Rear-Seat Motor Vehicle Travel in the U.S. Using National Data to Define a Population at Risk

Matthew J. Trowbridge, MD, MPH, Richard Kent, PhD

Background: Recent studies suggest that the relative protection offered by rear seating in motor vehicle crashes has decreased, potentially reflecting disproportionate advancements in front-seat safety technology. Safe adaptation of advanced front-seat restraint systems for the rear-seat environment will require exposure data that are currently unavailable.

Purpose: This study uses national data to quantify rear-seat occupancy patterns, restraint use, and annual travel exposure in the U.S. in order to support the development of advanced crash protection systems for rear-seat motor vehicle occupants.

Methods: Data from the 2000–2006 National Automotive Sampling System Crashworthiness Data System and 2001 National Household Transportation Survey were analyzed in 2008 to quantify occupancy patterns (e.g., seat position, restraint use) and annual person-trips for rear-seat passengers in the U.S.

Results: The overall proportion of person-trips by rear-seat occupants is relatively low (12.9%); however national at-risk exposure remains significant (approximately 39 billion annual person-trips). Annual rear-seat travel exposure is similar among children ≤12 years and adults (18.9 vs 19.1 billion person-trips) despite the fact that children are proportionally much more likely to ride in rear positions (79.3% vs 7.4%). Restraint use among adult rear-seat occupants was also much lower than among front-seat occupants (50.4% vs 82.2%).

Conclusions: While rear-seat occupancy is relatively low compared with front-seat occupancy at-risk rear-seat travel by both child and adult passengers in the U.S. remains significant. Restraint use by rear-seat occupants is much lower than that among front-seat passengers, particularly among adults and older children, substantially increasing injury risk. Development of future crash protection systems for rear-seat passengers must account for these exposure patterns to ensure safe and effective integration into production vehicles.

Introduction

Research continues to demonstrate a lower overall fatality risk for rear-seat passengers compared with matched front-seat passengers in motor vehicle crashes. However, the relative protection offered by rear-seat positions is decreasing, and among certain subpopulations, such as restrained occupants ≥50 years, has become negative. This trend likely reflects disproportionate advancements in front-seat crash protection compared with the rear seat. Preliminary assessments of front-seat technologies such as pre-tensioning and load-limiting seatbelts in the rear-seat environment indicate both feasibility and benefit, yet rear-seat exposure data necessary for safe integration into production vehicles are unavailable.

Failure to sufficiently anticipate occupancy patterns prior to introducing new safety countermeasures in motor vehicles can be dangerous; a notable example is first-generation passenger airbags that proved potentially fatal to child passengers traveling in the front seat during low-speed crashes.

The objective of this study was to quantify rear-seat occupancy patterns, restraint use, and annual travel exposure in the U.S. These data will help support the development of advanced crash protection systems for rear-seat motor vehicle occupants.

Methods

In 2008, rear-seat motor vehicle travel exposure in the U.S. was investigated using two federal sources: the 2000–2006 National Automotive Sampling System Crashworthiness Data System (NASS-CDS) and the 2001 National Household Transportation Survey (NHTS). NASS-CDS provides nationally representative data regarding motor vehicle crashes based on a weighted annual sample of approximately 5000 police-reported collisions. NASS-CDS includes detailed information for each...
crash, including seat position and restraint status of each involved vehicle occupant.

The NHTS is a periodic nationally representative survey of travel behavior.9 The 2001 NHTS collected information from 66,000 U.S. households through telephone surveys and trip diaries used to document travel during an assigned travel day. Information such as mode of travel, purpose, and distance are recorded for each trip; however data such as seat position during vehicle trips or seatbelt use are not. Weights are included in the data set to adjust for sampling error and bias when calculating national estimates.

Analysis Methodology

Seating position and restraint use data from NASS-CDS were combined with trip information from NHTS to investigate rear-seating position, restraint use, and overall travel exposure at a national level. First, the estimated proportion (\( \hat{p} \)) of national in-transit motor vehicle occupants who were rear seated was calculated from NASS-CDS. Second, an estimate of annual person-trips (\( \hat{N} \)) by rear-seat passengers was calculated by multiplying the estimated proportion of rear-seat occupants by a weighted national estimate of total annual person-trips (\( \hat{N} \)) derived from NHTS data:

\[
\hat{N} = \hat{N} \cdot \hat{p}.
\]

(1)

By assuming that \( \hat{p} \) and \( \hat{N} \) are independent, the estimated variance for each rear-seat person-trip estimate, \( \hat{v}(\hat{N}) \), was then calculated as

\[
\hat{v}(\hat{N}) = \hat{N} \cdot \hat{v}(\hat{p}) + \hat{p} \cdot \hat{v}(\hat{N}) + \hat{v}(\hat{N}) \cdot \hat{v}(\hat{p}).
\]

(2)

Analysis of NASS-CDS data was limited to “not at fault” vehicles (i.e., not responsible for the crash occurring) as a proxy for general in-transit vehicles because the demographics and occupancy patterns of at-fault drivers and passengers may not be generally representative.

Results

Seating Position and Annual Travel Exposure

Overall, 12.9% of in-transit U.S. motor vehicle occupants from 2000 to 2006 traveled in the rear seat (95% CI=11.2%, 14.6%). Total annual travel exposure for rear-seat passengers was approximately 39 billion person-trips (Table 1). Children aged <12 years were proportionally much more likely to be rear-seat passengers than adults 13–64 years (79.3% vs 7.4%). However, at a national level, annual rear-seat travel exposure was similar for both age groups (18.9 vs 19.1 billion person-trips for children and adults, respectively). Older passengers (aged >65 years) were relatively infrequent rear-seat occupants. Only 3.6% of older passengers were rear seated, accounting for only 717 million annual U.S. person-trips.

Most rear-seat occupants were seated in an outboard position (83.2%; 95% CI=79.9%, 86.5%), including 80.5% (95% CI=63.2%, 97.9%) of children aged ≥2 years. In contrast, 63.1% (95% CI=40.9%, 85.3%) of rear-seated infants (aged <2 years) were seated in the center position.

Rear-Seat Restraint Use

Restraint use by rear-seat passengers was much lower than it was among front-seat occupants (50.4% vs 82.2%, Table 2) and varied by age. For example, the proportion of belted older rear-seat passengers (aged >65 years) was approximately 10% higher than that of passengers aged 13–65 years (91.0% vs 80.1%, respectively). Similarly, while the large majority of children aged ≤12 years in rear seats were using some form of restraint (88.7%; 95% CI=80.9%, 97.5%), older children (aged 8–12 years) were much more likely to be unrestrained (20.7%; 95% CI=5.4%, 36.0%) than children in younger age groups.

Discussion

This study provides national estimates of rear-seat occupancy and travel exposure in the U.S. The results demonstrate that while that the overall proportion of person-trips taken as a rear-seat occupant in the U.S. is relatively low (12.9%), at-risk travel exposure by rear-seat passengers at a national level is substantial (approx-

### Table 1. Seat row and estimated annual person-trips for motor vehicle occupants in the U.S.

<table>
<thead>
<tr>
<th>Seat row</th>
<th>n²</th>
<th>Weighted</th>
<th>% (95% CI)</th>
<th>Annual person-trips</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>7524</td>
<td>5,198,921</td>
<td>87.1 (85.4, 88.9)</td>
<td>263,356,464,752</td>
<td>875,564,533</td>
</tr>
<tr>
<td>Rear</td>
<td>1287</td>
<td>768,492</td>
<td>12.9 (11.2, 14.6)</td>
<td>38,928,266,637</td>
<td>559,693,684</td>
</tr>
</tbody>
</table>

aUnweighted cases in 2000–2006

NASS-CDS, National Automotive Sampling System, Crashworthiness Data System

### Table 2. Restraint status by seat row for motor vehicle occupants in the U.S.

<table>
<thead>
<tr>
<th>Seat row</th>
<th>Seatbelt use</th>
<th>n²</th>
<th>Weighted</th>
<th>% (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>No</td>
<td>1722</td>
<td>884,963</td>
<td>17.9 (14.9, 20.8)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>5510</td>
<td>4,074,433</td>
<td>82.2 (79.2, 85.1)</td>
</tr>
<tr>
<td>Rear</td>
<td>No</td>
<td>695</td>
<td>381,580</td>
<td>49.7 (37.6, 61.7)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>592</td>
<td>386,913</td>
<td>50.4 (38.3, 62.4)</td>
</tr>
<tr>
<td>All rows</td>
<td>No</td>
<td>2417</td>
<td>1,266,542</td>
<td>22.1 (19.4, 24.9)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>6102</td>
<td>4,461,346</td>
<td>77.9 (75.1, 80.7)</td>
</tr>
</tbody>
</table>

aUnweighted cases in 2000–2006

NASS-CDS, National Automotive Sampling System, Crashworthiness Data System
imately 39 billion annual person-trips). In addition, despite the fact that children aged <12 years are more likely to travel in the rear seat than adults, overall rear-seat travel exposure at a national level for the two groups is similar (18.9 vs 19.1 billion annual person-trips). This demonstrates that improving crash protection for adult rear-seat passengers must continue to be a priority in the midst of efforts to develop and regulate advanced crash injury countermeasures for children in the rear-seat environment.

This analysis also demonstrates much lower seatbelt use in the rear seat (50%) compared with the front seat (82%). This finding is consistent with previous observational studies in the U.S., as well as recent Japanese studies, which show an even greater disparity (92.4% front vs 8.1% rear). Confirmation of low rear-seat restraint use has significant implications for injury prevention because many advanced safety technologies (e.g., force-limiting seatbelts) require elective restraint use in order to be effective. Unrestrained rear passengers also increase the risk of severe injury to front-seat occupants by a factor of approximately two. Finally, the finding that nearly 37% of rear-seated children aged <2 years ride in an outboard position reveals an untapped opportunity for safety benefit. Recent research suggests that the rear center seating position confers a 43% reduction in significant injury risk for children aged 0–3 years compared with outboard positions.

The primary strengths of this study are its use of nationally representative data and the calculations of annual travel-exposure estimates, specifically for rear-seat passengers. A key limitation is the reliance on crash data to estimate in-transit rear-seat occupancy and restraint use. Crash-involved occupants may not be fully representative of the general in-transit population in terms of seating position or other travel behaviors. For example, seatbelt usage is generally over-reported in crash-based data sets. It is therefore possible that the estimates of rear-seat restraint use reported here overestimate actual use. However, comparison with previous studies suggests that potential over-reporting is relatively small.

**Conclusion**

While rear-seat occupancy is relatively low compared with front-seat occupancy, at-risk rear-seat travel by both child and adult passengers in the U.S. remains significant. Restraint use by rear-seat occupants is much lower than it is among front seat passengers, particularly among adults and older children, substantially increasing injury risk. Development of future crash protection systems for rear-seat passengers must account for these exposure patterns to ensure safe and effective integration into production vehicles.

No financial disclosures were reported by the authors of this paper.

**References**