REAR SEAT OCCUPANTS IN FRONTAL CRASHES - ADULTS AND CHILDREN -
THE EFFECTS OF RESTRAINT SYSTEMS

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ABSTRACT

Data on passenger cars in frontal crashes were reviewed using NASS 1980-1991. Crashes with one or more rear seat passengers were included. Combinations (pairs) were made based on restraint use: lap-shoulder belts in the front seat (or no belts worn) and lap belts, or (no belts worn) in the rear seat. Crashes wherein passive restraints were worn or restraints for children were not included. The AIS was used for injury severity. The data indicate the rear seat is a safer environment. Lap belted rear seat occupants, children and adults, most always fared better than their front seat counterparts.

THE EFFECTS OF SEAT BELT RESTRAINT SYSTEMS have been well documented and need not be repeated here. For the most part, studies on the effectiveness of restraint systems only included the front seat occupant(s). In the rear seat, data are sparse, and generally only involve the use of lap belts (Gikas and Huelke, 1966, Huelke, 1978a, b, NTSB Safety Study, 1986, Evans, 1987, Huelke, et al, 1987, Huelke, 1987, Campbell, 1988, Evans, 1988a, b, Huelke, 1988a,b, Krafft, 1990). The National Transportation Safety Board (NTSB, 1986) reported on selected cases of lap belt induced injuries, cases where the investigators specifically searched for crashes with injuries to lap belted occupants.


MATERIALS AND METHODS

For this study, the National Accident Severity Study (NASS) data, was reviewed for the years 1980-1991. From these data, only frontal collisions of passenger cars (11-1 o'clock impact direction) were studied, cars without major secondary collision damage. Additionally, only cars equipped with an active belt system were selected; no cars with passive restraints (automatic shoulder belts or airbags) were included. "Adult" (15 years or older) front seat occupants were either unbelted or lap-shoulder belt restrained. In each crash there was at least one rear seat occupant, 15 years or older, either unbelted or lap belted. Occupant pairs were then formed, based on seating location (front and rear), and the various belt combinations. A pair consists of a rear seat occupant with the driver, and, if there was a front seat passenger, then another pair was made. Similarly, if there was a second rear seat occupant, another pair (or two) was identified. There are few lap-shoulder belted rear passengers and therefore they are not included in this analysis. In a similar manner, separately studied were rear seat children 5-14 years of age.

The Abbreviated Injury Scale (AIS) was used and the highest or most severe injury level, the Maximum Abbreviated Injury Scale (MAIS) was tabulated.

Table 1

<table>
<thead>
<tr>
<th>Variables Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Frontal crashes (11-1 o'clock-primary CDC)</td>
</tr>
<tr>
<td>• Passenger cars</td>
</tr>
<tr>
<td>• No major secondary damage</td>
</tr>
<tr>
<td>• No rollovers</td>
</tr>
<tr>
<td>• No passive restraints or child restraints included</td>
</tr>
<tr>
<td>• Adult front seat occupants-15 years or older</td>
</tr>
<tr>
<td>• Rear seat occupants-5-14 years, ≥ 15 years</td>
</tr>
<tr>
<td>• Known injury level (AIS)</td>
</tr>
</tbody>
</table>

RESULTS

Data derived from the front seat-rear seat adult pairs are shown in Table 2 where the frequency of all MAIS levels is presented along with the MAIS 2+ injury frequency shown in parenthesis.

In Table 2 the MAIS frequencies indicate that the rear seat adult occupants have a lower frequency of injury than those in the front seat. For example, when both the unbelted front and rear seat adult occupants were reviewed, 29% of the front seat occupants have a higher MAIS compared to those in the rear (11%). This holds true for all belting combinations except for the front lap-shoulder belted and rear unbelted occupant pairs where the frequency of the MAIS is the same (17%).

In all belting combinations the majority of MAIS of front and rear occupants were at the 0-1 level. Eliminating the MAIS 0 & 1, the sets with an injury level of MAIS 2+ for both front and rear seat adult occupants were separately reviewed (Table 2). Again, more adult front seat occupants had a higher MAIS level (2+) in all belting combinations except one—the rear unbelted adult occupants had a higher frequency of MAIS 2+ (55%) than the front lap-shoulder belted occupants (44%).
<table>
<thead>
<tr>
<th>Combinations</th>
<th>Front</th>
<th></th>
<th>Rear</th>
<th></th>
<th>Same</th>
<th></th>
<th>No. of Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>(MAIS 2+)</td>
<td>All</td>
<td>(MAIS 2+)</td>
<td>All</td>
<td>(MAIS 2+)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Front-unbelted &amp; Rear-unbelted</td>
<td>29 (58)</td>
<td>11 (31)</td>
<td>60 (11)</td>
<td>5259 (946)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front-unbelted &amp; Rear-lap belted</td>
<td>31 (56)</td>
<td>6 (33)</td>
<td>63 (11)</td>
<td>258 (27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front-lap shoulder belted</td>
<td>17 (44)</td>
<td>17 (55)</td>
<td>66 (1)</td>
<td>564 (73)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear-unbelted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front-lap shoulder belted &amp; Rear lap belted</td>
<td>21 (64)</td>
<td>8 (23)</td>
<td>71 (13)</td>
<td>543 (52)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The 5-14 year old rear seat children have a lower frequency of injury at all MAIS levels (Table 3), even when they are lap belted with the front adults restrained by lap-shoulder belts. The sets of MAIS 2+ for rear seat 5-14 year old children are few in number indicating the protection offered by the rear seat areas as well as the use of the lap belt.
Table 3
Injury Frequency
Front Seat Adults and Rear Seat Children (5-14 Years)

<table>
<thead>
<tr>
<th>Combinations</th>
<th>All MAIS Levels</th>
<th>No. of Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Front</td>
<td>Rear</td>
</tr>
<tr>
<td>Front-unbelted &amp; Rear-unbelted</td>
<td>31</td>
<td>8</td>
</tr>
<tr>
<td>Front-unbelted &amp; Rear-lap belted</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Front-lap shoulder belted Rear-unbelted</td>
<td>36</td>
<td>14</td>
</tr>
<tr>
<td>Front-lap shoulder belted Rear lap belted</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

DISCUSSION

The lower injury frequency at all MAIS levels, in most all of the belted (or unrestrained) sets, indicate that the rear seat occupants fare better than their front seat counterparts. This is also true when front seat adults are compared to younger rear seat passengers-5-14 year olds—for all belted combinations. Our data disagree with Nygren, et al (1982) and Norin, et al (1980) that the injury severity for unbelted front and rear seat occupants is similar. Our findings indicate that the unrestrained rear seat occupant injury frequency is about 63% lower than unrestrained front seat occupants.


These data that we present on passenger cars in frontal crashes with various belt use in the front and in the rear seats indicate that the rear seat is a much safer location than is the front seat in this set of frontal crashes, agreeing with citations mentioned earlier in this paper. The
data further indicate that there is no overall enhancement of injuries to occupants in the rear seat who were wearing lap belts.

Additionally, one would hope that the lap-shoulder belt in the rear seat will offer even further protection over that of the lap belt only. It is the supposition of some that if lap-shoulder belts are worn in the rear seat, the injury reducing effectiveness of the 3-point restraint would be similar to that in the front seat. Although we do not have data on lap-shoulder belted rear occupants, other studies should be mentioned that have indicated the lap-shoulder belted rear seat occupant is susceptible to seat belt injuries. Padmanaban and Ray, (1993) using two independent analysis did not find any measurable differences between rear seat lap or lap shoulder belt effectiveness. Because of the variety of sizes of individuals in the rear seat, it is unsure at this time whether a lap-shoulder belt will properly fit the anatomy of all ages of rear seat occupants, especially children who have different body portions than adults (Burdi, Huelke and Snyder, 1969). A slight deviation from the upright position laterally can degrade the effectiveness of the upper restraint system as well as a slouched precrash position of the rear passenger. Also, less leg room is often noted in the rear seat area versus the front seat area, and the belt conformity to the anatomical anchor points, especially of children, may be less than optimal, depending on the size of the individual.

Lane (1993) concluded that, "of adults restrained by three point belts, rear outboard occupants have a greater liability to SBS (seat belt syndrome) than left front occupants (passengers)". Our data agree with the study of Evans and Frick (1988b) on fatal risk, where they stated, "Hence when all occupants use the most commonly provided restraint systems, no difference is indicated in the fatality risk to front and rear outboard occupants. Using data from the Folksam Insurance Company, a low frequency of "injured" rear passengers, of all ages, using the lap or lap-shoulder belts, was found (Krafft, et al, 1990). Lane (1993), indicated that for children in the rear the relative risk of the seat belt syndrome (SBS) is twice as high for lap belt users than for those using the 3-point restraint. Yet, rear seat lap-shoulder belt users have nearly three times the risk of front seat passengers in 3-point belts. Twice as many children sustained SBS when 3-point restrained in the rear seat.

CONCLUSION

In this unique study of frontal crashes with front and rear seat occupants either belted or unrestrained in the same crash, the rear seat was identified as a safer environment, agreeing with other studies. It appears that unbelted rear passengers fare as well as lap-shoulder belted front seat occupants in the same frontal crashes. Lap belted rear occupants have a higher level of injury severity less often than lap-shoulder belted front seat occupants in the same crash. The exception to this is at the higher MAIS levels (2+) in adults when the rear passenger is unbelted and the front seat occupant is lap-shoulder belted. The 5-14 year old rear seat passengers have a lower frequency of injury at all MAIS levels when compared to front seat occupants.

REFERENCES


