Risk of Injury to Child Passengers in Compact Extended-Cab Pickup Trucks

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Despite the popularity of compact pickup trucks, many only have a single row, thereby limiting seating capacity. Manufacturers now produce extended-cab models that can accommodate at least 2 restrained rear occupants. These extended-cab models may be viewed as family vehicles by parents who want to follow safety recommendations that children be placed in the rear seat. However, little is known about the relative safety of pickup trucks for rear-seated occupants, particularly children.

Current compact extended-cab pickup trucks typically have small rear occupant compartments and most have side-facing, fold-down, or “jump” seats that are considered auxiliary, nonstandard seats by manufacturers and by the National Highway Traffic Safety Administration. In contrast, current full-size extended-cab pickup trucks, similar to other vehicles, typically have larger rear-occupant compartments and standard bench seats. Manufacturers’ instructions recommend that children be seated in the front seat of compact extended-cab pickup trucks in appropriate child restraints rather than in the auxiliary seats. The National Highway Traffic Safety Administration exempts these auxiliary jump seats from regulatory testing, and, as such, the relative safety of these seats has not been determined.

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crash surveillance system. Insurance claims from State Farm Insurance Co (Bloomington, Ill) function as the source of subjects, with telephone survey and on-site crash investigations serving as the primary sources of data.

Vehicles eligible for inclusion were State Farm insured, model year 1990 or newer, and involved in a crash with at least 1 child occupant aged 15 years or younger. Eligible crashes were limited to those that occurred in 13 states and the District of Columbia, representing 3 large regions of the United States (East: New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, North Carolina, and the District of Columbia; Midwest: Ohio, Michigan, Indiana, and Illinois; and West: California, Nevada, and Arizona). After policyholders consented to participate in the study, limited data were transferred electronically to researchers at the Children’s Hospital of Philadelphia and University of Pennsylvania. Data in this initial transfer included contact information for the insured driver, the age and sex of all child occupants, and a coded variable describing the level of medical treatment received by all child occupants (ie, no treatment, physician’s office or emergency department only, admitted to the hospital, or death).

A stratified cluster sample was designed to select vehicles (the unit of sampling) for conducting a telephone survey with the driver. In the first stage of sampling, vehicles were stratified on the basis of whether they were towed from the scene, and a probability sample of both towed and nontowed vehicles was selected at random, with a higher probability of selection for towed vehicles. In the second stage of sampling, vehicles were stratified on the basis of the level of medical treatment received by child occupants. A probability sample from each tow status/medical treatment stratum was selected at random. Probabilities of selection ranged from 0.025 for vehicles for which no child received medical treatment to 1.0 for vehicles for which a child died or was admitted to the hospital. In this way, the majority of injured children would be selected while maintaining the representativeness of the overall population. If a vehicle was sampled, the “cluster” of all child occupants in that vehicle were included in the survey.

Drivers of sampled vehicles for which at least 1 child received medical treatment were contacted by telephone (Ropen ASW, Princeton, NJ) and screened via an abbreviated survey to verify the presence of at least 1 child occupant with an injury. All vehicles with at least 1 child who screened positive for injury and a 10% random sample of vehicles in which all child occupants screened negative for injury were selected for a full interview. (The 2.5% of sampled vehicles for which no children were treated were also selected for a full interview.) The full interview involved a 30-minute telephone survey with the driver of the vehicle and parents of the involved children. Only adult drivers and parents were interviewed. The median length of time between the date of the crash and the completion of the interview was 6 days.

The eligible study population consisted of 126907 vehicles involving 189962 children. Claim representatives correctly identified 93% of eligible vehicles, and 77% of policyholders consented to participation in the study. Of these, 22% were sampled for interview and an estimated 82% of these were successfully interviewed (FIGURE). Comparing the included sample with known population values from State Farm claims, little difference exists; in both the sample and the population, 42%, 34%, and 24% of the vehicles were located in the East, Midwest, and West regions, respectively; 52% of the sampled vehicles were model 1996 or newer, compared with 51% of the population; 55% were passenger cars, 20% were passenger vans, 16% were sport utility vehicles, and 7% were pickup trucks, compared with 56%, 19%, 16%, and 7% in the population; and 33% were nondriveable, compared with 32% of the population. The mean age of the child occupants in the sample was 7.0 years, compared with 7.2 years in the population.

For cases in which child occupants were seriously injured or killed, in-depth crash investigations were performed. Cases were screened via telephone to confirm the details of the crash. Contact information from selected cases was then forwarded to a crash investigation firm (Dynamic Science Inc, Annapolis, Md), and a full-scale on-site crash investigation was conducted using custom child-specific data collection forms. Among cases selected for investigation, 97% were completed. For the purposes of this analysis, these cases were used to examine the validity of information obtained from the telephone survey.

Variable Definitions
Crashes involving passenger cars, vans, sport utility vehicles, and pickup trucks were included in the study. Pickup trucks were defined as trucks with an open cargo bed behind a closed cab. Pickup trucks were further classified as extended-cab (having 2 rows of seats) or regular cab (1 passenger row only). Compact pickup trucks were defined as those with a gross vehicle weight rating (truck weight plus carrying capacity) of less than 6000 lb (2722 kg). Compact pickup trucks weigh more than most passenger cars but are comparable in weight with sport utility vehicles and minivans. For classification based on cab type, the vehicle identification number was decoded using Vin-dicator (Insurance Institute for Highway Safety/Highway Loss Data Institute, Arlington, Va). Rear-seated children were believed to contribute to the excessive risk of compact extended-cab pickup trucks, so we restricted our analysis to children seated in vehicles with 2 or more rows of seats (97% of all children in the sample). We have combined full-size extended-cab pickup trucks with other vehicles, given that the rear seat of a full-size pickup truck is similar in design to rear seats in other passenger vehicles and that preliminary analyses indicated no significant difference in risk of injury among children in the second row of these vehicles when compared with other vehicles.
Direction of first impact was derived from a series of questions regarding the vehicle parts that were involved in the first collision. Crash severity was categorized both by the tow status of the vehicle (ie, whether the vehicle was towed from the crash scene) as indicated in the insurance claims data, as well as by driver report via the telephone survey of intrusion into the occupant compartment of the vehicle (ie, the integrity of the vehicle structure was lost and the interior space was reduced).

Seating location of each child was determined from the telephone survey. Among the 170 children for whom paired information on seating position (front vs rear) was available from both the telephone survey and crash investigations, agreement was 99% between the driver report and the crash investigator ($\kappa=0.99; P<.001$).

Restraint status of children was classified as either restrained or unrestrained as determined from the telephone survey. Among the 164 children for whom paired information on restraint use was available from both the telephone survey and the crash investigation, agreement was 89% between the driver report and the crash investigator ($\kappa=0.38; P<.001$).

Survey questions regarding injuries to children were designed to provide responses that were classified by body region and severity based on the Abbreviated Injury Scale score, and have been previously validated. For the purposes of this study, children were classified as injured if they had an injury likely to require medical attention, including any injury with an Abbreviated Injury Scale score of 2 or greater (ie, concussions and more serious brain injuries, all internal organ injuries, spinal cord injuries, and extremity fractures) and facial lacerations.

Separate oral consent was obtained from eligible participants for the transfer of claim information from State Farm to the Children’s Hospital of Philadelphia/University of Pennsylvania School of Medicine for the conduct of the telephone survey and for the conduct of the crash investigation. The study protocol was reviewed and approved by the institutional review boards of both the Children’s Hospital of Philadelphia and the University of Pennsylvania School of Medicine.

**Data Analysis**

The primary purpose of these analyses was to compute the relative risk of injury for children in compact extended-cab pickup trucks compared with children in other vehicles. Statistical significance was set at $P<.05$.

Because sampling was based on the likelihood of an injury, subjects least likely to be injured were underrepresented in the study sample in a manner potentially associated with the predictors of interest. To account for this potential bias, analytical methods were used to account for sampling weights, sampling strata, and sampling units.

To compute $P$ values and 95% confidence intervals (CIs) to account for the stratification of subjects by medical treatment, clustering of subjects by vehicle, and the disproportional probability of selection, Taylor Series linearization estimates of the logistic regression parameter variance were calculated using SAS-callable SUDAAN: Software for the Statistical Analysis of Correlated Data, version 7.5 (Research Triangle Institute, Research Triangle Park, NC). Results of logistic regression modeling are expressed as unadjusted and adjusted odds ratios (ORs) with corresponding 95% CIs. Adjustments included seating position (front vs rear), age of the child, restraint use, point of first impact, crash severity, and vehicle weight.

**RESULTS**

Complete interview data were obtained for 7192 vehicles with 2 or more seating rows involving 11 335 children, representing an estimated 110 423 children in 71 229 vehicles in the study population. Injuries were reported for
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Table 1. Child Occupant and Crash Characteristics by Vehicle Type

<table>
<thead>
<tr>
<th>Variables</th>
<th>Compact Extended-Cab Pickup Trucks</th>
<th>Other Vehicles*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unweighted, No.</td>
<td>Weighted, No. (%)</td>
</tr>
<tr>
<td>Sample size</td>
<td>143</td>
<td>1170 (100)</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2</td>
<td>11</td>
<td>101 (8.7)</td>
</tr>
<tr>
<td>3-4</td>
<td>11</td>
<td>50 (4.3)</td>
</tr>
<tr>
<td>5-8</td>
<td>32</td>
<td>333 (28.5)</td>
</tr>
<tr>
<td>9-12</td>
<td>54</td>
<td>311 (26.6)</td>
</tr>
<tr>
<td>13-15</td>
<td>25</td>
<td>374 (32.0)</td>
</tr>
<tr>
<td>Restraint used</td>
<td>137</td>
<td>1162 (99.3)</td>
</tr>
<tr>
<td>Rear-row seated</td>
<td>59</td>
<td>533 (45.6)</td>
</tr>
<tr>
<td>Interior contact</td>
<td>57</td>
<td>238 (20.3)</td>
</tr>
<tr>
<td>Direction of initial impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front</td>
<td>62</td>
<td>615 (52.6)</td>
</tr>
<tr>
<td>Side</td>
<td>21</td>
<td>155 (13.2)</td>
</tr>
<tr>
<td>Rear</td>
<td>56</td>
<td>378 (32.3)</td>
</tr>
<tr>
<td>Other/multiple</td>
<td>4</td>
<td>22 (1.9)</td>
</tr>
<tr>
<td>Intrusion</td>
<td>29</td>
<td>75 (6.4)</td>
</tr>
<tr>
<td>Towaway</td>
<td>80</td>
<td>301 (25.7)</td>
</tr>
<tr>
<td>Vehicle weight, mean (SEM), kg</td>
<td>1 512 (13.6)</td>
<td>1538 (3.2)</td>
</tr>
</tbody>
</table>

Other vehicles include full-size pickup trucks, passenger cars, passenger vans, and sport utility vehicles.

1536 of the sampled children, representing an estimated 1756 children or 1.6% of the population.

Child occupant characteristics and crash characteristics associated with each child occupant are given in Table 1. Children in compact extended-cab pickup trucks comprised 1.1% of the estimated overall population of children in crashes. On average, children in compact extended-cab pickup truck crashes were older, more likely to be restrained and seated in the front row, and more likely to contact the interior of the vehicle during impact than children in other vehicles. The crashes in which they were involved were more likely to be frontal-impact crashes and less likely to be multiple-impact crashes, although there was no significant difference in crash severity as measured by intrusion or tow status and virtually no difference in mean vehicle weight when comparing crashes involving compact pickup trucks with those involving all other vehicles.

Injuries occurred in 7.5% of the children in compact extended-cab pickup truck crashes compared with 1.6% of the children in other vehicle crashes. One compact extended-cab pickup truck crash involved a child with an injury (concussion) who had not initially received medical treatment and, as per our sampling algorithm, this crash had an unusually large sample weight compared with other children with injuries. Excluding this crash would result in an estimated risk of injury in compact extended-cab pickup trucks of 3.8%. To produce more conservative estimates of injury risks, we excluded this crash from further analyses.

The distribution of the injuries among the 32 (unweighted number) injured children in compact pickup trucks was as follows (note that some children had multiple injuries): 23 head injuries, 8 facial lacerations, 3 pulmonary contusions, 1 hemopneumothorax, 3 internal abdominal organ injuries (2 kidney and 1 spleen), 1 spinal cord injury, 5 upper-extremity fractures (3 forearm, 1 clavicle, and 1 unknown type), and 2 lower-extremity fractures (1 femur and 1 unknown type). All of these children underwent medical treatment: 11 were admitted to the hospital (6 to the intensive care unit), 18 were treated and released from the emergency depart-
children in the rear seat of full-size pickup trucks (2.1%; adjusted OR, 2.99; 95% CI, 0.72-12.33). The risk of injury to children in the front seat of compact pickup trucks is greater than that to those in the front seat of full-size pickup trucks, although this difference is less pronounced than in the rear seat (3.0% vs 1.8%; adjusted OR, 1.45; 95% CI, 0.41-5.16).

COMMENT

On average, children seated in compact extended-cab pickup trucks are not as safe as children seated in other vehicles, primarily because the protective effect of rear seating is not present in compact extended-cab pickup trucks. Therefore, parents with a choice of vehicles available to transport their children should not use compact pickup trucks. The hazards of riding in the front seats of vehicles for children are well known,13,14 and, in the current study, it was found that children in the front seats of compact extended-cab pickup trucks are at even higher risk of injury than children in the front seats of other vehicles, although this result did not reach statistical significance. Furthermore, children in the rear seats of compact pickup trucks are at substantially increased risk of injury compared with children in the rear seats of other vehicles. This increase in risk appears to be caused at least in part by contact with the interior of the vehicle at impact.

These results point to unique hazards of compact extended-cab pickup trucks that put children at risk. The rear occupant compartment of compact pickup trucks is smaller than that of most other vehicles. In addition, these rear seats provide only 2-point (ie, lap-only) restraints that allow for excessive upper body movement in the event of a crash. These factors may contribute to excess vehicle interior contact for occupants of compact pickup trucks. Furthermore, the trend toward increased risk of injury given vehicle interior contact in compact pickup trucks suggests that inadequate vehicle padding may contribute to the injuries sustained by child occupants in these vehicles. For example, the unpadded rear wall of most compact trucks may be struck by occupants either directly, in rear collisions, or on rebound, in frontal collisions, with children seated sideways.

For all vehicles sold in the United States, Federal Motor Vehicle Safety Standard (FMVSS) 201, Occupant Protection in Interior Impact (49 CFR 571.201) Section 55.2 requires that the portion of the seat back that is within the head impact area be tested by a prescribed procedure except in the case of side-facing, folding auxiliary jump seats. Section 55.2.1 of Standard 201 states that the testing requirements do not apply to such temporary seats. Therefore, testing for occupant protection in interior impact is not required for the rear seats in most compact pickup trucks. Results from this study suggest that this exemption should be reconsidered and that testing is needed to ensure sufficient rear occupant space to allow for head excursion in the event of a crash, as well as adequate padding in the rear occupant compartment space.

For more than 20 years, rear seating has been associated with reductions in risk of serious injury and fatality to children.13,14 Recognizing the safety advantages of rear seat occupancy, multiple national organizations, including the National Highway Traffic Safety Administration1 and the American Academy of Pediatrics,3...
have promoted rear seating for children. In the current study, 46% of children in compact extended-cab pickup trucks were in the rear seat, suggesting that many parents are attempting to follow these recommendations, even in compact pickup trucks. These data suggest that the rear seats in compact pickup trucks are not being used as auxiliary seats (i.e., ones that are not intended for regular use) as they were designed, but rather as common seating positions for child passengers. This provides further justification for removing the exemption for testing in FMVSS 201.

Limitations

This study relied on parent report of restraint use by children, which, if differentially reported by vehicle type, might have biased the results. To determine some potential effects of restraint misclassification, we assumed that those identified as unrestrained were indeed unrestrained and that the observed risk of injury among the unrestrained correctly estimates their risk. If we further assume that all of those classified as restrained in other vehicles were correctly classified, 42% of those classified as restrained in compact extended-cab pickup trucks would have to be unrestrained for the risk differences between those restrained in compact pickup trucks and those restrained in other vehicles to be eliminated. Since the maximum misclassification rate among compact extended-cab pickups (which requires the risk of injury among the restrained to be 0) is 49%, this is highly unlikely. Assuming a 20% misclassification rate among other vehicles (the maximum possible is 31%) would require a misclassification rate of 46% among compact extended-cab pickup trucks to nullify risk differences. It is highly unlikely that this large of a differential misclassification exists.

Ongoing comparisons of driver-reported child restraint use and seating position to evidence from crash investigations have demonstrated a high degree of agreement. In addition, our results on age-specific restraint use and seating position are similar to those of other recently reported population-based studies of child occupants.13,15,16

We have used ORs as an approximation to risk ratios; for unusual strata that are at very high risk of injury, such as unrestrained children in high-velocity crashes, this approximation fails and use of the OR will overstate the true increase in risk.

Surveillance data of the nature presented in this study cannot elucidate precise injury mechanisms. More detailed information on the nature and severity of the injuries, occupant kinematics, and the occupant compartment space and configuration is needed to inform regulations for testing.

Recommendations

For families who have a choice of vehicles available for transporting children, clinicians should advise parents against transporting children in compact pickup trucks. When an alternative vehicle is not available, it is not clear whether front vs rear seating is optimal for children in compact extended-cab pickup trucks, though either is clearly preferred to riding in the cargo area, which has a well-described fatality risk.2,3,7,18 In this case, clinicians should advise parents either to consult the vehicle owner’s manual or contact the vehicle manufacturer to obtain recommendations regarding optimal protection of children in the pickup truck.

Author Contributions: Study concept and design: Winston, Kallan, Elliott, Durbin. Acquisition of data: Winston, Kallan, Elliott, Menon. Analysis and interpretation of data: Winston, Kallan, Elliott, Menon, Durbin. Drafting of the manuscript: Winston, Kallan, Elliott, Durbin. Critical revision of the manuscript for important intellectual content: Winston, Kallan, Elliott, Menon, Durbin. Statistical expertise: Kallan, Elliott, Durbin. Obtained funding: Winston. Administrative, technical, or material support: Winston, Menon. Study supervision: Winston, Durbin. Funding/Support: This work was funded by State Farm Insurance Co.

Acknowledgment: We thank State Farm Insurance Co for financial support of this work through the Partners for Child Passenger Safety project. In addition, we thank the many dedicated claim representatives and personnel from State Farm, the research team on the Partners for Child Passenger Safety project and at TraumaLink who devoted countless hours to this study, and the parents who generously agreed to participate in the study.

REFERENCES