Teens have the highest crash rate of any group in the United States.

Teen Driver Risk in Relation to Age and Number of Passengers

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About the Sponsor

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Abstract

The presence of passengers in a vehicle has been shown to increase the risk of fatal crash involvement for teenage drivers; however, the studies that have quantified this relationship were based on data that are now over a decade old. In the years since these studies, most U.S. states have enacted graduated driver licensing systems that limit the number of passengers that young drivers are allowed to carry during their first several months of independent driving, and the number of 16- and 17-year-old drivers involved in fatal crashes each year has decreased by more than half. The objective of this study was to provide updated estimates of the relationship between the number and ages of passengers present and the crash risk per mile driven of 16- and 17-year-old drivers.

Data on crashes that occurred in years 2007–2010 and data on the number of miles driven in years 2008–2009 were examined. Rates of crash involvement and driver death per mile driven were estimated for 16- and 17-year-old drivers with no passengers; with one, two, and three or more passengers younger than age 21 (and no older passengers); and with at least one passenger aged 35 or older.

Compared with having no passengers, having one passenger younger than age 21 (and no older passengers) was associated with a 44% increase in a 16- or 17-year-old driver's risk per mile driven of being killed in a crash (Relative Risk [RR] 1.44, 95% Confidence Interval [CI] 1.01 – 2.04). Having two passengers younger than age 21 was associated with a doubling of a driver's risk of being killed in a crash, compared with having no passengers (RR 2.02, 95% CI 1.36 – 2.99). Having three or more passengers younger than age 21 was associated with roughly a quadrupling of a driver's risk of being killed in a crash, compared with having no passengers (RR 4.39, 95% CI 1.45 – 13.31). The relative risk of being involved in any police-reported crash in the presence of young passengers followed a similar pattern; however, the increases in relative risk of being involved in any police-reported crash were smaller and were not statistically significant.

Having at least one passenger aged 35 or older in the vehicle was associated with a 62% *decrease* in a 16- or 17-year-old driver's risk per mile driven of being killed in a crash (RR 0.38, 95% CI: 0.24 – 0.60), and a 46% decrease in the risk of being involved in any police-reported crash (RR 0.54, 95% CI 0.35 – 0.84), compared with having no passengers.

These results show that although the overall number of teen driver fatalities has decreased substantially over the past several years, carrying young passengers is still a significant risk factor for young drivers. In contrast, carrying adult passengers significantly reduces the risks of crash involvement.

Introduction

Per mile driven, drivers under the age of 20 have higher rates of involvement in fatal crashes than drivers of any other age group except drivers aged 80 and older (Insurance Institute for Highway Safety, 2012). Whereas the apparent over-involvement of older drivers in fatal crashes is predominantly attributable to their elevated probability of dying if they are involved in a crash—not excessive risk of crashing—young drivers' excessive involvement in fatal crashes is due to excessive crash risk (Li et al., 2003). While drivers aged 85 and older have the highest rate of death per mile driven, drivers aged 16-17 have the highest rate of involvement in crashes that result in the death of occupants of other vehicles or non-motorists (Tefft, 2008).

Several studies have found that in relation to their exposure (e.g., number of trips or number of miles driven), young drivers have higher rates of crash involvement, injury, and death when carrying passengers. Doherty et al. (1998) analyzed data from the province of Ontario, Canada on the driving exposure and crash involvement of drivers, and identified carrying passengers as a risk factor for drivers aged 16-19, and also found that having two or more passengers was associated with greater risk than having only one passenger. Chen et al. (2000) performed a similar analysis of data from the United States and found that carrying passengers was associated with increased risk of involvement in a crash fatal to the driver for drivers aged 16-19, and also found that the risk increased with the number of passengers. Rice et al. (2003) analyzed data from crashes in the state of California in which a driver aged 16 or 17 was injured, using a quasi-induced exposure method which involved comparing the relative frequency of crashes in which a young driver was versus was not deemed culpable. It was estimated that carrying teenage male passengers or mixed-gender combinations of teenage passengers was associated with significantly increased crash risk, carrying teenage female passengers was not associated with increased risk, and carrying passengers aged 30 or older was associated with significantly decreased risk. All three of these studies also identified driving during nighttime hours as an independent risk factor.

Between 1996 and the present, most U.S. states implemented some form of graduated driver licensing (GDL) system, in which a new driver initially is allowed to drive only under the supervision of a licensed adult passenger, and then receives an intermediate (or "provisional") license that allows unsupervised driving but only under certain conditions. The driver then receives a full-privilege license upon reaching a certain age (e.g., 18) or accumulating a certain amount of experience (e.g., 12 months) driving with the intermediate license. Several studies have estimated that GDL systems have reduced the fatal crash involvement of 16- and 17-year-old drivers by roughly 20-40% (Shope, 2007). In many states, the intermediate stage of licensure includes restrictions on carrying passengers. Fell et al. (2011) estimated that restrictions on carrying passengers have been associated with a 9% reduction in fatal crashes in which drivers aged 16-17 had teenage passengers, and Trempel (2009) estimated that laws that limited new drivers to carrying at most one teenage passenger reduced collision insurance claims of 16- and 17-year-old drivers by 4.8%.

The studies documenting the risks associated with carrying passengers were based on data that are now over a decade old: Doherty et al. (1998) analyzed data from 1988, Chen et al. (2000) analyzed data from 1992–1997, and Rice et al. (2003) analyzed data from 1993–1998.

In 1998, 2,589 16- and 17-year-old drivers were involved in fatal crashes. By 2010, this number had fallen by 56% to 1,150 (Fatality Analysis Reporting System, 2012). Given the proliferation of GDL systems and the large decrease in the overall annual number of fatal crash involvements of young drivers, the generalizability to the present time of the results of the previous studies of the relationship between passenger presence and crash risk is unknown. The objective of this study was to provide updated estimates of the relationship between passenger presence and crash risk, using data from the United States from years 2007-2010.

Methods

Main outcome measure

The number of drivers killed in crashes per mile driven and number of drivers involved in police-reported crashes (of any severity) per mile driven were estimated for drivers aged 16-17 years, in relation to the number and ages of passengers in the vehicle.

Data

Driver deaths

Data on 16- and 17-year-old drivers killed in crashes were obtained from the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS), which comprises data on all motor vehicle crashes that occur on public roadways in the United States and result in a death within 30 days of the crash. Data from crashes that occurred in years 2007–2010 were analyzed. Only crashes in which the teenage driver was operating a passenger vehicle (car, pickup truck, van, minivan, or sport utility vehicle [SUV]) were included; crashes in which the driver was operating a motorcycle, all-terrain vehicle, or other type of vehicle were excluded. There were 2,266 records of 16- and 17-year-old drivers killed in crashes over the study period.

Police-reported crashes

Data on 16- and 17-year-old drivers involved in police-reported crashes were obtained from the NHTSA's General Estimates System (GES), a stratified sample of all police-reported crashes in the United States. Records in GES are weighted to represent all police-reported crashes in the United States. Data from crashes that occurred in years 2007–2010 were analyzed. Only crashes in which the teenage driver was operating a passenger vehicle were included; crashes in which the driver was operating another type of vehicle were excluded. There were 14,656 records of 16- and 17-year-old drivers of passenger vehicles involved in police-reported crashes over the study period.

Miles driven

Data on the number of miles driven by 16- and 17-year-old drivers were obtained from the Federal Highway Administration's 2009 National Household Travel Survey (NHTS). The NHTS contains data on all of the trips taken by all members of a representative sample of households across the United States. In the NHTS, respondents entered data into a travel diary on an assigned date and reported it by means of a telephone interview. These data included the start time, end time, and length of each trip, the total number of passengers in the vehicle, and additional demographic data (including age) of passengers who were

members of the driver's household. Data were collected from March 2008 through April 2009 and were weighted to represent the travel of all United States households over a 365-day period. The 2009 NHTS included data from 7,188 respondents aged 16-17, of whom 4,799 were drivers, of whom 2,746 made a total of 9,663 trips as a driver of a passenger vehicle on their assigned travel day.

Data inspection

Crashes

Rice & Anderson (2009) noted that as of 2005, FARS data from several states appeared to under-report passengers who were not injured; Chen et al. (2000) reported that several GES primary sampling units (PSUs) also did so. To investigate whether there was evidence of systematic under-reporting of uninjured passengers in any state or PSU during the study period, the ratio of the proportions of passengers coded as uninjured to drivers (of any age, not limited to drivers aged 16-17) coded as uninjured was tabulated by state (in FARS) and by PSU (in GES) and was evaluated using an approximation of Pierce's criterion (1852) described by Gould (1855). In the FARS data, the average ratio of the proportion of passengers uninjured to the proportion of drivers uninjured was 0.96 (s.d. 0.20); records from the state of Virginia, with a ratio of 0.04, were excluded from the study (n=68). In the GES data, the average ratio was 0.93 (s.d. 0.19); records from PSUs 27 (ratio=0.04), 73 (ratio=0.14) and 93 (ratio=0.22) were excluded (n=951). Also excluded were records from individual vehicles in which the ages of passengers or the total number of passengers was unknown (FARS: n=7; GES: n=447). In total, records of 75 fatally-injured drivers (3.3% of original population) and 1,398 drivers involved in police-reported crashes (11.5% of original weighted sample) were excluded. This left 2,191 records of fatally-injured drivers and 13,258 records of drivers in police-reported crashes for the main analysis.

Miles driven

Of the original 9,663 driving trips of 16- and 17-year-olds in the NHTS sample, 110 (0.7% of weighted trips) had unknown lengths. An additional 23 trips (0.2% of weighted trips) had lengths deemed implausible on the basis of their calculated average speed (greater than 100 miles per hour)—these were replaced with missing values. Missing values of trip length were replaced for 109 trips with values predicted from linear regression of trip length on trip duration; 24 trips whose length and duration were both missing were excluded, leaving 9,639 trip records for the main analysis.

The weights of the NHTS data were adjusted to align the population of 16- and 17-year-olds estimated from the NHTS to the population of 16- and 17-year-olds in the United States as reported by the United States Census Bureau (2011). Adjustments were made separately by age and sex.

Analysis

Crash-involved 16- and 17-year-old drivers were classified according to the number and ages of passengers present in the vehicle. Classifications were:

- No passengers;
- 1, 2, or 3+ passengers under 21 years of age (and no passengers aged 21 or older);
- At least one passenger aged 35 or older (any number of passengers of other ages);
- Other (oldest passenger in vehicle aged 21-34).

The driving exposure of 16- and 17-year-old drivers was also grouped according to the same combinations of passengers. However, the NHTS only collects the ages of passengers who are members of the driver's household; the ages of passengers who were not members of the driver's household were unknown. For the purpose of the study, all passengers of unknown age (i.e., all passengers who were not members of the driver's household) were assumed to have been younger than 21 years of age. Provided that at least some passengers of unknown age were aged 21 or older, this method overestimates the number of miles driven with only passengers under age 21. Similarly, if any of the passengers of unknown age were aged 35 or older, this method underestimates the number of miles driven with passengers aged 35 or older.

Rates of drivers killed and of drivers involved in police-reported crashes per mile driven were estimated by dividing the annual average number of crash-involved drivers with each of the combinations of passengers defined previously by the number of miles driven by 16- and 17-year-old drivers with the same combination of passengers. Relative risks (ratios of rates) were computed for drivers with each passenger combination relative to drivers with no passengers. Rates and relative risks were also computed separately by single year of driver age, driver sex, time of day, and single vs. multiple-vehicle crashes. Rates and relative risks were not computed for drivers with passengers aged 21-34 because the data on miles driven contained too few trips on which young drivers had passengers in this age group to produce reliable estimates (n=29). Note that due to the assumption that all passengers of unknown age were under age 21, rates and relative risks estimated for drivers with passengers under age 21 represent *lower bounds* for the true rates and the true relative risks; similarly, rates and relative risks estimated for drivers with passengers aged 35 or older represent *upper bounds*.

Standard errors of the numbers of drivers involved in all police-reported crashes were estimated using generalized standard errors published by NHTSA (2011). Standard errors of the number of drivers involved in fatal crashes were estimated using Poisson approximations. Standard errors of the number of miles driven were estimated using jackknife replicate weights provided in the NHTS data file (FHWA, 2012). The standard errors of rates and relative risks were estimated on the log scale using first order Taylor series approximations; confidence intervals for risks and relative risks were estimated on the log scale using normal approximations.

Results

Table 1 shows the proportions of fatally-injured drivers and of all drivers involved in police-reported crashes in relation to the number and ages of passengers present. Of the 2,191 drivers aged 16-17 who were killed in crashes over the study period, 54.5% had no passengers, 2.9% had at least one passenger aged 35 years or older, 24.2% had one passenger younger than 21 years of age (and no older passengers), 9.3% had 2 passengers younger than age 21, 5.9% had 3 or more passengers younger than age 21, and 3.2% had at least one passenger aged 21-34 in the vehicle (but no passengers aged 35 or older). Variations in passenger groupings by driver age, sex, and time of day were small; drivers in single-vehicle crashes were less than half as likely as drivers in multi-vehicle crashes to have had a passenger aged 35 years or older. Among all 16- and 17-year-old drivers

involved in police-reported crashes, the proportions with 1, 2, or 3+ passengers under age 21 were lower than among fatally-injured drivers, and the proportions with no passengers or with a passenger aged 35 or older were higher than among fatally-injured drivers.

The annual number of 16- and 17-year-old drivers killed in crashes decreased by 47% over the study period, from 755 in 2007 to 398 in 2010. The number of drivers involved in police-reported crashes decreased by 23%, from 468,903 in 2007 to 361,433 in 2010. However, the distributions of drivers killed in crashes and of all drivers involved in crashes in relation to passenger groupings were relatively stable from year to year (Table 1).

Table 1 also shows the share of miles driven by 16- and 17-year-old drivers in relation to the number and ages of passengers present. Compared to 17-year-old drivers, 16-year-old drivers drove a substantially greater share of their total miles with a household member aged 35 or older in the vehicle. Drivers aged 16 also drove a substantially greater share of their miles than did 17-year-olds with one passenger under age 21. Table 1 suggests that drivers were far more likely to have had three or more passengers under age 21 when trips occurred between the hours of 10 PM and 5:59 AM than when trips occurred at other hours; however, this was based on only a small raw number of trips (n = 11) and thus should not be over-interpreted.

Table 2 shows the number of 16- and 17-year-old drivers killed in crashes per 100 million miles driven and number involved in police-reported crashes per 1 million miles driven in relation to the number and ages of passengers present. For drivers with no passengers, the per-mile driver death rate and crash involvement rate were both substantially higher for 16-year-old drivers than for 17-year-olds. The death rate of male drivers with no passengers was somewhat higher than the rate for female drivers with no passengers, whereas the corresponding rates of involvement in any crash were slightly higher for females than for males (neither difference approached statistical significance). The death rate per mile driven of 16- and 17-year-old drivers with no passengers was over 6 times as high between 10 PM and 5:59 AM as between 6 AM and 9:59 PM. The overall crash involvement rate per mile driven was elevated only slightly during these hours, and the difference did not approach statistical significance.

Figure 1 and Table 3 show the per-mile risks of being killed in a crash and of being involved in a police-reported crash in relation to the number and ages of passengers present, relative to the risks with no passengers present, for drivers aged 16-17. In general, having passengers under age 21 was associated with an increase in risk, and having adult passengers aged 35+ was associated with a decrease in risk (Figure 1; Table 3). Compared with having no passengers, having one passenger younger than age 21 (and no older passengers) was associated with a 44% increase in a 16- or 17-year-old driver's risk per mile driven of being killed in a crash (RR 1.44, 95% CI 1.01 – 2.04), having two passengers younger than age 21 was associated with a doubling of the driver's risk of being killed in a crash (RR 2.02, 95% CI 1.36 – 2.99), and having three or more passengers younger than age 21 was associated with a quadrupling in the risk of being killed in a crash (RR 4.39, 95% CI 1.45 – 13.31). The relationship between the relative risk of being involved in any police-reported crash and the presence of young passengers followed a similar pattern; however, the increases in relative risks of involvement in any police-reported crash were smaller and were not statistically significant.

Having at least one passenger aged 35 or older in the vehicle was associated with a 62% *decrease* in the risk per mile driven of being killed in a crash (RR 0.38, 95% CI: 0.24 – 0.60) and a 46% decrease in the risk of being involved in any police-reported crash (RR 0.54, 95% CI 0.35 – 0.84), compared with having no passengers.

Table 1. Driver deaths, drivers involved in police-reported crashes, and miles driven in relation to driver age, sex, time of day, and combination of passengers in the vehicle, drivers aged 16-17 years driving cars, pickup trucks, vans, minivans, or sport utility vehicles, United States, 2007-2010.

	No passengers	At least 1 passenger aged 35+	Number of passengers < 21 years old (All passengers < 21 years old)			Other passenger group	Total
			1	2	3+		
Driver deaths				**Row percent**			**N**
Total	54.5	2.9	24.2	9.3	5.9	3.2	2,191
Driver age 16	52.3	3.2	26.6	10.0	6.0	2.0	853
17	56.0	2.8	22.6	8.8	5.8	4.0	1,338
Male	53.1	3.2	25.1	9.5	6.2	2.7	1,385
Female	56.9	2.4	22.6	8.8	5.3	4.0	806
6AM–9:59PM	54.1	3.5	25.4	9.5	5.3	2.2	1,515
10PM–5:59AM	55.5	1.7	21.2	9.1	7.2	5.4	651
Single-vehicle crash	54.1	2.0	24.5	9.8	5.9	3.8	1,382
Multiple-vehicle crash	55.4	4.6	23.7	8.3	5.9	2.1	809
Crash year 2007	54.6	3.0	22.9	10.1	6.5	2.9	755
2008	57.1	2.4	24.1	8.7	5.6	2.2	553
2009	52.8	2.7	24.7	9.3	4.7	5.8	485
2010	53.0	3.8	26.1	8.5	6.5	2.0	398
All police-reported crashes				**Row percent (Weighted)**			**Weighted N**
Total	61.9	4.7	21.2	6.1	3.3	2.8	1,636,618
Driver age 16	59.5	6.5	21.2	6.4	3.4	3.1	653,563
17	63.5	3.5	21.2	5.9	3.2	2.6	983,055
Male	62.5	4.2	20.7	6.3	3.5	2.9	878,411
Female	61.3	5.3	21.9	5.7	3.1	2.7	758,208
6AM–9:59PM	62.3	4.8	21.2	5.9	3.1	2.7	1,499,711
10PM–5:59AM	58.0	3.3	21.3	7.4	5.7	4.3	136,907
Single-vehicle crash	64.6	2.9	20.3	6.7	3.5	1.9	350,143
Multiple-vehicle crash	61.2	5.2	21.5	5.9	3.2	3.0	1,286,476
Crash year 2007	63.5	4.5	20.8	5.8	3.4	2.1	468,903
2008	61.2	5.2	21.1	5.7	3.7	3.2	427,289
2009	61.7	4.4	20.5	6.7	3.3	3.3	378,993
2010	60.9	4.7	22.7	6.1	2.7	2.8	361,433
Miles driven[a]				**Row percent (Weighted)**			**Weighted miles (in millions)**
Total	63.8	9.0	19.7	5.4	1.6	0.6	20,899
Driver age 16	53.5	14.1	26.5	5.2	0.4	0.3	6,524
17	68.4	6.7	16.6	5.4	2.1	0.8	14,375
Male	63.2	9.5	17.9	6.2	2.1	1.1	11,592
Female	64.4	8.3	22.0	4.4	0.9	0.0	9,307
6AM–9:59PM	63.7	9.3	19.7	5.5	1.1	0.7	19,222
10PM–5:59AM	62.0	6.4	20.2	4.2	7.2	-	1,564

Data: Fatality Analysis Reporting System (2012), General Estimates System (2012), National Household Travel Survey (2009).

[a.] In data on miles driven, passenger age was unknown when the passenger was not a member of the subject driver's household. For the purpose of the study, non-household passengers were assumed to be under age 21. Thus, percentages shown for drivers with passenger aged 35+ and with other passenger group represent lower bounds, and percentages shown for drivers with 1, 2, or 3+ passengers < 21 years old represent upper bounds. Trips are weighted to reflect total miles driven over a 365-day period from May 2008 through April 2009.

Table 2. Rates of driver death and involvement in any police-reported crash in relation to driver age, sex, time of day, and combination of passengers in the vehicle, drivers aged 16-17, United States, 2007-2010.

	No passengers		At least 1 passenger aged 35+[a]		Number of passengers < 21 years old[a] (All passengers < 21 years old					
					1		2		3+	
Driver deaths	**Rate per 100 million miles driven (95% Confidence Interval)**									
Total	2.24	(1.88 – 2.68)	0.85	(0.56 – 1.31)	3.22	(2.38 – 4.36)	4.53	(3.19 – 6.42)	9.85	(3.30 – 29.41)
Driver age 16	3.19	(2.57 – 3.97)	0.73	(0.43 – 1.27)	3.29	(1.69 – 6.39)	6.26	(3.95 – 9.92)	44.55	(19.82 – 100.14)
17	1.90	(1.53 – 2.37)	0.96	(0.50 – 1.87)	3.17	(2.48 – 4.05)	3.77	(2.46 – 5.78)	6.53	(1.95 – 21.82)
Male	2.51	(1.91 – 3.30)	1.02	(0.61 – 1.69)	4.20	(3.14 – 5.63)	4.61	(2.94 – 7.25)	8.96	(2.03 – 39.62)
Female	1.91	(1.57 – 2.33)	0.62	(0.32 – 1.19)	2.22	(1.30 – 3.81)	4.37	(2.69 – 7.10)	12.28	(6.33 – 23.84)
6AM–9:59PM	1.67	(1.39 – 2.02)	0.75	(0.48 – 1.16)	2.54	(1.83 – 3.51)	3.41	(2.36 – 4.93)	9.43	(4.82 – 18.44)
10PM–5:59AM	9.31	(7.08 – 12.26)	2.75	(0.68 – 11.17)	10.90	(5.63 – 21.11)	22.57	(8.41 – 60.60)	10.43	(1.30 – 83.32)
Single-vehicle crash	1.40	(1.17 – 1.68)	0.36	(0.21 – 0.60)	2.05	(1.50 – 2.80)	3.03	(2.11 – 4.36)	6.19	(2.05 – 18.62)
Multiple-vehicle crash	0.84	(0.69 – 1.02)	0.49	(0.31 – 0.79)	1.17	(0.84 – 1.61)	1.49	(1.00 – 2.23)	3.67	(1.20 – 11.20)
All police-reported crashes	**Rate per 1 million miles driven (95% Confidence Interval)**									
Total	19.0	(15.3 – 23.5)	10.2	(6.9 – 15.1)	21.1	(15.3 – 29.2)	22.1	(15.4 – 31.8)	41.3	(13.8 – 123.5)
Driver age 16	27.8	(21.8 – 35.4)	11.5	(7.4 – 17.8)	20.1	(10.3 – 39.2)	30.6	(19.4 – 48.2)	194.6	(87.7 – 432.0)
17	15.9	(12.4 – 20.3)	9.1	(4.9 – 16.8)	21.8	(16.8 – 28.5)	18.4	(12.0 – 28.3)	26.6	(8.0 – 88.6)
Male	18.7	(13.9 – 25.2)	8.3	(5.2 – 13.1)	21.9	(16.0 – 29.9)	19.5	(12.3 – 30.8)	31.8	(7.2 – 140.6)
Female	19.4	(15.5 – 24.2)	13.1	(7.8 – 22.1)	20.3	(11.8 – 34.8)	26.8	(16.7 – 42.8)	67.2	(35.6 – 126.9)
6AM–9:59PM	19.1	(15.3 – 23.7)	10.2	(6.9 – 15.1)	21.0	(14.9 – 29.5)	21.1	(14.5 – 30.6)	53.8	(27.7 – 104.4)
10PM–5:59AM	20.5	(15.1 – 27.8)	11.4	(3.0 – 43.4)	23.0	(11.7 – 45.3)	38.8	(14.3 – 105.5)	17.4	(2.2 – 139.6)
Single-vehicle crash	4.2	(3.4 – 5.3)	1.4	(0.86 – 2.2)	4.3	(3.1 – 6.1)	5.2	(3.5 – 7.8)	9.4	(3.1 – 28.8)
Multiple-vehicle crash	14.8	(11.9 – 18.3)	8.9	(6.0 – 13.1)	16.8	(12.1 – 23.2)	16.9	(11.7 – 24.4)	31.8	(10.6 – 95.4)

Data: Fatality Analysis Reporting System (2012), General Estimates System (2012), National Household Travel Survey (2009).

[a.] In the National Household Travel Survey data used to compute crash rates per mile driven, passenger age was unknown for passengers who were not members of the subject driver's household. For the purpose of the study, all non-household passengers were assumed to be under age 21, thus estimated risk of driving with a passenger aged 35+ is an upper bound, and estimated risks of driving with 1, 2, or 3+ passengers < 21 years old are lower bounds.

Most estimates of relative risks within subgroups were imprecise, largely due to the sparseness of the NHTS data on trips with specific combinations of passengers; however, they generally followed the same pattern as the overall results. The presence of a passenger aged 35+ was associated with a significantly larger decrease in the relative risk of involvement in single-vehicle crashes than in the relative risk of involvement in multiple-vehicle crashes; this applied to both crashes in which the driver was killed (Ratio of Relative Risks [RRR] 0.44, 95% CI 0.32 – 0.60) and to all police-reported crashes (RRR 0.54, 95% CI 0.38 – 0.76). Having three or more passengers under age 21 appeared to increase the relative risk to a greater degree for 16-year-old drivers than for 17-year-old drivers; the ratios of relative risks of driver death and of involvement in any police-reported crash both approached statistical significance (driver death: RRR 4.1, 95% CI: 0.92 – 18.0; all police-reported crashes: RRR 4.2, 95% CI: 0.96 – 18.3). Although the magnitudes of the relative risks did appear to vary across subgroups for some passenger combinations, no other subgroup differences approached statistical significance at the 95% confidence level.

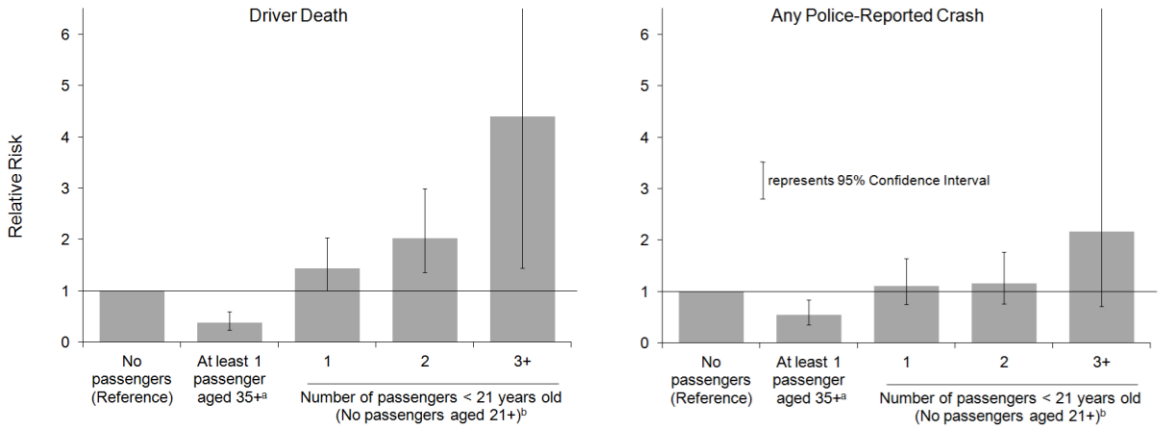

Figure 1. Relative risk of driver death (left) and of involvement in any police-reported crash (right) per mile driven in relation to combination of passengers in the vehicle, drivers aged 16-17, United States, 2007-2010.
Data: Fatality Analysis Reporting System (2012), General Estimates System (2012), National Household Travel Survey (2009).

[a.] In the National Household Travel Survey data used to compute crash rates per mile driven, passenger age was unknown for passengers who were not members of the subject driver's household. For the purpose of the study, all non-household passengers were assumed to be under age 21, thus the relative risk shown for driving with a passenger aged 35+ is an upper bound.
[b.] Relative risks shown for driving with 1, 2, and 3+ passengers < 21 years old represent lower bounds.

Table 3. Relative risks of driver death and of involvement in any police-reported crash per mile driven in relation to driver age, sex, time of day, and combination of passengers in the vehicle, drivers aged 16-17, United States, 2007-2010.

	No Passengers	At least 1 passenger aged 35+[a]	Number of passengers < 21 years old (All passengers < 21 years old)[a]		
			1	2	3+
Driver deaths per mile driven	**Relative Risk (95% Confidence Interval)**				
Total	1 (Reference)	0.38 (0.24 – 0.60)	1.44 (1.01 – 2.04)	2.02 (1.36 – 2.99)	4.39 (1.45 – 13.31)
16	1 (Reference)	0.23 (0.13 – 0.41)	1.03 (0.51 – 2.07)	1.96 (1.18 – 3.26)	13.95 (6.03 – 32.29)
17	1 (Reference)	0.51 (0.25 – 1.02)	1.66 (1.20 – 2.31)	1.98 (1.23 – 3.20)	3.43 (1.01 – 11.68)
Male	1 (Reference)	0.40 (0.23 – 0.72)	1.67 (1.12 – 2.50)	1.84 (1.08 – 3.12)	3.57 (0.79 – 16.19)
Female	1 (Reference)	0.32 (0.16 – 0.64)	1.16 (0.65 – 2.06)	2.28 (1.35 – 3.86)	6.41 (3.21 – 12.81)
6AM–9:59PM	1 (Reference)	0.45 (0.28 – 0.72)	1.52 (1.04 – 2.21)	2.04 (1.35 – 3.08)	5.64 (2.81 – 11.32)
10PM–5:59AM	1 (Reference)	0.30 (0.07 – 1.23)	1.17 (0.57 – 2.39)	2.42 (0.87 – 6.75)	1.12 (0.14 – 9.11)
Single-vehicle crash	1 (Reference)	0.26 (0.15 – 0.44)	1.46 (1.02 – 2.10)	2.16 (1.44 – 3.25)	4.41 (1.44 – 13.48)
Multi-vehicle crash	1 (Reference)	0.59 (0.35 – 0.98)	1.39 (0.95 – 2.02)	1.78 (1.14 – 2.77)	4.36 (1.40 – 13.54)
All police-reported crashes per mile driven	**Relative Risk (95% Confidence Interval)**				
Total	1 (Reference)	0.54 (0.35 – 0.84)	1.11 (0.75 – 1.64)	1.16 (0.76 – 1.77)	2.17 (0.71 – 6.63)
16	1 (Reference)	0.41 (0.25 – 0.68)	0.72 (0.35 – 1.47)	1.10 (0.66 – 1.84)	7.00 (3.04 – 16.10)
17	1 (Reference)	0.57 (0.29 – 1.11)	1.38 (0.96 – 1.97)	1.16 (0.71 – 1.90)	1.67 (0.49 – 5.72)
Male	1 (Reference)	0.44 (0.25 – 0.76)	1.17 (0.76 – 1.80)	1.04 (0.60 – 1.80)	1.70 (0.37 – 7.74)
Female	1 (Reference)	0.68 (0.38 – 1.19)	1.05 (0.58 – 1.88)	1.38 (0.82 – 2.32)	3.47 (1.77 – 6.80)
6AM–9:59PM	1 (Reference)	0.53 (0.34 – 0.84)	1.10 (0.73 – 1.65)	1.11 (0.72 – 1.70)	2.82 (1.40 – 5.67)
10PM–5:59AM	1 (Reference)	0.56 (0.14 – 2.20)	1.12 (0.54 – 2.36)	1.90 (0.67 – 5.40)	0.85 (0.10 – 6.97)
Single-vehicle crash	1 (Reference)	0.32 (0.19 – 0.54)	1.02 (0.68 – 1.53)	1.23 (0.78 – 1.94)	2.22 (0.71 – 6.94)
Multi-vehicle crash	1 (Reference)	0.60 (0.38 – 0.94)	1.14 (0.77 – 1.68)	1.14 (0.75 – 1.75)	2.15 (0.70 – 6.60)

Data: Fatality Analysis Reporting System (2012), General Estimates System (2012), National Household Travel Survey (2009).

[a.] In the National Household Travel Survey data used to compute crash rates per mile driven, passenger age was unknown for passengers who were not members of the subject driver's household. For the purpose of the study, all non-household passengers were assumed to be under age 21, thus estimated relative risk of driving with a passenger aged 35+ is an upper bound, and estimated relative risks of driving with 1, 2, or 3+ passengers < 21 years old are lower bounds.

Discussion

Drivers aged 16-17 were shown to be at increased risk per mile driven of being killed in a crash when carrying young passengers, and the risk increased further as the number of young passengers increased. Risks of involvement in police-reported crashes of any severity appeared to follow a similar pattern; however, the increases in the risk of involvement in any police-reported crash were smaller than the increases in risk of driver death and did not even approach statistical significance. In contrast, young drivers' risk of involvement in any police-reported crashes and risk of being killed in a crash were both reduced significantly when carrying an adult passenger aged 35 or older.

Somewhat unexpectedly, it was estimated that the presence of one young passenger increased a 16-year-old driver's risk of being killed in a crash by only 3% (RR 1.03, 95% CI 0.51 – 2.07), whereas the risk for a 17-year-old driver increased by 66% (RR 1.66, 95% CI 1.20 – 2.31) in the presence of one young passenger. However, the difference in these two estimates is not significantly larger than what might be expected to occur by chance alone under the hypothesis that the effect of having one young passenger does not vary by age (Ratio of Relative Risks 0.62, 95% CI 0.29 – 1.34). Thus, these estimates are not inconsistent with the hypothesis that the estimated effect for drivers aged 16 and 17 combined applies equally to drivers aged 16 and drivers aged 17, i.e., that the presence of one young passenger is associated with a 44% increase in the risk of death per mile driven (RR 1.44, 95% CI 1.01 – 2.04).

Relation to other research

This study confirms that the results originally reported in the seminal study by Chen et al. (2000) are still broadly applicable today. In that study, Chen et al. analyzed data on driver deaths from years 1992-1997 and data on driving exposure from years 1995-1996 to estimate relative risk of driver death per driving trip in relation to the number of passengers present, and found that having one, two, or three or more passengers increased the per-trip risk of driver death by 39%, 86%, and 182%, respectively, for 16-year-old drivers, and by 48%, 158%, and 207%, respectively for 17-year-old drivers. Although Chen et al. did not formally investigate the per-trip or per-mile risk of involvement in crashes that were not fatal to the driver, they analyzed the rate of driver deaths per police-reported crash and reported that having teen-aged passengers and having passengers aged 20-29 both were associated with increased risk of driver death in the event of a police-reported crash, thus implying that the presence of young passengers must have increased the per-trip risk of severe crashes to a greater extent than it increased the risk of less-severe crashes. This was investigated formally and was confirmed in the current study. This study also extends the results of Chen et al. by taking advantage of the limited data available on the ages of passengers riding with young drivers to estimate *lower bounds* for the risks associated with carrying multiple *young* passengers and *upper bounds* for the risks associated with carrying *adult* passengers.

In a similar study, Ouimet et al. (2010) analyzed fatal crash data from years 1999-2003 and travel data from 2001-2002 to estimate the relative risk of fatal crash involvement per mile driven for drivers ages 15-20 in relation to the age and sex of passengers when there was one passenger in the vehicle. The data analyzed by Ouimet et al., like the data analyzed in

the current study, only contained information about the age and sex of passengers who were members of the driver's household. The authors used a hot-deck imputation method to estimate the distribution of age and sex among all passengers, including the non-household passengers, and reported that the number of miles driven with adult passengers aged 35+ was substantially greater than the number of miles driven with peers of the driver, which they noted might have been an artifact of their method. In addition, the results of that study may be of limited generalizability to drivers ages 16-17; examination of the data used to estimate miles driven in the current study shows that 79% the total miles driven by drivers aged 15-20 were driven by drivers aged 18-20.

A study that used in-vehicle cameras to observe a sample of 40 newly-licensed teenage drivers for their first 18 months of licensed driving (Klauer et al., 2011) reported results very similar to those of the current study with respect to the distributions of passengers in the vehicles of young drivers. In that study, a passenger aged 19 or older was present for about 13-14% of all miles driven by the study subjects during their first three months of licensed driving and for about 7-8% of all miles driven during months 4-18 of licensed driving; passengers aged 13-18 were present for 26-28% of all miles driven during study subjects' first 12 months of licensed driving and for about 21-22% of all miles driven in months 13-18. In the current study, an adult aged 21 or older was present for 15.2% of miles driven by 16-year-olds and 7.5% of miles driven by 17-year-olds; passengers younger than 21 years of age were present for 32.1% of miles driven by 16-year-olds and 24.1% of miles driven by 17-year-olds. This close agreement suggests that the assumption made in the current study that all non-household passengers were under age 21 yielded a reasonable approximation of the overall age distribution of the passengers riding with drivers aged 16-17.

This study estimated that having an adult passenger aged 35 years or older decreased a 16- to 17-year-old driver's risk per mile driven of involvement in any police-reported crash by 46% and decreased the driver's risk of being killed in a crash by 62%. Having an adult passenger in the vehicle was shown to be especially protective against the risk of involvement in single-vehicle crashes. This makes sense. Although the data analyzed in this study do not identify one driver or another as being "at fault" for any crash, it is likely that a greater proportion of young drivers' single-vehicle crash involvements than multiple-vehicle crash involvements were at least partially attributable to some action or error committed by the young driver; thus, it is likely that an adult passenger could help to prevent a greater proportion of young drivers' single-vehicle crashes than multiple-vehicle crashes. The magnitude of the risk reduction estimated here for carrying an adult passenger agrees very well with the estimate of Rice et al. (2003) that carrying an adult passenger was associated with a 70% reduction in a 16- or 17-year-old driver's risk of being involved in a crash in which he or she was injured and was deemed culpable. While the relationship of the adult passengers to the drivers was not known in either study, it is likely that in many cases they were the driver's parents.

In a study in which in-vehicle cameras and other data collection equipment were used to monitor 42 teen-aged drivers for their first 18 months of licensed independent driving, Simons-Morton et al. (2011) found that the presence of an adult passenger was associated with a 74% reduction in the rate of involvement in crashes or near crashes per mile driven and a 68% reduction in high g-force events (e.g., hard acceleration, braking, or swerving) compared with driving alone. The authors did not conclude whether this effect was due to

teens moderating their behavior in the presence of adult passengers, whether the adult actively helped the driver (e.g., by pointing out hazards), both, or something else. In a similar study conducted for the AAA Foundation for Traffic Safety, Goodwin et al. (2012) used in-vehicle cameras to observe the driving of a different sample of 52 newly-licensed teenage drivers and found that electronic device use was 86% less frequent and other distracted-driving behaviors were 75% less frequent when a parent or other adult was present in the vehicle than when the driver was alone, illustrating that teenage drivers modify at least some aspects of their behavior in the presence of adult passengers.

This study does not shed light on the mechanisms by which the presence of young passengers increases the risk of fatal crash involvement for young drivers. Williams and Tefft (2012) analyzed data from fatal crashes that involved 16- or 17-year-old drivers in years 2005-2010 and reported that in comparison to fatal-crash involved drivers with no passengers, a greater proportion of those with teenage passengers were speeding, drinking alcohol, and coded on the police crash report as having contributed to the crash in at least some way, and reported that the proportions speeding, drinking alcohol, and contributing to the crash increased as the number of teenage passengers increased. Goodwin et al. (2012b) used in-vehicle cameras to collect data from a sample of newly-licensed young drivers in North Carolina, and found that drivers were more likely to speed, tailgate, and "show off" when multiple teenage passengers were present. The authors also noted that they observed few instances in which the passengers actively encouraged these behaviors, suggesting that it was the passengers' mere presence that elicited such behavior from the driver. In contrast, in another study also using in-vehicle cameras and other data collection equipment to study a sample of newly-licensed young drivers, Simons-Morton et al. (2011) found that elevated g-force events (e.g., hard braking, swerving) were somewhat less frequent when teenage passengers were present than when the driver was alone. The contrast between the results of these studies suggests the relationship between the presence of young passengers and the behavior of a young driver is complex.

Limitations

The national survey that was used to estimate driving exposure in relation to the age and number of passengers did not collect data on the ages of passengers who were not members of the driver's household. For the purpose of the study, it was assumed that all non-household passengers were less than 21 years of age. While this is unlikely to be correct, it provides clear and useful insights: risks reported in this study for young drivers carrying only passengers under age 21 represent *lower bounds* for the true risks associated with carrying passengers under age 21, and risks reported here represent *upper bounds* for the true risks (equivalently: lower bounds for the true risk reductions) associated with carrying passengers aged 35 or older.

The driving exposure data contained too few trips with household passengers aged 21-34 to estimate relative risks for drivers with passengers in this age range. Chen et al. (2000) reported that the presence of passengers aged 20-29 was associated with increased crash severity (greater average number of driver deaths per police-reported crash), and Williams & Tefft (2012) found that major risk factors such as speeding and alcohol use were as prevalent or more prevalent in fatal crashes of 16- and 17-year-old drivers with passengers aged 20-29 as with multiple teenage passengers. However, in the data analyzed in the current study, only 3.2% of fatally-injured 16- and 17-year-old drivers and 2.8% of all 16-

and 17-year-old drivers involved in police-reported crashes had any passengers aged 21-34 and no passengers aged 35 or older.

Although it is clear that having young passengers in the vehicle increases risk for young drivers and having adult passengers decreases risk, the results of this study do not provide evidence of the actual age (of the passenger) at which the passenger's presence ceases to increase a driver's risk or the age that it becomes a protective factor. The upper age cutoff for young passengers was placed at age 21 to align with most existing state GDL passenger restrictions. The lower age cutoff of 35 was selected for adult passengers to capture passengers old enough that they could plausibly have been the driver's parents. These cutoff points were selected *a priori*; they were not outcomes of the study.

Among fatally-injured drivers in this study, 25% had a full-privilege driver's license, 59% had an intermediate or provisional license with some restrictions, 4% had a learner's permit that allowed driving only with a licensed adult passenger, and 12% were unlicensed. However, data on the type of license that the driver possessed was not available in the data on all police-reported crashes nor in the data on driving exposure; thus, the results reported here are based on all driving done by drivers aged 16 and 17 irrespective of the type of driver's license that they possessed. Most of the miles driven by drivers in the exposure data likely had a license that allowed driving without an adult in the car; however, some may have had learner's permits, and some may have even been unlicensed.

As noted previously, the annual number of crashes and deaths of 16- and 17-year-old drivers decreased sharply over this period, which suggests that there may have been changes in driving exposure over this period as well. However, data on driving exposure were available for only the one-year period from approximately May 2008–April 2009. The main analyses were based on crash data from years 2007–2010 because the numbers of driver deaths with specific combinations of passengers were prohibitively small to produce stable estimates using only one year of data. To test the sensitivity of the results to possible systematic changes in exposure over the study period, the main analyses were replicated using crash data from the one-year period from May 2008 through April 2009. Using crash data from only this period, the estimated relative risks of driver death associated with having an adult passenger, 1 passenger under age 21, 2 passengers under age 21, and 3 or more passengers under age 21 were 0.45, 1.47, 1.71, and 3.81, respectively, compared with 0.38, 1.44, 2.02, and 4.39 when estimated using crash data from 2007–2010; relative risks of involvement in any police-reported crash varied even less in relation to the time period of the crash data analyzed.

Estimates of the amount of driving done by young drivers with various combinations of passengers relied on drivers' self-reports of the trips that they took, the lengths of those trips, and the passengers present in the vehicle, all of which could be subject to both random error and bias. Although any error in the reported number or length of trips would affect estimates of absolute risks (e.g., crashes per mile driven), neither random errors nor systematic error unrelated to the combination of passengers present (e.g., under-reporting of miles driven by 25% uniformly across all passenger groups) would bias the relative risk of driving with a specified combination of passengers vs. driving alone. Bias could still be present, however, if errors in estimated miles driven varied by passenger combination (e.g., if trips with multiple teenage passengers were more likely to be unreported), if the reporting of passenger presence was itself subject to error, or if the driving patterns of teen

drivers who participated in the NHTS differed from the driving patterns of teen drivers who did not participate.

Finally, by design, this study could not demonstrate that the relationship between the presence of passengers and the risk of crash involvement was causal. While it appears that having multiple young passengers increases risk and having adult passengers decreases risk, this study cannot rule out the possibility that teen drivers who carry multiple young passengers tend to have higher crash risk independent of the presence of the passengers, and similarly, that teen drivers who drive with adult passengers tend to have lower risk independent of the presence of the passengers. However, the results of this study, in conjunction with other studies that have examined different populations using diverse methods, suggest that the presence of young passengers does indeed increase the crash risk of young drivers, and that the presence of adult passengers decreases risk.

Conclusion

This study shows that, per mile driven, 16- and 17-year-old drivers are more likely to be killed in a crash when they have young passengers in their vehicle than when they are driving alone. Their risk was found to increase by an estimated 44% when one passenger under age 21 (and no older passengers) was present in the teen driver's vehicle, approximately double when two passengers under age 21 were present, and more than quadruple when three or more passengers under age 21 were present. The effect of young passengers on the risk of involvement in any police-reported crash appeared to follow a similar pattern; however, increases in the risk of any police-reported crash were smaller and were not estimated precisely enough to even approach statistical significance. It is clear that discouraging teen drivers from carrying passengers and/or discouraging teenagers from riding with young inexperienced drivers would benefit the safety of teenagers both as drivers and as passengers.

Having an adult passenger aged 35 or older was associated with nearly a 50% reduction in 16- or 17-year-old drivers' risk of involvement in any crash and over a 60% reduction in the risk of being killed in a crash. Parents clearly can play a major role in protecting their teenagers by riding with their teens, even after licensure, to continue to support the development of safe driving habits. In addition, parents can help to protect their teens from the risks associated with teenage drivers carrying teenage passengers by enforcing applicable state passenger restrictions, and by supplementing state laws with their own rules regarding carrying teenage passengers or riding with teen drivers.

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