ARTICLE

Risk Factors for Death Among Older Child and Teenaged Motor Vehicle Passengers

Flaura Koplin Winston, MD, PhD; Michael J. Kallan, MS; Teresa M. Senserrick, PhD; Michael R. Elliott, PhD

Objective: To identify and prioritize risk factors for passenger death.

Design: Retrospective cohort captured in 2 databases: US census of fatal crashes (Fatality Analysis Reporting System) and US-representative sample of police-reported crashes (National Automotive Sampling System Crash Data System).

Setting: Crashes in 50 states and the District of Columbia from January 1, 2000, to December 31, 2005.

Participants: A total of 45 560 passengers aged 8 to 17 years in crashes, representing 2 545 168 passengers (weighted).

Main Exposures: Age and sex of driver, vehicle and road type, restraint use, seating position, day of week, month, time of day, and speed limit.

Outcome Measure: Passenger fatality.

Results: Approximately 424 000 passengers (aged 8-17 years) annually were in tow-away crashes and experienced a fatality rate of 3.9 per 1000. Just more than three-quarters as many passengers (aged 8-17 years) were in crashes with 16- to 19-year-old drivers as with all adult drivers (those aged ≥25 years), with double the passenger fatality rate. For drivers aged 16 to 17 years, passenger fatalities doubled between passenger ages 11 to 12 years and increased to a peak at a passenger age of 16 years. Of crashes with child passenger fatality, 21.2% involved alcohol. In crashes with drivers younger than 18 years, the greatest risk factors for death for passengers aged 8 to 17 years were drivers younger than 16 years, restraint nonuse, and high-speed roads (≥55 and 45-54 mph).

Conclusions: While passenger risks because of restraint nonuse require continued attention, interventions must be developed to address risk because of travel on high-speed roads and riding with drivers younger than 16 years. For safety, child passengers and their parents should monitor these characteristics of the drive and the driver. Anticipatory guidance about passenger risks should begin by the age of 11 years.

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Author Affiliations: Center for Injury Research and Prevention (formerly TraumaLink), The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania (Drs Winston, Senserrick, and Elliott and Mr Kallan); Division of General Pediatrics, Department of Pediatrics (Dr Winston), Leonard Davis Institute for Health Economics (Dr Winston), and Center for Clinical Epidemiology and Biostatistics, School of Medicine (Mr Kallan), University of Pennsylvania, Philadelphia; and Department of Biostatistics, School of Public Health, and Institute for Social Research, University of Michigan, Ann Arbor (Dr Elliott).

FOR OLDER CHILDREN AND teenagers (aged 8 to 17 years) in the United States, motor vehicle crashes (MVCs) are the leading cause of death and are greater than malignant neoplasms, homicide, and suicide combined.[1] The crash injury risks to younger child passengers (those <8 years) have been well described, and effective interventions to increase proper restraint and rear seating have been developed.[2-5] As children grow through adolescence, their passenger experience changes, most notably carriage by nonparent drivers[6-8]; however, to our knowledge, fatality risk factors for these older child and adolescent passengers have not been delineated.[9]

With the profound developmental and social changes that occur from childhood through adolescence, we hypothesized that different passenger age groups would have different fatality risk profiles. In particular, we focused on risk factors that could be easily assessed by parents before a vehicle trip and by the child and adolescent passengers during the trip. Children aged 8 through 12 years, the group for whom the least is known about risk factors,[10] compose the youngest age group for this study. Most children aged 8 to 12 years have graduated from booster seats to seat belts, but should remain seated in the rear.[11] We categorized passengers into 3 age groups: those beyond the current age recommendation for booster seats but still several years before the driving process ("older children," aged 8-12 years), younger teenaged passengers who are not yet drivers ("predrivers," aged 13-15 years), and older teenaged passengers who are likely newly licensed drivers themselves (aged 16-17 years).[12]

An important risk factor for all passengers is driver age, particularly newly licensed teenaged drivers.[8,9] Based on previous research, we hypothesized decreasing risk attributed to driver age groups as follows: highest for drivers younger than 16 years (most of whom are below common licensing age and at high crash risk),[12-14] followed by drivers aged 16 to 17 years (young and newly licensed drivers), then drivers aged 18 to 19 years (older teenaged drivers with likely more driving experience and somewhat reduced crash risk),[15] then drivers aged 20 to 24 years (young adult drivers for whom alcohol-related crash risk becomes more prominent),[16] and, with the lowest risk, drivers 25 years and older, who will serve as our comparison adult sample.

Within the passenger age groups, we hypothesized the following assessable risk factors: restraint use,[2-5] seating position,[4] driver license status,[15] driver alcohol use,[16] driver sex,[17] number of passengers who are not adults,[6,18,19] and vehicle type.[20,21] Day of week, time of day, month, and season were also considered,[22,23] as were road type[24] and speed limits.[25]

The purpose of this article was to simultaneously assess multiple risk factors for death among older child and teenaged passengers in MVCs to develop risk profiles by passenger age groups to inform passenger safety interventions directed at child and adolescent passengers and their parents.

METHODS

This study used 2 data sources, the US National Highway Traffic Safety Administration Fatality Analysis Reporting System (FARS) and the US National Highway Traffic Safety Administration National Automotive Sampling System Crash Data System (NASS-CDS), to create a single cohort of children aged 8 to 17 years in tow-away crashes (ie, those crashes severe enough to require towing from the scene). Tow-away crashes in which a child or teenager died were drawn from FARS, and tow-away crashes in which a child or teenager survived were drawn from the FARS (child and teenaged survivors of fatal crashes) and the NASS-CDS. By applying methods developed previously,[5] the case-fatality ratios (deaths per tow-away crash) under various driving conditions were compared and a multivariate model was created to determine the independent risk factors of older child or teenager passenger death.

STUDY POPULATION

The cohort was nationally representative of older child and adolescent passengers under the legal majority age (18 years) in tow-away MVCs that occurred between January 1, 2000, and December 31, 2005. Subjects were grouped into 3 passenger age groups: 8 to 12, 13 to 15, and 16 to 17 years. Herein, the population is also referred to collectively as "child passengers."

DATA SOURCES

Fatality Analysis Reporting System

The FARS is a census of crash-involved fatalities. To be included in the FARS, a crash must involve a motor vehicle traveling on a public traffic way in the 50 states and the District of Columbia and result in the death of a person (occupant of a vehicle or a nonoccupant) within 30 days of the crash. For this study, all crashes involving at least 1 (nondriver) passenger fatality (aged 8-17 years) were included. Data for FARS come from a variety of sources, including police crash reports, state vehicle registration and driver licensing files, vital statistics, coroner and medical examiner reports, hospital medical records, and emergency medical service reports. To be comparable with the NASS-CDS database described later, 7% of children in vehicles involved in fatal crashes who could be driven from the scene were excluded from the analysis. Crashes between 2000 and 2005 were analyzed. A few crashes in which only nonoccupants (eg, pedestrians) died, and children known not to be in an enclosed seating position (eg, those seated in the open bed of a pickup truck), were also excluded from the analysis. Given these inclusion criteria, we identified within the FARS 9807 children aged 8 to 17 years who died in passenger vehicle crashes from 2000 to 2005; an additional 30 755 children aged 8 to 17 years were in passenger vehicle crashes in which someone else died and were included in the FARS data set.

National Automotive Sampling System Crash Data System

A sample of child passengers involved in nonfatal crashes was obtained from the NASS-CDS. The NASS-CDS is a representative 3-stage probability sample selected annually from all police-reported crashes that resulted in vehicles having to be towed from the scene for damage (tow-away crashes). The first stage consists of a sample of geographic regions (primary sampling units) across the United States. A sample of police jurisdictions is then drawn with probability proportional to the number of crashes investigated within the jurisdiction. The third stage consists of a sample of crashes stratified by crash severity and model year, with an oversample of more severe crashes. Approximately 5000 vehicles per year were sampled as part of the NASS-CDS. Data for the NASS-CDS were collected via trained crash investigators based on crash site evidence, interviews with drivers and passengers, and reviews of medical records. Within the NASS-CDS, we identified 4998 children between the ages of 8 and 17 years who were passengers in a passenger car, van, pickup truck, or SUV involved in a nonfatal crash sampled from 2000 to 2005. Because of the complex sample design of the NASS-CDS, these 4998 children represent 2 504 606 children meeting our inclusion criteria.

Combined FARS/NASS-CDS Cohort

Therefore, the combined FARS and NASS-CDS cohort of child passengers in tow-away crashes totaled 45 560 over the 6 years of study and represented 2 545 168 older child and adolescent passengers.

Both FARS and NASS-CDS data sets have no individual identifiers and are publicly available; therefore, no institutional review board approval was required for these analyses.

VARIABLE DEFINITIONS

Age

Three passenger age group categorizations were described by year of age: 8 to 12, 13 to 15, and 16 to 17 years. Driver age was categorized into 5 age groups by year of age: younger than 16, 16 to 17, 18 to 19, 20 to 24, and 25 years and older.

Driver Licensure

The FARS data also allowed a license status variable to be included: learner (requires supervision), licensed (including full and intermediate, provisional, probationary, or other restricted licenses), and unlicensed (including suspended and revoked licenses). This information was, however, unavailable in the NASS-CDS and, therefore, license status analyses were limited to fatal crashes only.

Occupant Restraint

Restraint use and seating row were explored as dichotomous variables (restraint use vs nonuse and front vs rear seating). Restraint status information was missing in approximately 6% of the FARS and 1.5% of the NASS-CDS cases. Because preliminary analyses suggested that the fatality risks were similar for those who were unrestrained and those of unknown restraint, we included unknown restraint cases together with those known to be unrestrained in the analysis.

Driver Alcohol Use

Alcohol use was determined based on blood alcohol content (BAC). Given the legal drinking age across the United States is 21 years, we examined the presence of any alcohol (BAC level, >0) vs none (BAC level, 0). Because reliable BAC measures, defined as those obtained by breath or saliva tests, were either missing or unknown for drivers of 5571 (5.7%) of the fatally injured children, we used the multiple imputations of BAC level available in the FARS. Point estimates and confidence intervals for alcohol use were determined using the standard method for combining point and variance estimates from each of the multiple imputed data sets.[26] Because the NASS-CDS data set did not contain a driver alcohol use variable, alcohol could not be explored as a risk factor in any of the multivariate models, and analyses involving alcohol were limited to the fatal crashes only.

Other Variables

Vehicle type was categorized into passenger cars, cargo vans, pickup trucks, SUVs, and minivans. Day of week was explored by individual days and weekdays (Monday to Thursday) vs weekend days (Friday to Sunday). Time of day was explored in terms of daytime (6 AM through 9:59 PM) and nighttime (10 PM through 5:59 AM) hours, split according to the commonly recommended hours for nighttime driving restrictions for newly licensed drivers.[1,27] Road type was examined in terms of the presence or absence of physical division, including a barrier: not physically divided, physically divided without barrier, physically divided with barrier, and one way or other. Speed limits were grouped as less than 35, 35 to 44, 45 to 54, 55 mph or more and unknown or none.

STATISTICAL ANALYSES

Case-fatality ratios were estimates weighted to account for sampling in the NASS-CDS and calculated based on the aggregated 6 years (2000-2005) of data in the combined FARS/NASS-CDS cohort data set.

Logistic regression modeling was used to compute the relative risk of death for child passengers as a function of a variety of predictors, including age of driver, age of passenger, driver restraint use, passenger restraint use, seating position, driver sex, vehicle type, day of week, time of day, season of crash, and speed limit. To estimate adjusted relative risks, we used odds ratios (ORs) from logistic regression; ORs will approximate relative risks when the outcome is uncommon, as fatalities are in this study. To determine important independent predictors of child passenger mortality, a backward selection procedure was used in which predictors with the largest *P* values were dropped until all remaining predictors were significant at $\alpha = .10$. All predictors, except season (which showed little variation among fatality crashes), were included in the final model. Effect modification because of driver age was assessed for driver restraint, driver sex, passenger seating row, and time of day to analyze for differences between the driver age group and the reference driver age group (aged ≥25 years).

To account for the unequal probability of selection for controls in the NASS-CDS, case weights equal to the inverse of the probability of selection and adjusted to known crash totals were used to account for the oversampling of severe crashes in the NASS-CDS. (Case weights in the FARS were set to 1, consistent with the FARS being a census of all fatalities.) To adjust inference to account for the disproportional probability of selection of subjects and stratification and clustering of subjects by geographic region and vehicle, robust χ^2 tests of association and Taylor series linearization estimates of the logistic regression variances were calculated using SAS-callable SUDAAN (Software for the Statistical Analysis of Correlated Data, Version 9.1; Research Triangle Institute, Research Triangle Park, North Carolina).

RESULTS

DESCRIPTION OF FATAL CRASH CHARACTERISTICS FOR PASSENGERS AGED 8 TO 17 YEARS

Over 6 years, an average of 424 195 children aged 8 to 17 years, per year, were passengers in tow-away MVCs, with an overall case-fatality ratio of 4 deaths per 1000 tow-away crashes. An overview of the characteristics of fatal crashes is provided in **Table 1**, before examining risks by passenger age groups. Between 2000 and 2005, 9807 children aged 8 to 17 years in an enclosed seating position died as passengers in tow-away MVCs. More than half of the children (54.4%) died as passengers of young drivers (aged <20 years). Almost two-thirds of the children who died were unrestrained. Almost two-thirds of the deaths occurred with male drivers. Using the multiple imputed FARS data, driver alcohol use was a factor in more than one-fifth of cases (21.2%; 95% confidence interval, 20.3%-22.1%). More than one-sixth of drivers were unlicensed. Sport-utility vehicles and pickup trucks were the most prevalent vehicle types, after passenger cars, in the crashes involving fatalities. Fatalities more commonly occurred on weekends, with little seasonal variation. More than half of the deaths occurred on the highest-speed roads (≥55 mph).

The distribution of fatalities by passenger age varied with driver age group, as presented in **Figure 1**. For crashes with adult drivers aged 25 years and older, the number of passenger fatalities was nearly constant for each passenger ages from 8 to 17. For crashes with drivers aged 20 to 24 years, there was a general trend of increasing passenger fatalities from passenger age 10 through 17 years. For crashes with drivers aged 16 to 17 years, the increase in fatalities begins at the age of 11 years. For drivers aged 18 to 19 years, the increase in fatalities begins at the age of 12 years.

FATALITY RISK FOR PASSENGERS AGED 8 TO 17 YEARS IN TOW-AWAY CRASHES: UNIVARIATE ANALYSES

Using the combined FARS/NASS-CDS data set, **Figure 2** displays the exposure of child passengers to tow-away

Table 1. Distribution of Child Passenger Characteristics in Tow-Away Crashes, by Status of the Crash as Fatal or Nonfatal: 2000-2005[a]

Characteristic	Fatal Crash	Nonfatal Crash	All Crashes
Age of passenger, y			
8-12	23.1	34.8	34.8
13-15	30.5	32.0	32.0
16-17	46.4	33.2	33.2
Unrestrained passenger	65.9	15.0	15.2
Front row seating of passenger	53.2	48.6	48.7
Age of driver, y			
<16	3.9	1.2	1.2
16-17	31.8	28.2	28.3
18-19	18.7	11.4	11.4
20-24	11.8	7.6	7.6
≥25	33.8	51.6	51.6
Unrestrained driver	44.6	9.6	9.7
Male driver	63.5	48.9	49.0
Driver died	27.4	0.4	0.5
Driver used alcohol	21.2	[b]	[b]
Driver license status			
Learner	1.8	[b]	[b]
Licensed	79.6	[b]	[b]
Unlicensed	17.4	[b]	[b]
Unknown	1.2	[b]	[b]
Vehicle type			
Passenger car	66.1	62.3	62.3
Large van	1.3	1.2	1.2
Pickup truck	11.0	6.9	6.9
Sport-utility vehicle	15.2	17.2	17.2
Minivan	6.4	12.4	12.4
Crash time			
10 PM-5:59 AM	27.4	10.9	10.9
6 AM-9:59 PM	72.2	89.1	89.1
Unknown	0.4	0	0
Time of year[c]			
Jan-Mar	21.4	20.8	20.8
Apr-Jun	26.1	26.4	26.4
Jul-Sep	28.5	29.4	29.4
Oct-Dec	24.0	23.5	23.5
Day of week			
Mon-Thu	43.1	54.0	54.0
Fri-Sun	56.9	46.0	46.0
Speed limit, mph			
<35	8.2	19.6	19.6
35-44	13.7	34.8	34.7
45-54	17.5	21.0	21.0
≥55	58.9	22.7	22.8
Unknown or none	1.7	1.9	1.9

[a] Data are from the US Department of Transportation Fatality Analysis Reporting System (FARS) for fatal crashes and from the National Automotive Sampling System Crash Data System (NASS-CDS) for nonfatal crashes. Data are presented as actual percentage for fatal crashes (the FARS is a census of fatal crashes) and as weighted percentage for nonfatal crashes (the NASS-CDS is a sample of tow-away crashes). Child passengers were those aged 8 to 17 years; a fatal crash was one in which a child passenger died, and a nonfatal crash was one in which no child passenger died.
[b] Characteristic not recorded in the NASS-CDS.
[c] Percentages may not total 100 because of rounding.

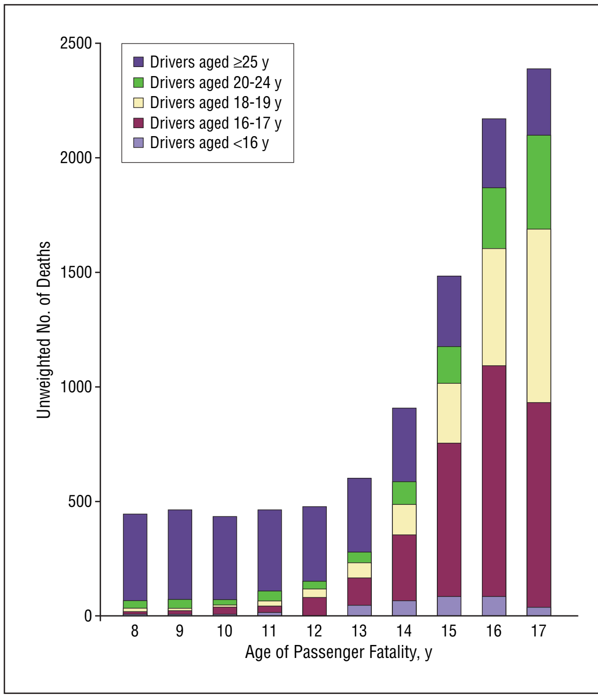

Figure 1. Distribution of child passenger (aged 8-17 years) fatalities in tow-away crashes by passenger age and driver age group. Data are from the US Department of Transportation Fatal Analysis Reporting System from January 1, 2000, to December 31, 2005.

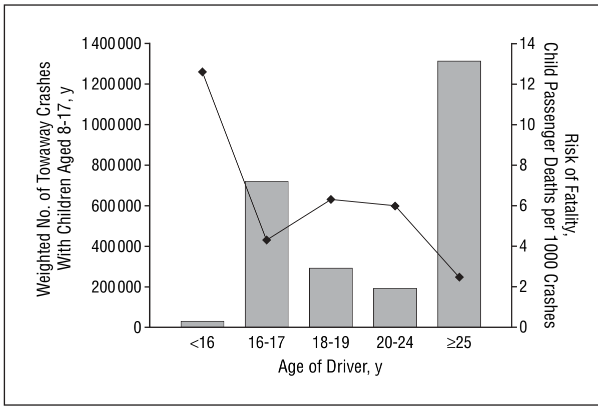

Figure 2. Exposure of child passengers (aged 8-17 years) to tow-away crashes (bar plot) and the associated fatality risk by driver age group (line plot). Data are from the US Department of Transportation Fatal Analysis Reporting System from January 1, 2000, to December 31, 2005.

crashes with the associated fatality risk by driver age. The highest risk of death was in crashes with drivers younger than 16 years, but these crashes occurred less frequently than with drivers at older ages. There were approximately three-fourths as many children in tow-away crashes with drivers in the combined 16 to 17 and 18 to 19 years age groups as with all drivers 25 years and older; in addition, the risk of fatality with these younger drivers was at least double that with drivers 25 years and older.

Table 2 presents exposures and case-fatality ratios (deaths per 1000 tow-away collisions) overall and then by the 3 passenger age groups. Between 2000 and 2005, an estimated 2 545 168 children aged 8 to 17 years were in tow-away crashes. Approximately 4 children in 1000 tow-away crashes (0.39%) died, increasing with child age: 2.6 for those aged 8 to 12 years, 3.7 for those aged 13 to 15 years, and 5.4 for those aged 16 to 17 years.

Table 2. Case-Fatality Ratio per 1000 Tow-Away Crashes for Child Passengers Overall and by Passenger Age Group[a]

Characteristic	All Passengers Aged 8-17 y	Passengers Aged 8-12 y Only	Passengers Aged 13-15 y Only	Passengers Aged 16-17 y Only
Passenger restraint				
Restrained	1.5 (**3343**)	1.2 (1005)	1.4 (970)	2.1 (1368)
Unrestrained	16.7 (**6464**)	18.6 (1259)	14.5 (2019)	17.8 (3186)
Passenger seating row				
Front row	4.2 (**5219**)	3.7 (829)	3.3 (1543)	5.1 (2847)
Rear row(s)	3.5 (**4588**)	2.2 (1435)	4.1 (1446)	5.9 (1707)
Age of driver, y				
<16	12.6 (**379**)	34.4 (49)	13.8 (206)	9.1 (124)
16-17	4.3 (**3117**)	3.2 (155)	3.9 (1065)	4.8 (1897)
18-19	6.3 (**1832**)	6.9 (95)	6.1 (471)	6.3 (1266)
20-24	6.0 (**1160**)	4.4 (168)	7.9 (308)	6.0 (684)
≥25	2.5 (**3319**)	2.3 (1797)	2.3 (939)	4.8 (583)
Driver restraint				
Restrained	2.4 (**5432**)	1.8 (1479)	2.2 (1660)	3.2 (2293)
Unrestrained	17.7 (**4375**)	16.6 (785)	17.6 (1329)	18.1 (2261)
Driver sex				
Male	5.0 (**6232**)	3.8 (1019)	4.1 (1929)	6.4 (3284)
Female	2.8 (**3575**)	2.0 (1245)	3.1 (1060)	3.8 (1270)
Driver fatality				
Yes	218.3 (**2683**	190.2 (637)	209.3 (821)	244.0 (1225)
No	2.8 (**7124**)	1.8 (1627)	2.7 (2168)	4.0 (3329)
Vehicle type				
Passenger car	4.1 (**6487**)	3.1 (1200)	3.4 (1962)	5.3 (3325)
Large van	4.3 (**127**)	2.9 (54)	4.6 (34)	11.8 (39)
Pickup truck	6.1 (**1077**)	5.3 (273)	6.9 (320)	6.2 (484)
Sport-utility vehicle	3.4 (**1489**)	2.0 (448)	4.2 (483)	5.9 (558)
Minivan	2.0 (**627**)	1.4 (289)	2.6 (190)	3.9 (148)
Crash time				
10 PM-5:59 AM	9.6 (**2688**)	5.0 (296)	9.8 (761)	11.5 (1631)
6 AM-9:59 PM	3.1 (**7083**)	2.4 (1963)	3.0 (2218)	4.1 (2902)
Time of year				
Jan-Mar	4.0 (**2099**)	2.1 (448)	4.7 (623)	5.5 (1028)
Apr-Jun	3.8 (**2560**)	2.2 (583)	3.6 (775)	6.3 (1202)
Jul-Sep	3.7 (**2797**)	2.6 (697)	3.9 (858)	4.9 (1242)
Oct-Dec	3.9 (**2351**)	3.8 (536)	3.1 (733)	5.0 (1082)
Day of week				
Mon-Thu	3.1 (**4230**)	2.1 (981)	2.7 (1334)	4.7 (1915)
Fri-Sun	4.8 (**5577**)	3.1 (1283)	5.2 (1655)	6.0 (2639)
Speed limit, mph				
<35	1.6 (**803**)	0.9 (111)	1.6 (263)	2.1 (429)
35-44	1.5 (**1346**)	0.7 (200)	1.3 (398)	2.6 (748)
45-54	3.2 (**1714**)	2.0 (341)	2.9 (516)	4.5 (857)
≥55	10.0 (**5774**)	5.5 (1592)	11.8 (1751)	17.3 (2431)
Unknown or none	3.5 (**170**)	0.9 (20)	4.1 (61)	6.7 (89)

[a] Data are given as weighted ratio (number of deaths per 1000 tow-away crashes) for child passengers (aged 8-17 years). Data are from the Fatality Analysis Reporting System and the National Automotive Sampling System Crash Data System from January 1, 2000, to December 31, 2005.

While the fewest child passenger deaths occurred with drivers younger than 16 years, the case-fatality ratio was highest with these drivers within each passenger age group. Case-fatality ratios were also consistently higher when passengers were unrestrained vs restrained, were traveling with male vs female drivers, and were traveling on weekends vs weekdays. Rear vs front row seating position presented a lower case-fatality ratio for the youngest passenger group, while minivans were the safest vehicle for all passenger age groups. The case-fatality ratio increased incrementally from the 2 lowest speed groupings (<35 and 35-44 mph), to 45- to 54-mph roads, and again to 55-mph roads or more, both overall and by each passenger age group.

FATALITY RISK FOR PASSENGERS AGED 8 TO 17 YEARS IN TOW-AWAY CRASHES: ADJUSTED ANALYSES

Table 3 presents the adjusted risk factors for child passenger fatality in tow-away crashes overall and by passenger age group. Because death is a rare outcome, ORs approximated relative risks. When compared with children in tow-away crashes with drivers 25 years and older, those with drivers younger than 16 years were at a significantly increased risk of death. The greatest independent risks of death, however, were 55-mph roads or more and passenger unrestrained, with 45- to 54-mph roads also high risk. These risk factors were the leading fac-

Table 3. Risk Factors for Child Passenger Fatality in Tow-Away Crashes Overall and by Passenger Age Group[a]

Characteristic	All Passengers Aged 8-17 y	Passengers Aged 8-12 y Only	Passengers Aged 13-15 y Only	Passengers Aged 16-17 y Only
Age of passenger, y				
8-12	1 [Reference]	NA	NA	NA
13-15	0.84 (0.67-1.05)	NA	NA	NA
16-17	0.80 (0.55-1.14)	NA	NA	NA
Age of driver, y				
<16	4.28 (2.65-6.91)	7.04 (3.82-12.97)	5.43 (3.46-8.52)	2.49 (1.12-5.53)
16-17	1.10 (0.81-1.50)	0.59 (0.13-2.68)	1.55 (1.09-2.19)	0.89 (0.53-1.51)
18-19	1.00 (0.64-1.56)	1.77 (0.70-4.48)	1.79 (0.91-3.52)	0.78 (0.46-1.30)
20-24	1.48 (1.04-2.09)	1.56 (0.61-4.03)	2.39 (1.31-4.35)	0.95 (0.54-1.67)
≥25	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Unrestrained passenger	9.61 (7.53-12.27)	17.49 (10.87-28.14)	13.67 (8.78-21.30)	6.17 (4.25-8.96)
Front row passenger seating	1.48 (1.19-1.82)	1.77 (1.07-2.93)	2.12 (1.34-3.35)	1.03 (0.76-1.38)
Unrestrained driver	1.60 (1.14-2.25)	1.86 (1.19-2.91)	1.32 (0.72-2.41)	1.84 (1.22-2.77)
Male driver	1.33 (0.98-1.82)	0.95 (0.56-1.60)	1.09 (0.81-1.46)	1.62 (1.14-2.32)
Vehicle type				
Passenger car	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Large van	0.97 (0.43-2.20)	0.51 (0.16-1.70)	1.36 (0.61-3.02)	1.47 (0.67-3.21)
Pickup truck	0.48 (0.24-0.98)	0.41 (0.17-0.99)	0.51 (0.31-0.84)	0.51 (0.20-1.34)
Sport-utility vehicle	0.92 (0.63-1.35)	0.56 (0.37-0.84)	1.23 (0.59-2.58)	1.00 (0.74-1.35)
Minivan	0.47 (0.28-0.80)	0.38 (0.23-0.62)	1.32 (0.79-2.22)	0.31 (0.09-1.11)
Crash time				
10 PM-5:59 AM	2.08 (1.52-2.85)	2.24 (1.35-3.71)	1.68 (1.13-2.50)	2.15 (1.35-3.41)
6 AM-9:59 PM	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Day of week				
Mon-Thu	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Fri-Sun	1.45 (1.10-1.93)	1.23 (0.90-1.69)	1.57 (1.18-2.09)	1.24 (0.87-1.78)
Speed limit, mph				
<35	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
35-44	1.45 (1.03-2.04)	1.08 (0.59-2.00)	1.27 (0.68-2.37)	1.89 (1.23-2.92)
45-54	4.15 (2.38-7.25)	4.61 (2.33-9.10)	3.92 (1.88-8.17)	4.17 (2.07-8.40)
≥55	12.47 (7.75-20.07)	16.59 (8.52-32.31)	13.25 (7.79-22.54)	12.60 (7.52-21.11)
Unknown or none	2.89 (0.93-8.97)	2.18 (0.38-12.58)	2.79 (0.65-12.03)	2.92 (1.04-8.17)

Abbreviation: NA, data not applicable.
[a] Data are given as adjusted odds ratio (95% confidence interval) and were determined via multivariate logistic regression modeling, including all characteristics simultaneously. Data are from the Fatality Analysis Reporting System and the National Automotive Sampling System Crash Data System from January 1, 2000, to December 31, 2005. Because death is a rare outcome, the odds ratios approximate relative risk. Child passengers were those aged 8 to 17 years.

tors across the 3 age subgroups (8-12, 13-15, and 16-17 years) studied.

EFFECT MODIFICATION WITH DRIVER AGE

We also considered whether the effects of the various predictors of fatality risk differed by the age of the driver. Being unrestrained increased risk of injury more in older drivers than in younger drivers, cars were consistently higher risk than other vehicle types among adult drivers only, and the increased risk of death during weekend crashes and higher-speed crashes was much more pronounced among drivers younger than 16 years. Effect modification was statistically significant for passenger restraint at $P < .001$. Significance at this level was not reached for other factors, likely because of the small sample sizes.

COMMENT

This study provides estimates of the prevalence of and risk factors for fatality among older child and adolescent passengers in the United States. During a 6-year period, 2.5 million children were involved in tow-away crashes, with a case-fatality ratio approximating 4 deaths per 1000 tow-away crashes. While fatalities with adult drivers decreased slightly with passenger age, more fatalities by age of child for younger drivers was noted for passengers starting at the ages of 11 to 12 years. We found 4 factors, while varying in order, were consistently the greatest predictors of death for older child and adolescent passengers overall and by passenger age group. These were nonuse of restraint, high-speed and midspeed roads (≥55 and 45-54 mph, respectively), and driver age younger than 16 years. Furthermore, we found that passenger restraint use was more protective among drivers 20 years and older.

Our study supports earlier findings[2-5,25] on the crucial role of restraints in preventing fatalities to child passengers and the increased risk presented by travel on high-speed roads. The importance of restraint is highlighted in parent interventions[11]; however, the risk to children as passengers traveling on high-speed roads is not commonly addressed. Ontario has legislated restrictions on freeway driving for teen drivers in the adult-supervised driving phase of graduated licensing (learner phase),[28] and an exemplary parent-teenager driving agreement program has included driving on high-speed roads as a recommended restriction for newly licensed drivers.[29,30] The latter approach may be more practical than introducing licensing restrictions, because it is not always possible to avoid high-speed roads. It may also be more beneficial for learner drivers to gain experience in this high-risk condition while under supervision and in the safest driving stage they will experience during their lifetime.[15] High-speed roads can be equipped with additional safety features, such as roadside and midlane barriers, offering better protection in areas with only unsealed or poorly maintained roads as alternatives.[24] Nevertheless, interventions could aim to raise awareness of this risk and develop strategies for passengers and drivers to reduce distractions and negative influences in this high-risk condition.[31,32]

Our findings also support previous research[8,9] showing inflated crash risk to teenaged passengers of teenaged drivers, but also extend this research to explore risks by several young driver age groups, including drivers younger than 16 years and those aged 20 to 24 years, and by several passenger age groups, including preteenaged older child passengers. While tow-away crashes with drivers younger than 16 years were the least common among the driver age groups, likely because of the lowest driving exposure, they posed the most extreme fatality risk to child passengers compared with any other driver age group. Many states have introduced restrictions on carriage of young passengers in their graduated licensing systems, but some states that allow driving while younger than 16 years do not restrict passengers, including on licenses that allow travel solely to and from school or for farming reasons.[12,33] Our consistent finding of drivers younger than 16 years as a fatality risk factor for all passenger age groups suggests that these states should raise the minimum licensing age or, at minimum, restrict nonadult passengers for these drivers. Recently published research[13,14] suggests, however, that as many as 1 in 10 drivers younger than 18 years are actually unlicensed. Additional research, intervention development, and evaluation must be pursued nationally to address unlicensed driving, particularly among those who present extreme risk: drivers younger than 16 years. Few studies on young unlicensed driving are identifiable in published literature.[13,14,34] Also needed is a better understanding about the relationships among the drivers and the passengers. It is unclear how much of the additional risk is due to younger children being driven by older friends vs older siblings; previous research[35] has shown that children being driven by teenaged siblings are at lower risk for injury in a crash than children being driven by other teenagers (although still at higher risk than when being driven by adults). Because licensure status is not collected in the NASS-CDS and relationship data are not collected in either the FARS or the NASS-CDS, either changes to the data collection procedure must be made or new studies must be conducted to obtain this information.

Our analysis was not without limitations. Approximately 6% of the FARS and 1.5% of the NASS-CDS children aged 8 to 17 years (and the associated drivers) were missing restraint status information and were combined with the unrestrained. As a sensitivity analysis, we combined those missing restraint status with the restrained; the resulting OR of fatality for being unrestrained vs restrained was reduced to 6.55 (95% confidence interval, 5.11-8.39). Little change resulted in the OR of the other predictors. Among these 8- to 17-year-old passengers, seating position was either unknown or nonapplicable (eg, seated in an unenclosed area) in 4% of the FARS cases and in 1% of the NASS-CDS cases. In addition, 0.5% of data were missing in both data sets for driver age, vehicle type, crash time, and day of week. While alcohol use was noted in a large minority of fatal crashes, a lack of compatibility between the FARS and NASS-CDS data sets on this variable precluded inclusion of alcohol as a factor in multivariate modeling.

In conclusion, messages by health care providers (including physicians, nurses, and others), schools, and public health officials need to inform parents of the risk to their preteenaged and young teenaged children when these children are passengers of drivers younger than 25 years. Emphasis should be placed on the risks due to restraint nonuse, travel on high-speed roads, and riding with drivers younger than 16 years. These findings can guide parents' decisions about with whom and where they permit their children to ride in vehicles. Furthermore, child passengers should be made aware of factors they should monitor about the drive and the driver when they are passengers of young drivers. Ideally, the messages should be delivered to child passengers and their parents before the children turn 11 years because it is at the age of 10 years when increases in passenger fatalities with young drivers first emerge.

For the safety of child and adolescent passengers, licensing laws must progress toward higher minimum licensing ages and restrict carriage of nonadult passengers by newly licensed drivers. Similarly, schools should review their policies around carpooling of older child and young adolescent passengers by young drivers. This point was also highlighted in the 2007 American Academy of Pediatrics School Transportation Safety policy statement.[36]

Concurrently, more research to understand and reduce unlicensed driving is essential, especially targeting drivers younger than 16 years. Further work needs to explore how best to reach families and young teens in preventing exposure to these high-risk situations.

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Correspondence: Flaura Koplin Winston, MD, PhD, The Children's Hospital of Philadelphia, 3535 Market St, Ste 1150, Philadelphia, PA 19104 (flaura@mail.med.upenn.edu).
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