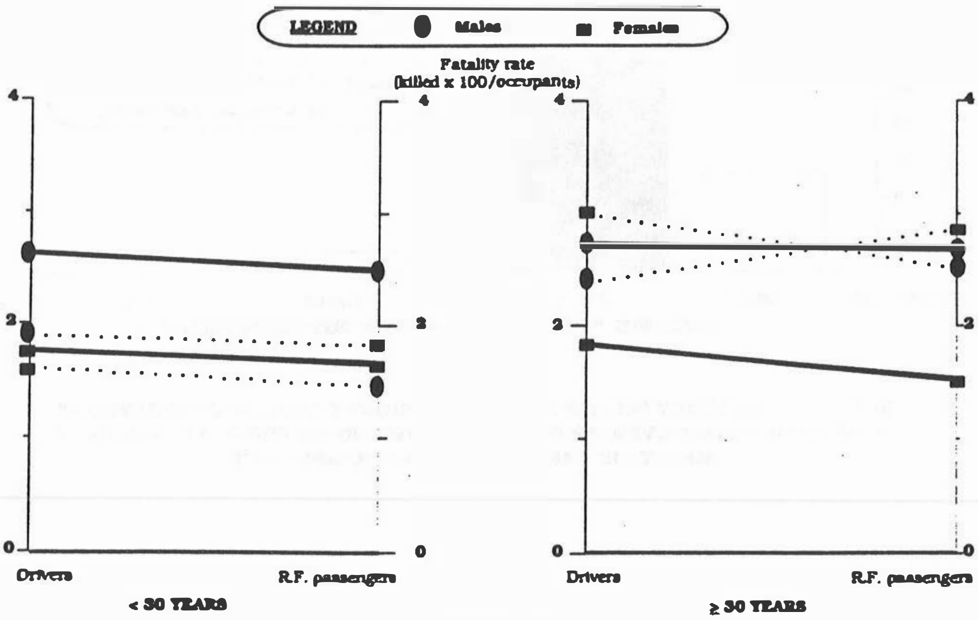


FIGURE 4
FATALITY RATE COMPARISONS FOR FRONTAL IMPACT BELTED FRONT OCCUPANT PAIRS ACCORDING TO SEX AND AGE FOR TWO AGE CLASSES
(Source : Gendarmerie file 1983 to 1992)

The only exception is older women drivers accompanied by males of the same age. Due to better impact tolerance than their drivers, the passengers show a 20 % lower fatality rate (2.4 versus 3).

Let us now examine the results of the detailed analyses.

2. DATA OF THE DETAILED SURVEY

This section provides information concerning the influence of frontal overlap, intrusion and mean acceleration on the frequency and overall severity of injuries to front passengers and the breakdown of their injuries by body area.

OVERLAPS on the front of the cars occupied by the 818 drivers "alone on board", and also for 620 "driver/front passenger" pairs, are shown in Figure 5.

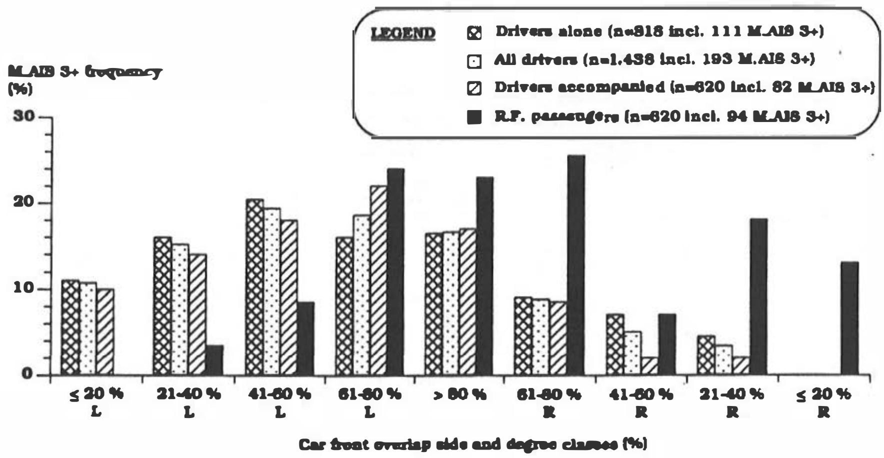


FIGURE 5

M.AIS 3+ FREQUENCY (%) BROKEN DOWN IN TERMS OF SEAT LOCATION, FOR EACH CAR FRONT OVERLAP DEGREE CLASS FOR BELTED FRONT OCCUPANTS INVOLVED IN FRONTAL IMPACTS (Source LAB)

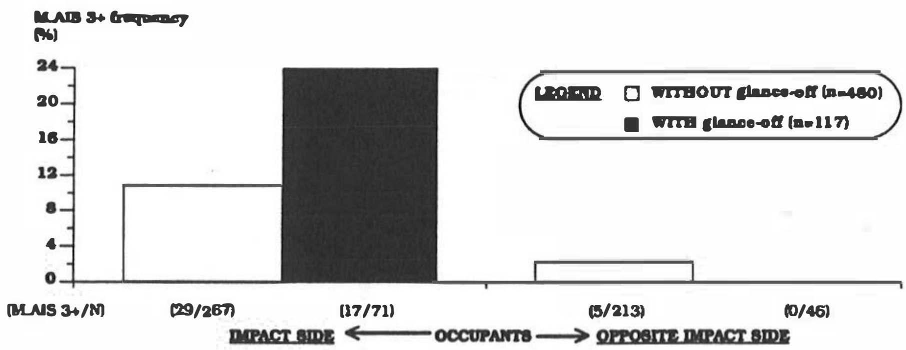


FIGURE 6

M.AIS 3+ FREQUENCY (%) FOR 597 BELTED FRONT OCCUPANTS INVOLVED IN ≤ 40 % CAR FRONT OVERLAP DEGREE ACCORDING TO THE SEAT OCCUPANT IMPACT SIDE AND GLANCE-OFF OCCURRENCE

It can be observed here that the frequency of M.AIS 3+ for front passengers ranges from 0 in the case of impacts affecting the far left area, to 25 % for overlaps exceeding 60 %. In general, large overlaps are associated with higher severity rates, especially when the occupant is located in the area of contact with the obstacle.

Impacts with overlap ≤ 40 % on the left side concern only:

- 19 % (116/620) of front passengers involved in crashes;
- 2 % (2/94) of front passengers injured severely or killed. This clearly indicates the weak representativeness of this type of overlap for their specific protection.

In all, even taking into account drivers "alone on board", all overlaps ≤ 40 %, whether on the driver side *or even* on the passenger side, cover 30 % (622/2,058) of all front occupants, but only 18 % (53/287) of all injuries of M.AIS 3+. One must also allow for the influence of glance-offs, i.e. cases in which the vehicle continues on its trajectory for at least 10 metres beyond the point of impact without pulling along any opposing vehicle.

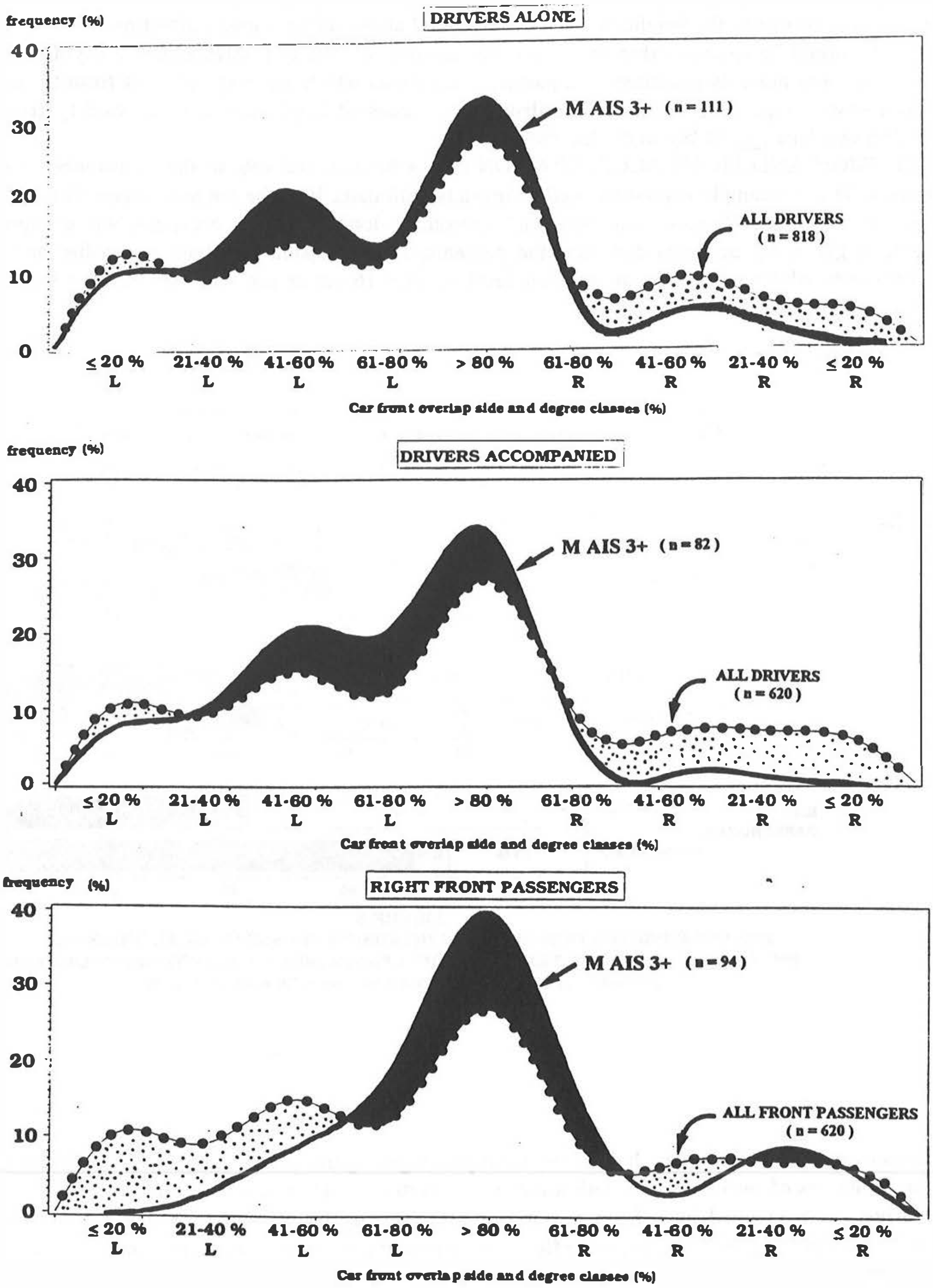


FIGURE 7

BREAKDOWN (%) OF FRONTAL IMPACTS AND OF M.AIS 3+ BELTED FRONT OCCUPANTS AS A FUNCTION OF OVERLAP DEGREE CLASS AND FRONT OCCUPANT GROUP

In these circumstances, a major proportion of the energy is dissipated by sliding during the post-collision phase. Figure 6 shows the breakdown of 597 occupants (not including 25 occupants, among whom two M.AIS 3+, for want of information on glance-off) involved in impacts with overlap $\leq$ 40 %, as a function of the glance-off and the occupant's position relative to the impact. The severity rate for the 338 occupants located on the impacted side reaches a very high level in the event of glance-off alone. Outside of these very specific conditions, severity remains moderate or low. In other words, out of all the 287 M.AIS 3+, impacts with overlap $\leq$ 40 % "WITHOUT glance-off" by the car cover only 12 % (34/287) of cases.
This approach is fully confirmed by the breakdowns of frontal impacts and severe occupant injuries (M.AIS 3+) as a function of overlap classes depending on the position occupied (Figure 7). The shaded areas correspond to a diminished risk while the black parts indicate a heightened risk
For front passengers, the heightened risks correspond above all to impacts affecting 60 % or more of the car front. It should be specified that these high-overlap impacts nearly always generate asymmetric deformations of the car (and possibly passenger compartment intrusion) which are very different from those related to a 0° barrier impact type (10). Even for the drivers, the areas of heightened risk are weakly correlated with the smallest overlaps ($\leq$ 40 %) on the left side.
INTRUSION AND MEAN ACCELERATION play a fundamental role in the occurrence of severe and fatal injuries. The sub-sample is now reduced to impacts with delta-V in the range between 35 and 65 km/h and, as was specified in the "Samples and Methods" section, no longer includes occupants whose injuries are known.
Figure 8 gives, by occupant position, the percentage of occupants involved in crashes and of M.AIS 3+ according to whether intrusion at the door level reaches 16 cm or not, and whether the mean acceleration is lower than 11 g or not.

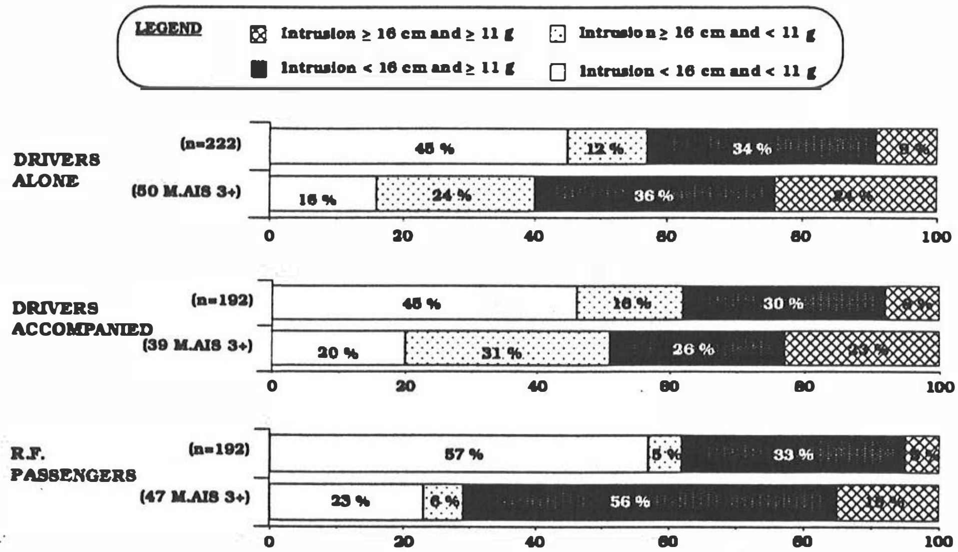


FIGURE 8
RELATIVE PROPORTION OF UPPER INTRUSION VERSUS MEAN ACCELERATION BREAKDOWN (%) OF BELTED FRONT OCCUPANTS AND M.AIS 3+ BY SEAT LOCATION
(Source : LAB sample with ΔV between 35 and 65 km/h)

It is noteworthy that more than half of the front passenger injuries of M.AIS 3+ were observed in the absence of high degrees of intrusion, but with a mean acceleration of 11 g or more. This proportion is lower by half for drivers accompanied by a front passenger. This specific feature indicates that front passengers must be protected chiefly against the harmful effects of strong accelerations, since they are much less concerned by intrusion than the drivers.
THE BREAKDOWN OF 100 INJURIES OF AIS 3+ by body area among the front passengers (Figure 9) shows, in order, the thorax (37 %) and the abdomen (23 %) as the regions most severely affected. For *their* drivers, the percentages applying to these same regions are lower by half.

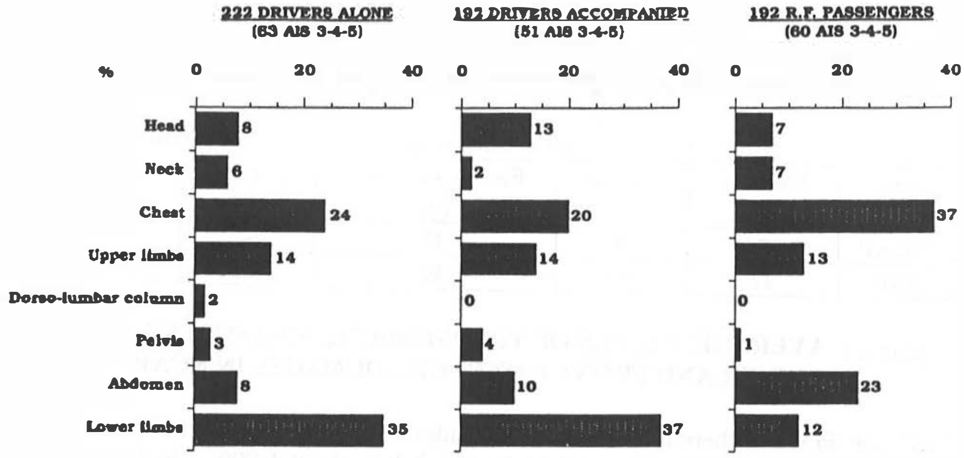


FIGURE 9

BREAKDOWN BY SEAT LOCATION OF 100 AIS 3-4-5 INJURIES BY BODY AREA FOR BELTED FRONT OCCUPANTS INVOLVED IN FRONTAL IMPACTS OF DELTA-V BETWEEN 36 AND 65 KM/H (Source : LAB file)

DISCUSSION

The comparison of the above-mentioned results with papers from other investigation teams do not reveal major differences as long as the data are excerpted in the same ways. P. Thomas (11) indicates that front overlaps above 60 % (both left or right) cover 53 % of M.AIS 1-2, 58 % of the severely injured and 56 % of fatalities among belted front occupants involved in frontal impacts.

The corresponding figures for small overlap under 41 % are lower (respectively 34 %, 28 % and 20 %). The author and others (12, 13) highlight chiefly that the highest severity rate (severely and fatally injured/total occupants) is recorded by occupants who sustained the intrusion in small overlap frontal impacts, which are nevertheless less frequent. All these authors point out that the risks are mainly related to severe leg injuries attributable to intrusion. Is there any explanation of this phenomenon ? In the early eighties, F. Zeidler (14) gave a very clear and determinative explanation of this high risk of leg injuries in offset car-to-car head-on collisions. Because small front overlap impacts are more likely to result in two cars spinning away from each other, it is necessary to separate cases according to the "glance-off" occurence. When there is glance-off, the delta-V of the car is much lower than the EES which better reflects car damage and intrusion. In those circumstances, the author highlights that legs are exposed to a high risk of severe injury due to the speed with which intruding areas impact the legs. As the "glance-off" phenomenon is not taken into account in the previous surveys, it follows that the given conclusions are less pertinent, contrary to the LAB study (15).

This criticism applies equally to A. Hobbs (16) who tried to separate the relative importance of intrusion and that of deceleration. Taking note of the difference of risk between the two front occupants when intrusion is limited to only one side of the passenger compartment, he concludes that the "overwhelming predominance of intrusion strongly suggests that benefits would arise from its reduction, even at the expense of greater deceleration and consequently higher seat belt loads". It is well-known that intrusion on one side of the passenger compartment and car glance-off are factors which decrease the acceleration sustained by the front occupant located on the side opposite to the intrusion (in general a front passenger). In spite of this fact, the importance of thoracic-abdominal injuries to belted front passengers is evident in real-world accidents.

FRONTAL EXPERIMENTAL TESTS give data on the risks incurred by front seat occupants in comparison with their drivers.

The ADAC, whose test is at 40 % overlap (rigid barrier), installs no front passenger dummy.

TRL and the consumer magazine "Which ?" performed three tests at 40 % overlap with a deformable barrier at a speed of 55 km/h, but the results from the dummy measurements have not been made available.

All that remained, therefore, were the NCAP results published by J.R. Hackney (17) and those published by "Auto-Motor und Sport" in its own magazine. Table 2 shows that in the NCAP tests of the "0° barrier - 56 km/h" type, the thorax of the front passenger sustains on average 6 g less than his/her driver.

		3 ms acceleration		Belt loading	
Tests	Number of cars	Drivers (g)	Front passengers (g)	Drivers (N)	Front passengers (N)
NCAP	126	49	43	-	-
AMS	32	53	39	5,830	6,770

Table 2 : **AVERAGE VALUES OF THE THORACIC MEASUREMENTS RECORDED ON DRIVER AND FRONT PASSENGER DUMMIES IN NCAP AND AMS TESTS**

In the "AMS" tests in which there is a 50 % overlap with the rigid barrier, the difference is even greater, at 14 g on average. Moreover, the force measured in the seat belt is about 1,000 N higher for the front passenger dummy compared with the one in the driver position. If we refer to real-world crash data (18) and to ISO experts, it is clear that this last parameter is reliable in the absence of contact or any special restrain (such as air-bag) because it correlates well with the thoracic deflection which is the reference thoracic injury criterion adopted for the future European frontal impact regulation. We might add that improvements in protection can be expected due to the seat-belt pre-tensioning systems and airbags which now equip new vehicles. For the abdomen, proposals concerning the control of its protection on the dummy, in particular by the prevention of submarining (19), are in the discussion stage in the international organizations.

CONCLUSIONS

Analysis of the risk incurred by BELTED FRONT PASSENGERS involved in REAL-WORLD FRONTAL IMPACTS was performed on the basis of two complementary data banks. The analysis was :
- quantitative, through the processing of about 350,000 cases of belted front occupants (of which 85,000 severe injuries and fatalities) involved in frontal impact in France over a ten-year period, and
- qualitative, by a thorough examination of more than 2,000 cases of belted front occupants (of which about 300 M.AIS 3+) taken from the LAB multi-disciplinary survey, in which the most relevant technical parameters are taken into account.

It is found that :
1. ***30%*** of belted front occupants injured severely or killed ***are passengers*** and that their protection cannot be neglected ;
2. the ***risks*** of severe injuries incurred by front passengers are ***at least comparable*** to those incurred by the ***drivers*** ;
3. ***large overlaps*** (≥ 60 %) at the front of the car are the cause of most of the severe or fatal injuries suffered by belted front passengers. The same is true moreover for the drivers ;
4. ***Only 2 %*** of belted front passengers, in frontal impact, sustaining injuries of M.AIS 3+ were involved in an impact ***with overlap ≤ 40 % on the left side*** .An experimental evaluation of frontal real-world accidents must ensure an optimized balance between driver and passenger protection;
5. ***56 % of belted front passengers injured severely or killed*** in frontal impacts of delta-V ranging between 36 and 65 km/h sustained a mean acceleration greater than or equal to 11 g ***in the absence of significant intrusion at their seat location***;
6. ***One quarter of the fatalities*** among front passengers are ***women aged 60 and over***. Their fatality rate is clearly higher since they represent only 12 % of all front passengers;
7. ***The thorax and abdomen*** are the body areas most severely affected for front passengers (37 % and 23 % respectively of all severe and fatal injuries, i.e. double the percentages observed for *their* drivers);
8. The information obtained from the analyses of real-world accidents and the measurements recorded on dummies justify the ***adoption of the thoracic deflection criterion*** for the future European regulatory procedure. Proposals relating to the control of abdominal protection must still be taken into account.

ACKNOWLEDGEMENTS

This work could not have been performed without the cooperation of the National Police and National Gendarmerie departments and their personnel, who provided us with assistance on a daily basis.

REFERENCES

(1) J.R. Hill, G.M. Mackay and A.P. Morris
"Chest and Abdominal Injuries Caused by Seat Belt Loading"
Proceedings of the 36th Annual Conference of A.A.A.M., Portland (Oregon) - October 1992

(2) S.H. Backaitis and D. Dalmotas
"Injury Patterns and Injury Sources of Unbelted and Three Point Belt Belted Car Occupants in Injury Producing Frontal Collisions"
Proceedings of the 29th Annual Conference of A.A.A.M., Washington D.C. - October 1985

(3) C. Thomas, G. Faverjon, C. Tarrière, F. Hartemann, C. Got, A. Patel
"The Main Causes of Risk Differences for Belted Drivers and their Belted Front Passenger in Frontal Collisions"
Proceedings of 9th International Conference on Experimental Safety Vehicles, Kyoto- November 1982

(4) L. Evans
"Traffic Safety and the Driver"
Library of Congress - 1991 - pp. 51

(5) Association for the Advancement of Automotive Medicine
"The Abbreviated Injury Scale - 1990 Revision"

(6) P. Ventre, J. Provensal
"Proposition d'une Méthode d'Analyse et de Classification des Sévérités de Collisions en Accidents Réels"
Proceedings of IRCOBI Conference, Amsterdam - June 1973

(7) C. Tarrière, A. Fayon, F. Hartemann
"The Contribution of Physical Analysis of Accidents Towards Interpretation of Severe Traffic Trauma"
Proceedings of 19th STAPP Car Crash Conference, San Diego - November 1975

(8) Laboratory of Physiology and Biomechanics Associated with Peugeot SA/Renault
"Assessment of Crash Severity"
Published at the Workshop on Assessment of Crash Severity, Göthenburg, September 1984

(9) H.Fontaine, Y.Gourlet
"Sécurité des véhicules et de leurs conducteurs"
INRETS Report No. 175, February 1994

(10) S. Koltchakian, C.Thomas, C.Tarrière
"Inadequacy of 0° Degree Barrier Test With Real World Frontal Accidents"
Proceedings of 12th International Technical Conference on Experimental Safety Vehicles, Göteborg, May 1989

(11) P. Thomas
"Real-World Collisions and Appropriate Barrier Tests"
Proceedings of the 14th ESV Conference, Munich, May 1994

(12) I. Planath, H. Norin, S. Nillsson
"Severe Frontal Collisions with Partial Overlap - Significance, Test Methods and Car Design"
Frontal Impact Protection - Seat Belts and Air-Bags, SAE SP-947, 1993

(13) D. Otte, H. Von Rheinbaben and H. Zwipp
"Biomechanics of Injuries to the Foot and Anke Joint of Car Drivers and Improvements for an Optimal Car Floor Developpment"
Proceedings of 36th Stapp Car Conference, SAE paper 922514

(14) F. Zeidler, G. Sturtz, H. Burg and H. Rau
"Injury Mechanisms in Head-On Collisions involving Glance-Off"
Proceedings of the 25th Stapp Car Conference, SAE paper 811025

(15) J.Y. Foret-Bruno, J.Y. Le Coz, C. Thomas, G. Brutel
"In-Depth Analysis of Frontal Collisions as regards the Influence of Overlaps and Intrusion on Occupant Severe and Fatal Injuries"
Proceedings of the 14th Enhanced Safety Vehicles, Munich, May 1994

(16) C.A. Hobbs
"The Need for Improved Structural Integrity in Frontal Impacts"
Proceedings of 13th International Technical Conference on Experimental Safety Vechicles, Paris, November 1991

(17) J.R. Hackney
"The Effects of FMVSS N°.208 and NCAP on Safety as Determined from Crash Test Results"
Proceedings of 13th Experimental Safety Vehicles Conference, Paris (France) - November 4-7, 1991

(18) J.Y. Foret-Bruno, C. Thomas, F. Hartemann, A. Fayon, C. Tarrière, A. Patel, C. Got
"Correlation Between Thoracic Lesions and Force Values Measured at the Shoulder of 92 Belted Occupants Involved In Real Accidents"
Proceedings of 23rd Stapp Car Crash Conference- Ann Arbor - October, 1978

(19) J. Uriot, M. Page, C. Tarrière, F. Bendjellal, F. Loiseleux, M. Saloum and P. Fournier
"Measurement of Submarining on Hybrid III 50e and 5e Percentile Dummies"
Proceedings of 14th International Technical Conference on Enhanced Safety of Vehicles, Munich - May 1994