Teen drivers and the risk of injury to child passengers in motor vehicle crashes

I G Chen, M R Elliott, D R Durbin, F K Winston

Objectives: The first aim was to examine the relationship between driver’s age (novice teens, older teens, and adults) and child passenger’s restraint status, front row seating, and injury risk. The second aim was to explore whether there was an excess injury risk to child passengers in teen crashes compared to those in adult crashes by examining the contributing factors.

Methods: A cross-sectional study involving telephone interviews with insured drivers in a probability sample of 12,163 crashes involving 19,111 children was conducted. Sequential logistic regressions were employed.

Results: Among child passengers aged 4–8, appropriate restraint was <1% for novice teens, 4.5% for older teens, and 26.5% for adults. Front row seating for children <13 years was more common in the novice teen group (26.8%) than in the other two groups. Compared with children riding with adults, those with both teen groups experienced excess injury risk. After adjusting for crash severity, there was a 43% reduction in the OR for novice teens (OR 1.58, 95% CI 1.14 to 2.19) and a 24% reduction for older teens (OR 2.15, 95% CI 1.42 to 3.26). After adjusting for vehicle type, child’s restraint status, and front row seating, there was a further 19% reduction in the OR for novice teens (OR 1.37, 95% CI 1.00 to 1.88) and another 13% reduction for older teens (OR 1.74, 95% CI 1.14 to 2.66).

Conclusion: These findings suggest ways in which graduated driver licensing laws may be further enhanced to better protect passengers from the excess injury risk associated with teen crashes.

METHODS

Study population and data collection

Data for this cross-sectional study were collected as part of the Partners for Child Passenger Safety project between 1 December 1998 and 30 November 2002. A detailed description of the overall study methods has been published previously. The project consists of a large-scale, child-specific crash surveillance system: insurance claims from State Farm Insurance Corporation (Bloomington, Illinois) function as the source of subjects, with telephone interview and on-site crash investigations serving as the primary sources of data. Vehicles qualifying for inclusion were insured by State Farm, with a model year 1990 or newer, and involved in a crash with at least one child occupant under 16 years of age. Qualifying crashes were limited to those that occurred in 15 states and the District of Columbia. 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 (CHOP/Penn).

Based on the stratum of the vehicle tow status, medical treatment received by child occupants(s), a stratified cluster sample was designed in order to select vehicles (the unit of sampling) for the conduct of a telephone survey with the driver. The probabilities of selection ranged from 0.025 for...
vehicles in which no child received medical treatment to 1.0 for vehicles in which a child died or was admitted to the hospital. If a vehicle was sampled, the “cluster” of all child occupants in that vehicle was included in the survey. Drivers of sampled vehicles were contacted by phone and screened via an abbreviated survey to verify the presence of at least one child occupant with an injury. The full interview involved a 30 minute telephone survey with the driver of the vehicle and parent(s) of the involved children. Only parents and drivers 16 years of age or older were interviewed. The study protocol was reviewed and approved by the institutional review boards of both CHOP/Penn.

The eligible study population consisted of all 430 308 children riding in 288 187 State Farm insured vehicles. Claim representatives correctly identified 95% of eligible vehicles, and 73% of policyholders consented to participate in this study. Of these, 18% were sampled for interview and an estimated 81% of these were successfully interviewed, for an overall response rate of 56%. Examining the characteristics of claims for which consent for the telephone survey was denied, or contact was not achieved, reveals no differences in the age, crash location (that is, state), or driveable status of the vehicle when compared to claims on which an interview was conducted.

Variable definitions
A survey instrument was designed for the telephone interview including questions regarding injuries, seating position, restraint use, and restraint type for each child occupant. Based on the Abbreviated Injury Scale (AIS) score, serious injuries were defined as those deemed clinically significant: all injuries with AIS scores of 2 or greater as well as AIS 1, facial and scalp lacerations injuries. The ability of parents to accurately distinguish AIS 2 or greater injuries from those less severe has been validated for all body regions of injury.20 Three driving groups were defined by driver’s age: novice teen (< 17 years), older teen (18 or 19 years), and adult (≥ 20 years). According to the recommendations for age appropriate restraint and seating position for children by the American Academy of Pediatrics23,24 and National Highway Traffic Safety Administration (NHTSA),25 child’s age was grouped as 0–3, 4–8, 9–12, and 13–15 years. Appropriate restraint use was defined as children under age 1 year weighing less than 20 pounds (9 kg) who were in a rear-facing child safety seat; aged 1–3 and over 20 pounds who were in a forward-facing child safety seat; aged 4–8 who were restrained in some form of child restraint system (typically booster seats); and aged 9–15 years who were restrained in both lap and shoulder belts. Those restrained children who were not in the above categories were defined as inappropriately restrained. A three level crash severity (that is, any intrusion, no intrusion and non-driveable, and no intrusion and driveable) was determined both by whether or not the vehicle was towed from the crash scene as indicated in the insurance claims data, and by driver report of any intrusion into the occupant compartment of the vehicle (that is, the integrity of the vehicle structure was lost and the interior space was reduced). Information on the classification of vehicles was obtained from the vehicle identification number using VINDICATOR.25

Analysis plan
All analyses were conducted on the weighted sample with weights inversely proportional to their probability of selection to reduce the selection effects introduced by the sampling procedure26 using SAS callable SUDAAN.27 The robust $\chi^2$ tests of association were calculated. Odds ratios (OR) were obtained from logistic regressions to approximate the relative risk of serious injury.28 As suggested in Robertson’s causal model of motor vehicle injury,29 there are several possible paths of causation whereby specific factors are proposed to explain the causes of motor vehicle occupant injury. As briefly presented here, injury results from energy generated by speed and mass necessary for the damage of vulnerable tissue. Thus, the speed and size of the vehicle are important predictors of injury risk. Impacts to the vehicle by the driver such as reaction time, vision, intelligence, and motor function are contingent on the demands of the driving environment and are hypothesized to affect injury risk through the loss of vehicle control just before a crash. Based on this model, we proposed a simplified possible causal pathway by first presenting the unadjusted association of driver age to child injury risk (model 1). We then adjusted for child age due to the different distribution of child age groups among the three driver groups and the different injury risk of the child age groups (model 2). Next, we adjusted for crash severity as a proxy for the speed of the vehicle (model 3), followed by adjustment for factors related to vehicle size, restraint use, and seating position (model 4). In this sequential order, we can identify the contribution of modifiable factors to the excess risk for children riding with teen drivers through causal pathways. Results of logistic regression modeling are expressed as unadjusted and adjusted OR with corresponding 95% confidence intervals (CI).

RESULTS
Completed interviews were obtained on 19 111 children in 12 163 crashes representing 243 352 children in 157 824 crashes. Children riding with drivers with unknown age were excluded from the analyses (n = 52). Overall, 2.6% of the children (n = 1084) were driven by novice teens (n = 755), 1.6% (n = 504) by older teens (n = 371), and 95.8% (n = 17 471) by adults (n = 10 999). Table 1 displays passenger, driver, and vehicle characteristics for the three driving groups. When compared with adults, both teen groups had higher percentages of older and female child passengers; children sitting in the front; and unrestrained children. In addition, more child passengers riding with both teen groups were in older vehicles, in passenger cars, and in more severe crashes. Children traveling with both teen groups had a lower percentage of having at least one adult passenger. The highest injury risk for child passengers (5.0%) was found in the novice teen group, sequentially followed by the older teen group (4.3%), and then by the adult group (1.5%).

As shown in table 1, overall, more child passengers were restrained appropriately when with teen drivers compared with those with adults. However, table 2 provides age stratified distribution of child restraint status, front row seating, and serious injury among the three driver groups. The age stratified analyses demonstrate a consistent pattern of less appropriate restraint of younger child passengers with teen drivers. For example, among child passengers aged 4–8 years old, appropriate restraint use was <1% for novice teen drivers, 4.5% for older teen drivers, and 23.6% for adult drivers ($\chi^2$ test: p<0.001). Similarly, front row seating for children under age 13 riding with novice teen drivers was more common than for children with the other two driver groups, although the difference was not statistically significant (novice teen: 26.8%; older teen: 14.8%; adult: 14.6%; $\chi^2$ test: p = 0.31). Within each driver group, as the age of child passenger increased, the injury risk also increased. Traveling with novice teen drivers, children age 13–15 years had the highest injury risk (5.9%).

In table 3, model 1 presents the crude OR for child passenger injury for each teen driver group compared to adult drivers. In model 2, after adjusting for child age groups, those
with both teen groups experienced excess injury risk (for novice teens, OR 2.76, 95% CI 2.10 to 3.63; for older teens, OR 2.83, 95% CI 1.90 to 4.21). In model 3, after adjusting for crash severity, there is a 43% reduction in the odds ratio for children riding with novice teens (OR 1.58, 95% CI 1.14 to 2.19) and a 24% reduction for those with older teens (OR 2.15, 95% CI 1.42 to 3.26). In model 4, after adjusting for vehicle type, child’s front row seating and restraint status, there is a further 19% reduction in the odds ratio for children riding with novice teens (OR 1.37, 95% CI 1.00 to 1.88) and a further 13% reduction for those with older teens (OR 1.74, 95% CI 1.14 to 2.66). As can be seen, the effect of the driver age groups on child injury risk varied considerably from the crude analysis to the final multivariate analyses by adding sequentially child age, and each set of modifiable factors. However, excess risks related to the driver’s age still remained.

### DISCUSSION/CONCLUSION

Previous research has documented the increased injury and death risks to teen drivers and their teen passengers. While children riding with teen drivers may be more likely to be in a crash than children riding with other drivers, children in crashes with teen drivers should, in principle, fare no worse than children in crashes with mature drivers. However, our results extend those early findings to provide the first evidence of the excess risk to child passengers posed by teen drivers based on individual level crash data. Although only 4% of the children in our study were driven by teens, these children had about three times the injury risk when compared with those driven by adults.

In our study, about 40% of the children driven by teens were under 13 years, suggesting that teens not only drive other teens, but they also drive younger children. The age distribution of child passengers in our study differs from

#### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Novice teen (n = 1084 child passengers)</th>
<th>Older teen (n = 504 child passengers)</th>
<th>Adult (n = 17,471 child passengers)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child passenger characteristics</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Serious injury</td>
<td>5.0 (275)</td>
<td>4.3 (120)</td>
<td>1.5 (2309)</td>
<td>&lt;0.001</td>
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<td>Age group</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0–3</td>
<td>4.4 (26)</td>
<td>29.6 (94)</td>
<td>29.2 (4124)</td>
<td></td>
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<tr>
<td>4–8</td>
<td>10.3 (73)</td>
<td>7.7 (48)</td>
<td>34.0 (5798)</td>
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<tr>
<td>9–12</td>
<td>13.1 (158)</td>
<td>20.9 (93)</td>
<td>23.4 (4692)</td>
<td></td>
</tr>
<tr>
<td>13–15</td>
<td>72.2 (822)</td>
<td>41.8 (265)</td>
<td>13.4 (2853)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40.5 (429)</td>
<td>41.6 (216)</td>
<td>38.9 (8321)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>59.5 (655)</td>
<td>58.4 (288)</td>
<td>51.1 (9150)</td>
<td></td>
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<tr>
<td>Front seating</td>
<td>72.0 (553)</td>
<td>36.4 (218)</td>
<td>20.6 (411)</td>
<td>&lt;0.001</td>
</tr>
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<td>Restraint status</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Appropriate</td>
<td>72.3 (725)</td>
<td>68.7 (326)</td>
<td>65.0 (10472)</td>
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<tr>
<td>Inappropriate</td>
<td>19.3 (181)</td>
<td>28.3 (115)</td>
<td>32.3 (6035)</td>
<td></td>
</tr>
<tr>
<td>Unrestrained</td>
<td>8.4 (166)</td>
<td>3.0 (49)</td>
<td>2.7 (879)</td>
<td></td>
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<tr>
<td><strong>Driver characteristics</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SE) age</td>
<td>16.3 (0.06)</td>
<td>18.4 (0.06)</td>
<td>37.1 (0.14)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Male</td>
<td>36.5 (482)</td>
<td>31.8 (185)</td>
<td>28.5 (4692)</td>
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</tr>
<tr>
<td>Female</td>
<td>63.5 (602)</td>
<td>68.3 (319)</td>
<td>71.5 (12779)</td>
<td></td>
</tr>
<tr>
<td>No restraint use</td>
<td>4.3 (83)</td>
<td>7.4 (45)</td>
<td>3.9 (920)</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Other occupant characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult passenger presence</td>
<td>17.0 (117)</td>
<td>10.3 (59)</td>
<td>27.9 (4,476)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of passengers</td>
<td></td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>1</td>
<td>39.9 (365)</td>
<td>44.3 (198)</td>
<td>28.6 (4,827)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60.1 (719)</td>
<td>55.7 (306)</td>
<td>71.4 (12,636)</td>
<td></td>
</tr>
<tr>
<td><strong>Vehicle characteristics</strong></td>
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<td></td>
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</tr>
<tr>
<td>Passenger car</td>
<td>72.2 (793)</td>
<td>74.5 (391)</td>
<td>47.8 (9368)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Large van</td>
<td>0.2 (10)</td>
<td>0.11 (4)</td>
<td>3.0 (459)</td>
<td></td>
</tr>
<tr>
<td>Pickup truck</td>
<td>5.4 (62)</td>
<td>4.2 (27)</td>
<td>6.2 (977)</td>
<td></td>
</tr>
<tr>
<td>Sport utility vehicle</td>
<td>13.2 (105)</td>
<td>17.2 (60)</td>
<td>18.5 (2711)</td>
<td></td>
</tr>
<tr>
<td>Minivan</td>
<td>9.1 (114)</td>
<td>3.9 (22)</td>
<td>24.5 (3956)</td>
<td></td>
</tr>
<tr>
<td>Model year</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1990–1993</td>
<td>32.1 (365)</td>
<td>35.0 (167)</td>
<td>20.5 (4174)</td>
<td></td>
</tr>
<tr>
<td>1994–1996</td>
<td>32.4 (385)</td>
<td>32.1 (173)</td>
<td>28.3 (5475)</td>
<td></td>
</tr>
<tr>
<td>1997–2003</td>
<td>35.6 (334)</td>
<td>32.8 (163)</td>
<td>51.2 (7817)</td>
<td></td>
</tr>
<tr>
<td><strong>Crash severity</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No intrusion (drivable)</td>
<td>36.7 (139)</td>
<td>47.3 (92)</td>
<td>65.3 (6752)</td>
<td></td>
</tr>
<tr>
<td>No intrusion (non-drivable)</td>
<td>47.3 (600)</td>
<td>40.9 (269)</td>
<td>26.7 (7207)</td>
<td></td>
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<tr>
<td>Intrusion</td>
<td>16.0 (307)</td>
<td>11.8 (132)</td>
<td>8.0 (3384)</td>
<td></td>
</tr>
</tbody>
</table>

Note: There were no missing data for the following variables: serious injury, child’s gender, driver’s gender, vehicle type, vehicle model year, adult passenger presence, and number of passengers; the weighted distribution of missing data for the following variables was: 0.02% (unweighted n = 13) for child’s age, 0.02% (unweighted n = 58) for front row seating, 0.3% for restraint status (unweighted n = 111), 0.5% for drivers’ no restraint use (unweighted n = 86), 0.6% for crash severity (unweighted n = 157). Because of missing data, only valid percentages were reported.

*p Values were obtained from χ² tests.
previous research in part due to our study inclusion criteria. Yet our data can provide a unique opportunity to examine how younger children fare with teen drivers. Our finding on the excess injury risk for children in teen crashes, particularly in novice teen crashes, was primarily explained by the more severe crashes those teen drivers incurred. These results are consistent with those of others, which have demonstrated that teens are involved in more severe crashes than adult drivers. The crash severity is likely a function of the teen driver’s inexperienced driving or risk-taking behavior or immaturity. The fact that crash severity reduces more excess risk in novice teen group than in older teen group may explain some effect of driving inexperience. Also, our data appear to support these findings of increased risky driving behavior among teens in that more children riding with teen drivers were in more severe crashes than adults and more children were riding with unrestrained teens, compared with those with adults.

Driver education and graduated driver licensing programs were designed to improve driving skills, and to help teen drivers avoid high risk driving situations. However, driver education failed to reduce the crash rates among teen drivers. Although several studies have demonstrated the effectiveness of graduated driver licensing laws on reducing both fatal and non-fatal crashes among teenage drivers, our data still demonstrate an excess injury risk to child passengers in teen crashes. Since parents are often more motivated to ensure the safety of their young children, interventions should ensure that parents are aware of the excess risk of allowing their teens to drive younger siblings. In addition, the promotion of ideal graduated driver licensing system in all American states and parental management of teen driving are needed to reduce the high crash rate among teen drivers and eventually decrease the excess injury risk for their child passengers.

The American Academy of Pediatrics and NHTSA recommend that all children under age 13 should be seated in the rear in an age appropriate restraint. Of note, our data demonstrated that novice teen drivers are more likely to transport child passengers under 13 in the front seat, not to restrain their child passengers, and to restrain children aged 4–8 inappropriately compared with adults. These behaviors, in part, contributed to the excess injury risk to children riding with teens. The provision of teenage passenger restriction in graduated driver licensing programs allows for exemptions if the passenger is a family member of the driver. Since there are often practical needs for such exemptions, our findings suggest that specific educational interventions regarding child passenger safety should be designed for teens. Provisions for age appropriate restraint and rear seating for child passengers should merit special consideration in graduated driver licensing programs.

More teens in our study drove older or smaller vehicles than adults. Driving or riding in older and smaller vehicles increased the injury risk for both drivers and passengers. In addition, our results showed that vehicle type explained some of the increased injury risk associated with teen driver crashes. As recently suggested, more attention should be given to choosing a safe vehicle for teen drivers.

Ten states included in our study (California, Delaware, Indiana, Nevada, New Jersey, New York, North Carolina, Illinois, Virginia, and West Virginia) initiated some form of
In 15 American states and the District of Columbia, between December 1998 and November 2002, compared with children in adult driver crashes, those in novice and older teen driver crashes experienced excess injury risk. A high rate of age inappropriate restraint for children aged 4–8 years occurs in both novice and older teen driver crashes. Front row seating for children <13 years were more common in novice teen driver crashes than in older teen or adult driver crashes. Much of the excess child injury risk found in both novice and older teen driver crashes is associated with crash severity, vehicle type, child passenger’s restraint status, and child passenger’s front row seating. Provisions for age appropriate restraint and rear seating for young child passengers should merit special consideration in graduate driver licensing programs.

Key points

- In 15 American states and the District of Columbia, between December 1998 and November 2002, compared with children in adult driver crashes, those in novice and older teen driver crashes experienced excess injury risk.
- A high rate of age inappropriate restraint for children aged 4–8 years occurs in both novice and older teen driver crashes.
- Front row seating for children <13 years were more common in novice teen driver crashes than in older teen or adult driver crashes.
- Much of the excess child injury risk found in both novice and older teen driver crashes is associated with crash severity, vehicle type, child passenger’s restraint status, and child passenger’s front row seating.
- Provisions for age appropriate restraint and rear seating for young child passengers should merit special consideration in graduate driver licensing programs.

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Teen drivers, child passengers, and motor vehicle crashes


COCHRANE CORNER

The Cochrane Injuries Group (CIG) is a network of researchers and practitioners who are dedicated to improving the effectiveness of interventions to prevent injury. The group aims to produce high-quality systematic reviews of the evidence base on injury prevention and to disseminate these findings to a wide audience.

Contributors to Injury Prevention have recently published two Cochrane reviews on the treatment of organophosphorus poisoning. This is one of the most common types of poisoning worldwide, with the majority of the victims being in developing countries. Self-poisoning is responsible for many of the cases. Oximes—drugs which appear to reactivate the enzyme acetylcholinesterase, which organophosphorus inhibits—are part of the standard treatment. However, a systematic review of evidence for the use of oximes found that very few studies have taken place to evaluate this treatment, and these had been inconclusive. A further treatment option involves alkalinisation, with sodium bicarbonate used in most cases. Although there are theoretical grounds for thinking that this could be useful, virtually no research has been done and the effectiveness of this approach must remain in the realm of speculation. Thus we have yet another situation where the lack of effective treatment for a condition has highlighted the need to know which prevention measures are effective.

In what kind of state then is the evidence base on poisoning prevention? One of the admirable features of the Cochrane Library is that, as well as including all Cochrane’s systematic reviews, it allows users to see what systematic reviews have been produced by others. A search of the Library’s Database of Abstracts of Reviews of Effectiveness (DARE) is undoubtedly the best way of tracking down non-Cochrane systematic reviews. A DARE search, however, reveals no reviews at all that specifically address interventions to prevent any kind of poisoning.

There is one poisoning prevention review in CIG’s pipeline. Reviewers working with us are examining the effectiveness of childproof containers. We have thus made a very modest start in this neglected area. More, much more, remains to be done and we would very much like to hear from anyone who would like to take on a systematic review of the evidence for the effectiveness of an intervention to prevent poisoning.

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REFERENCES