INJURIES IN PRIMARY AND SUPPLEMENTARY AIRBAG SYSTEMS

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Abstract

In this study, an attempt was made to compare injury rates to restrained occupants in airbag deployed and non-airbag deployed vehicles in four different countries. Analyses were conducted both on "raw" data-sets and also with assumptions that injuries to the lower limbs are unaffected through interaction with a deploying airbag.

This study reveals problems with comparing data from more than one country and highlights a requirement for a harmonised global approach to accident data collection particularly with a corresponding growth in vehicle export markets.

Introduction

In terms of the history of vehicle safety, the driver airbag, a device designed to control forces and deceleration to the human body during a traffic crash is a relatively new addition to the vehicle, despite being conceptualised in the 1950's.

In North America, prototype airbags first became available in the 1970's but not until the mid-1980's were they mass-produced for fitment in passenger cars. Such airbags were designed to be used as 'primary' restraint systems; that is, they were designed to provide a baseline of protection to those occupants who do not wear seat belts and to add protection to those who do use belts.

Elsewhere, airbags became available somewhat later than in North America. Generally they took the form of supplementary restraint systems (SRS's) which provide optimum protection to the restrained occupant in a frontal crash.

Because of relatively high seat-belt wearing rates in Europe and Australia, airbag systems tend to be designed differently to those in USA (Fildes et al, 1996). The airbag deployment threshold is usually set higher (around 25 km/h, depending on the manufacturer and crash circumstances) so that the airbag deploys only when a crash is of such severity that the seat-belts alone can not afford complete protection. The rate at which the airbag inflates also tends to be lower. This means that different airbag systems are used in these vehicles when compared with the more aggressive systems developed for unrestrained occupants in North America.

In terms of providing optimal crash protection, it has been suggested that the combination of seat belts and airbags provides the most effective restraint system (Williams & Lund, 1988). Although the development and testing of airbags is achieved in laboratory studies under rigorously controlled crash-tests, a true assessment of the injury-reduction capability of such systems can only be determined from studies of real-world crashes in which the airbag has deployed. Such studies have revealed mixed fortunes; studies of larger more aggressive airbag systems in North America, (where the belt usage rate is in the region of 60%) have raised some issues with deployments (Huelke et al, 1994; Huelke and Reed, 1996a & 1996b; Dalmotas et al, 1996) while in other countries where the restraint use is high, the benefits of less aggressive systems are apparent (Langwieder et al, 1996, Fildes et al 1996).

However, in parallel with these individual country-specific analyses of airbag effectiveness, there is an increasing trend towards global trade and importation or exportation of vehicles (Thomas & Otte; 1996). Consequently, manufacturers find it advantageous to minimise the design variation necessary to sell their products internationally. Such manufacturers also aim to reduce injuries sustained in their vehicles and can gain a marketing advantage in being able to demonstrate the safety of their products. Therefore it is necessary to provide the commercial car industry with in-depth feedback on field-studies of airbag performance. Optimally, research should be able to provide governments and industry with comparisons of airbag performance in differing countries. This would provide evaluations of product capability and would aid identification of factors that contribute to overall product effectiveness in each country. However, in practice, the process of providing data that is comparable across research organisations is difficult to achieve because of differences in interpretation of procedural guidelines, sampling considerations, resources and customer-driven specifications. In this study, we provide a case-example in which a comparison of injury outcomes across countries was undertaken.

Method

Data were obtained from recent retrospective studies of vehicle crashes and occupant injuries in the USA (NASS database), Australia (CVF database), Canada (PCS and the ADS databases) and Germany (GDV database). These databases involved a combination of person-entry and vehicle-entry criteria (tow-away crashes) at varying levels of crash severity. Vehicles in each study were inspected a few days after the collision in panel shops and/or recovery yards. Injury information was obtained either from the occupant themselves or from hospital or coronial records. Injuries were rated according to the Abbreviated Injury Scale 1985 or 1990 editions.

All vehicles were involved in a frontal impact in which the principal direction of force (PDoF) applied to the front of the vehicle was between 2 and 10 o'clock. Seat belt use in each study was determined retrospectively at the time of inspection based on the available evidence of seat belt loading, such as markings on the webbing, buckle and/or tongue, or from distortion of the D-ring or B-pillar cladding.

Data were collected on seat belt use, airbag fitment and deployment, impact direction, vehicle damage, occupant injuries and contacts. Crash severity (delta-V) was estimated from damage profiles using the CRASH 3 program (NHTSA, 1986) for the USA and Australia or from more detailed calculations in Germany (delta-V was not available in the Canadian database).

Only a limited number of analyses were possible at this time due to possible confounding influences and time and resource constraints available. Given the focus on assessing airbag benefits in this paper, only data for drivers in frontal crashes who wore their seat belts in vehicles with or without airbags were analysed. Representatives in each country undertook the analysis of their own database and these findings were collated at the Monash University Accident Research Centre in Melbourne, Australia.

Results

Raw Data Analysis

An initial analysis was undertaken of the data set analyses immediately available in each of the four countries and these findings are presented in Tables 1-2 and Figure 1.

These results show that for the US, Australia and Canada, airbags led to a reduction in AIS 2+ injuries in most body regions. For Germany, it was only possible to examine injury differences to the head, chest, abdomen and lower limbs from this database which showed airbag benefits for the head and abdomen but dis-benefits to the chest and lower limbs.

Table 1 *Probability of injury by country for drivers with seat belt restraints alone.*

Unadjusted Injury Risk - AIS 2+				
Body Region	USA	Australia	Canada	Germany
Head	2.0%	12.9%	7.6%	9.5%
Face	0.6%	2.4%	3.7%	
Neck	0.1%	3.5%	0.6%	
Chest	1.7%	14.1%	5.7%	3.5%
Abdo/pelv	0.5%	2.4%	2.1%	3.0%
Spine	0.1%	1.2%	1.3%	
U. limb	1.9%	7.1%	5.3%	
L. limb	1.6%	4.7%	6.6%	8.5%

Table 2 *Probability of injury by country for drivers with seat belt and airbag restraints.*

Unadjusted Injury Risk - AIS 2+				
Body Region	USA	Australia	Canada	Germany
Head	1.0%	4.8%	2.9%	5.4%
Face	0.2%	-	0.3%	
Neck	0.1%	-	0.0%	
Chest	1.2%	6.3%	1.4%	8.1%
Abdo/pelv	0.2%	-	0.6%	2.7%
Spine	0.1%	3.2%	0.6%	
U. limb	2.6%	4.8%	2.3%	
L. limb	3.5%	4.8%	1.7%	10.1%

It is possible that the German results can, in part, be explained by an over-representation in the sample of older drivers. Apart from the German results, this suggests that airbags are a benefit in reducing severe injuries in the areas where improvements are expected, notably the head, face, chest and abdominal regions. Some aspects of these findings need to be discussed.

First, the size of effect was quite varied across all countries. For example, the US head and chest reduction was relatively small compared to all others and especially so for Australia. This may reflect differences in airbag performance between countries where the design criteria were known to be different. In Australia and Germany, for instance, airbags are designed for a restrained population, whereas North American airbags are designed to be used with an unrestrained population and therefore deploy at lower thresholds and are more aggressive. However, there are other possible explanations for this also. It is understood that the NASS sample in the US includes non-deployed airbag cases in the seat belt restrained category in these data, thus the seat belt-only sample could have been of lower crash severity overall which might help explain this difference.

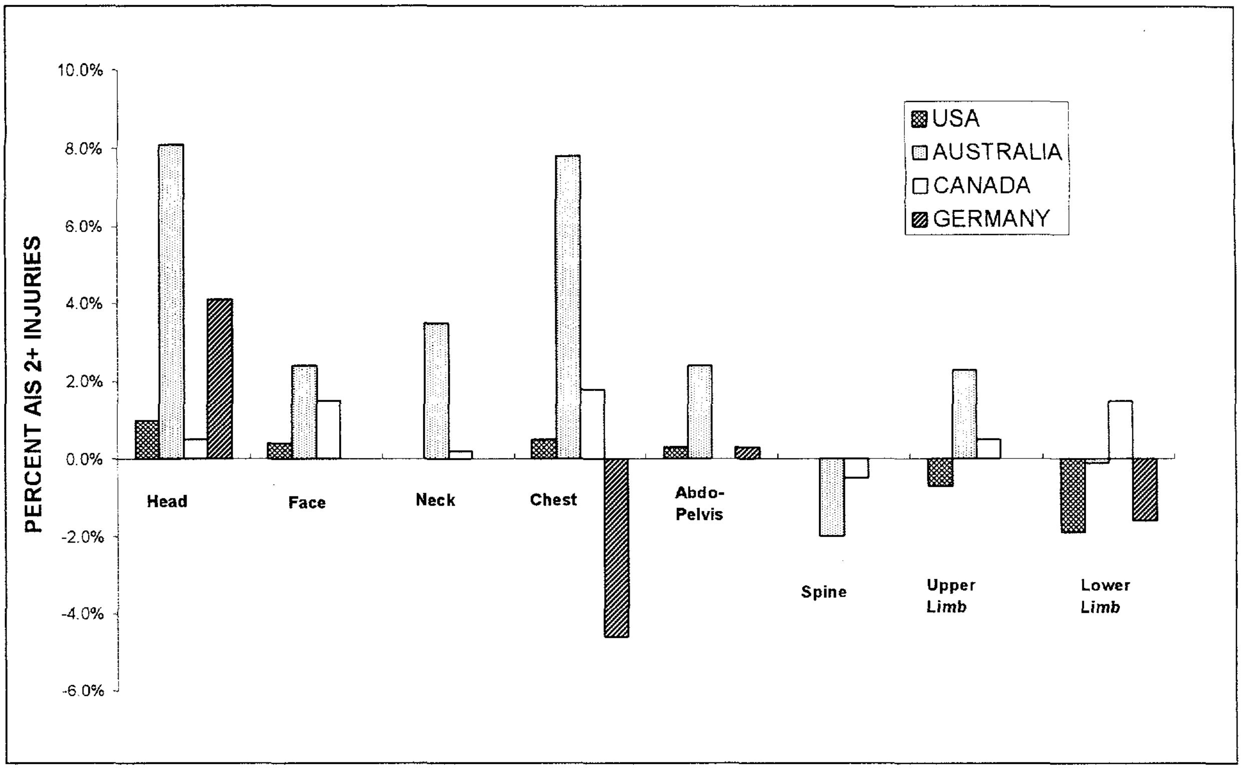

Figure 1 *Difference in percent of injuries for drivers with seat belt only and seat belt and airbag restraints.*

In three of the four countries, lower limb injuries were more frequent in the airbag sample than the seat belt only sample which was unexpected as airbags should have little influence on these injuries. This further suggests that the two samples in some of these countries were not of similar crash severity and therefore, these findings may be quite biased. Furthermore, it became apparent that not all samples had similar entrance criteria. In the USA and Australia for example, both samples were vehicle based with a tow-away threshold. In Canada and Germany, at least on of the samples was injury based where an occupant needed to be injured for inclusion.

In Australia, it was known that the crash severity distributions between samples were quite similar which is reflected in the comparatively similar lower limb results in this country. Unfortunately, though, at this time, it was not possible to control accurately for delta-V in the analyses of the other countries. One way in which these severity differences might be alleviated would be to assume that there should be no difference in lower limb injuries between the samples in each country and to adjust all other injuries by equating lower limb injuries between the two samples. This was only possible though for intra-countries and for samples involving vehicle entrance criteria, hence these adjustments were confined to the USA and Australian samples only.

Table 3 *Probability of Injury by Country for the* *adjusted* *seat belt only data*

Unadjusted Injury Risk - AIS 2+		
Body Region	USA	Australia
Head	4.4%	13.2%
Face	1.3%	2.5%
Neck	0.2%	3.6%
Chest	3.7%	14.4%
Abdo/pelv	1.1%	2.5%
Spine	0.2%	1.2%
Upper limb	4.2%	7.3%
Lower limb	3.5%	4.8%

NB: Data were adjusted by equating lower limb injury %s with the seat belt and airbag distributions and then weighting all other body region %s accordingly.

Adjusted Data Analysis

Table 3 shows the seat belt only sample results from Table 1 re-adjusted to equate with the same frequency of lower limb injuries as in the seat belt and airbag sample in Table 2 for each of the four countries. The different injury outcomes when subtracting the original airbag findings from the adjusted seat belt only sample are shown in Figure 2 below.

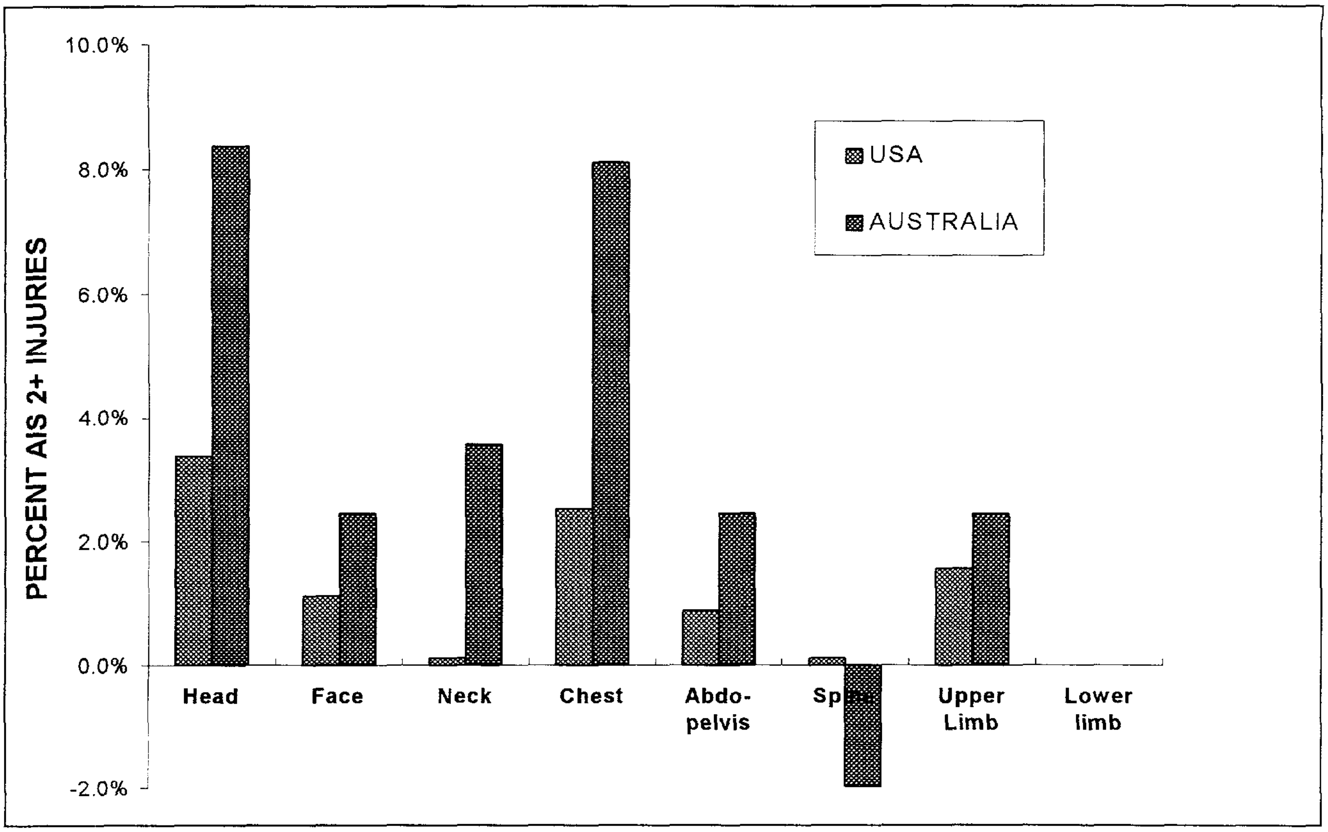

Figure 2; Difference in percent of injuries for drivers with the adjusted seat belt only and the original seat belt and airbag restraints.

The adjusted results show substantial increases in injury reductions for US airbags after adjustment, although still less than that reported for Australia for head, neck, chest, upper limb and abdominal injury benefits. This can be explained by the fact that airbags in the USA have a much lower deployment threshold than in Australia and thus it would be expected that overall more injuries would be apparent for the higher deployment (higher crash severity) population of cars. Thus, even with this adjustment, the two samples were still substantially different in other ways that could not be controlled for in this preliminary analysis.

The apparent increase in spinal injuries in the Australian airbag sample has been previously reported in Fildes et al (1996) and is probably a function of the small sample of cases available for this analysis. As noted earlier, this needs to be monitored closely in future analyses.

Discussion

This comparative analysis of airbag performance across countries has demonstrated the difficulty of undertaking these analyses without the ability to control adequately for all possible extraneous influences in these data sets. Given greater resources and more time, it would be possible to obtain the four data sets and to undertake an analysis with more control of the possible confounding factors such as crash type and severity, vehicle mass and so on. Unfortunately, this was not possible at this stage.

Even so, this analysis demonstrates that airbags do reduce occupant injury in all of the four countries examined here. In particular, there were reductions in life threatening injuries to the head, chest (except for Germany) and to the abdomen and pelvic regions. These results are especially important for guidance to designers and authorities as countries move towards harmonisation and optimising the benefits of this new safety technology.

While it seemed appropriate to equate the USA and Australian samples on the basis of similar severe lower limb injury results, the legitimacy of this procedure is not fully understood. For example, seat belt wearing status is not always reliable as seat belt loading evidence can be difficult to find on occasions. This is particularly so for the airbag sample as these devices can often alleviate belt loading in many minor severity crashes. Of more importance, though, is the consequence of applying a constant weighting factor to all body region injuries equivalent to the lower limb injury differences between the two samples.

Without more definitive evidence, it is not possible to judge what effect this had on the effectiveness figures and therefore these findings need to be treated with a degree of caution.

The Need for Harmonised Databases

This analysis has illustrated the benefits of both primary and supplementary restraint airbags as well as potential problems in attempting to compare safety performance of vehicles across countries. More precision with these results would have been possible had greater control been possible over some of the extraneous influences when undertaking these analysis. While this was partly a resource issue, there were still a number of fundamental differences in the data collection methods that would always be a source of contamination in these results.

It is clear that the only way to evaluate safety performance unambiguously using real world injury data is by the establishment of harmonised data collection methods and databases between countries. A number of key variables need to be included such as crash type, crash severity, injury coding, seat belt wearing, airbag deployment, and so on to permit comparative analyses to be undertaken. Also, the data collection methods and entrance criteria must also be consistent to be sure that the findings are meaningful and reliable.

It is understood that the European Commission have a committee who are working towards the establishment of a harmonised data collection procedure in Europe, the so called Community European Road Accident database system (CARE). Currently, there is a committee formed by the European Union to examine the feasibility of such a database and what information should be contained on it. It is still very much in the formative stages of the project and a 10 year time-line has been established for its possible introduction. There is, at present, a long standing OECD database (IRTAD) containing details on fatalities within Europe and CARE which may provide supplementary injury information.

The degree to which development and implementation of this data collection procedure and database would suffice the needs identified here would be worthwhile establishing. As this committee efforts seems to be aimed at harmonised mass data records, there may not be sufficient detail included to provide the degree of control required for these analyses. If this is the case, there would be considerable merit in the formation of a harmonised procedure for in-depth crash investigation procedures. This would provide at least two benefits.

1. It would provide manufacturers and government authorities with the data necessary to compare in-vehicle safety performance internationally.
2. It would enable countries to share their data and thus permit more powerful analyses using well controlled and detail information not currently available.

As this study has shown, at present, it is not straightforward process to combine data from several sources to derive a composite data-set with which in turn to empirically answer research questions. Therefore any degree of harmonisation between crash injury studies may have considerable benefits if an acceptable approach to the method of harmonisation can be found.

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