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Using the U.S. National Household Travel Survey to estimate the impact of passenger characteristics on young drivers' relative risk of fatal crash involvement

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Abstract

Motor vehicle crashes are the main cause of morbidity and mortality in teenagers and young adults in the United States. Driving exposure and passenger presence, which can both vary by driver and passenger characteristics, are known to influence crash risk. Some studies have accounted for driving exposure in calculating young driver fatal crash risk in the presence of passengers, but none have estimated crash risk by driver sex and passenger age and sex. One possible reason for this gap is that data collection on driving exposure often precludes appropriate analyses. The purpose of this study was to examine, per 10 million vehicle trips (VT) and vehicle-miles traveled (VMT), the relative risk of fatal crash involvement in 15–20-year-old male and female drivers as a function of their passenger's age and sex, using solo driving as the referent. The Fatality Analysis Reporting System (1999–2003) provided fatal motor vehicle crash data and the National Household Travel Survey (NHTS, 2001) provided VT and VMT. The NHTS collects driving exposure for both household and non-household members (e.g., friends, colleagues), but demographic characteristics only on household members. Missing age and sex of non-household passengers were imputed with hot deck using information from household passengers' trips with non-household drivers, thereby enabling the calculation of crash rate and relative risk estimates based upon driver and passenger characteristics. Using this approach, the highest risk was found for young male drivers with 16–20-year-old passengers (relative risk [RR] per 10 million VT = 7.99; 95% confidence interval [CI], 7.34–8.69; RR per 10 million VMT = 9.94; 95% CI, 9.13–10.81). Relative risk was also high for 21–34-year-old passengers, again particularly when both drivers and passengers were male. These effects warrant further investigation and underscore the importance of considering driving exposure by passenger characteristics in understanding crash risk. Additionally, as all imputation techniques are imperfect, a more accurate estimation of U.S. fatal crash risk per distance driven would require national surveys to collect data on non-household passenger characteristics.

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1. Introduction

Motor vehicle crashes are the main cause of morbidity and mortality in teenagers and young adults (Centers for Disease Control and Prevention, 2008). Passenger presence is a critical factor in the crash involvement of drivers under 21 years old (e.g., Aldridge et al., 1999; Bédard and Meyers, 2004; Chen et al., 2000; Doherty et al., 1998; Lam, 2003; Preusser et al., 1998). Besides driver age, a number of other features may interact with passenger presence to influence crash risk, such as driver sex and passenger age and sex. Examining the effect of driver and passenger sex on fatalities per 1000 crashes, Chen et al. (2000) found higher risk for male and female teenage drivers with male passengers. Observing the age and sex of drivers and passengers in vehicles leaving high school parking lots, Simons-Morton et al. (2005) found that compared to general traffic, teenagers, especially males, drove at higher speeds and followed other vehicles more closely while in the presence of male teenage passengers.

While these two studies have shown the higher impact of male passengers on teenage drivers, results of other studies investigating combinations of driver and passenger characteristics have contradicted these findings. For example, Fu and Wilmot (2008) found a higher crash risk for teenage and young drivers carrying passengers of their own age group and sex. Other studies found no sex effect of young passengers on young drivers (Aldridge et al., 1999; Rueda-Domingo et al., 2004). This ambiguity might be partially explained by important methodological and conceptual differences between studies. Methodological inconsistencies include dissimilar driver and passenger age groupings, stratification of the data (e.g., two levels: driver age by driver sex vs. three levels: driver age by driver sex by passenger age), sources of data (e.g., national vs. state databases), and types of crash (e.g., fatal only vs. all crashes).

Another critical difference between studies is how risk exposure is conceptualized. To assess crash risk, the estimation of crash rates per distance driven, which requires a reliable numerator (e.g., fatal crash) and denominator such as vehicle trips (VT) or vehicle-miles traveled (VMT), is generally considered paramount. Some studies on the effects of passengers have examined fatalities or other types of crashes per number of trips or distance driven (Chen et al., 2000; Doherty et al., 1998; Engstrom et al., 2008; Reiss et al., 1995; Williams and Wells, 1995). Other strategies for incorporating exposure have employed different rate-based analyses: fatalities per certain number of crashes (e.g., Chen et al., 2000) or per licensed drivers or population (e.g., Fu and Wilmot, 2008; Williams and Karpf, 1983; Williams and Shabanova, 2003; Williams and Wells, 1995) and at-fault per not at-fault crashes, i.e., induced or quasi-induced exposure technique (e.g., Aldridge et al., 1999; Padlo et al., 2005; Preusser et al., 1998). Some studies have ignored exposure by only using crash or injury frequency to determine crash or injury risk (e.g., Bédard and Meyers, 2004; Lam 2003; Senserrick et al., 2007).

Adjusting crash frequency for exposure is vital to unbiased estimation of crash risk, especially as exposure to risk conditions may vary considerably between drivers. For example, compared to older drivers, young drivers aged 16 to 20 years old in the United States have the highest fatal crash rate per total population (Chang, 2008), despite driving about half mileage than 20 to 64 year olds (Hu and Reuscher, 2004). Thus, failure to account for driving exposure would underestimate young drivers' crash risk. In contrast, estimates showing a higher crash risk for drivers and passengers of the same age and sex (Fu and Wilmot, 2008) may inflate young drivers' crash risk if their driving exposure is greater with same-sex passengers. While this is a probable scenario given the likelihood that most teenagers have more same-sex friends (Hartup, 1992; Poulin and Pedersen, 2007), little is actually known about the effects of passengers' age, sex, and relationship to the driver (e.g., sibling, friend, acquaintance), on young drivers' exposure. While some studies have accounted for driving exposure in calculating teenage and young drivers' crash risk in the presence of passengers (Chen et al.,

2000; Doherty et al., 1998; Engstrom et al., 2008; Reiss et al., 1995; Williams and Wells, 1995), they have not estimated crash risk by driver sex and passenger age and sex.

There are two possible explanations for both the absence of studies examining these factors and the use of alternative approaches to driving exposure. First, there is a dearth of accurate driving exposure data. Second, when available, such data are often collected in ways that preclude appropriate analyses. In the United States, this problem is encountered with the National Household Travel Survey (NHTS; Hu and Reuscher, 2004), the only national probability survey allowing calculation of annual VT and VMT for estimation of population crash risk using rate-based analyses. The NHTS gathers driving exposure for both household and non-household members (e.g., friends, colleagues), but only collects the demographic characteristics of household members. The absence of non-household passenger age and sex data prevents unbiased crash rate estimations that account for driving exposure according to passenger characteristics. This shortcoming may explain why Chen et al. (2000) used two different methods to investigate the impact of driver and passenger characteristics on teenagers' fatal crash risk. To calculate crash risk by driver age and sex, fatalities per 10 million trips were estimated because driving exposure according to these characteristics was available from the NHTS for both household and non-household members. However, to calculate crash risk by passenger age and sex, fatalities per 1000 crashes were calculated because driving exposure data by non-household passenger age and sex were unavailable. As there are no national probability surveys that include information on non-household passengers' age and sex in the United States, driving exposure for various driver/passenger age and sex combinations is unknown, which prevents accurate crash rate estimations by passenger characteristics. Understanding the risks associated with passenger characteristics would be key to our capacity to better develop and target psychosocial interventions.

The current study extends the work by Chen et al. (2000) by calculating fatalities per 10 million VT and VMT by young driver sex and passenger age and sex. Specifically, we used the NHTS to estimate the relative risk of fatal crash involvement in young male and female drivers as a function of their passenger's age and sex, compared to solo driving. In order to overcome gaps related to drivers' exposure to non-household passengers by age and sex, we employed hot-deck imputation (Ford, 1983), a technique that has been useful in grappling with missing data in travel surveys (Zimowski et al., 1997). Finally, we focused special attention on the effect of young male passengers on young drivers.

2. Method

2.1. Data

2.1.1. Fatal crash involvement—The Fatality Analysis Reporting System (FARS, 2008) contains all fatal crashes on U.S. public roads that result in the death of at least one person within 30 days of the crash. It provided data on fatal motor vehicle crashes from 1999–2003 in which drivers 15 to 20 years old were involved, but not necessarily as fatality victims. The FARS data are unique compared to other U.S. crash data as they are not a probability sample, and they are collected with standard data collection and quality control protocols over the 50 states, the District of Columbia, and Puerto Rico. Database information includes number, age, and sex of vehicle occupants. Fatal crashes with one or two occupants (i.e., 0 vs. 1 passenger) involving automobiles, sport utility vehicles, pickups, vans, and motor homes were examined; those involving large trucks and motorcycles were not. Of the vehicles involved in fatal crashes during the five-year study period, 29 077 had available data on age and sex for both drivers and passengers; less than 0.02% of the total data was missing and excluded from analyses. The FARS provides a reliable measure of fatal crash incidence, which was used as the numerator for fatal crash involvement rate calculations.

2.1.2. Driving exposure—Driving exposure was defined as annual vehicle trips (VT) and vehicle-miles traveled (VMT), expressed in 10-millions. It was estimated using the 2001 daily travel data of the National Household Travel Survey (NHTS; Hu and Reuscher, 2004), which used data from 26 038 participant households to calculate national estimates of annual VT and VMT. Only trips with one or two occupants (i.e., 0 vs. 1 passenger) were considered. A trip was defined as one-way travel from one address to another, such as from home to school. For each trip, the survey included trip length (i.e., distance in miles), trip purpose (e.g., going to school), total number of vehicle occupants, but age and sex for household members only. Table 1 describes some young drivers' trip characteristics, including the availability of passenger age and sex characteristics, for driver and passenger types considered in this study: a) household driver/no passengers, b) household driver/household passenger, c) household driver/non-household passenger, and d) non-household driver/household passenger. VT and VMT expressed in 10-millions are the denominators used for fatal crash involvement rate calculations.

2.2. Analyses

All data and analyses are presented by one passenger, irrespective of age and sex, and by 20 driver/passenger conditions: young driver sex and passenger sex and age (i.e., 12 years old or younger, 13 to 15 years old, 16 to 20 years old, 21 to 34 years old, and 35 years and older). Data are also shown for the no passenger condition.

2.2.1. Imputation technique—The missing non-household passengers' age and sex were assigned with hot deck (Ford, 1983), a single imputation technique, allowing the use of the known VT and VMT information in the calculation of crash rate and relative risk estimates by driver/passenger characteristics. Hot-deck imputation replaces missing data by estimates based upon other cases sharing similar characteristics. The same procedure was conducted for all driver and passenger groups, but only results for young drivers are reported in this paper.

In the current study, similar trip and income characteristics were assumed between the following two driver/passenger groups: household driver/non-household passenger (Table 1, row c) and non-household driver/household passenger (Table 1, row d). Thus, the hot-deck imputation replaced missing non-household passenger age and sex of row "c" with household passenger age and sex of row "d." Specifically, the procedure was conducted with the Westat macro WESDECK (proprietary SAS macro). It assigned passenger age and sex from a donor trip (one of the 775 two-occupant trips in which a household member was the passenger of a non-household driver) to a recipient trip (one of the 829 two-occupant trips in which a non-household member was the passenger of a household driver). The hot-deck imputation used three hard boundary trip characteristics (i.e., time of day, week vs. weekend, 11 trip purpose categories including going home or to school) to define hard boundary imputation cells, and six soft boundary trip and income characteristics (i.e., trip distance, urban/suburban/rural, region, season, average speed, household income) to define soft boundary imputation cells within hard boundary imputation cells. For each recipient trip, a donor trip with the same soft boundary imputation cell (e.g., same trip distance and average speed) was randomly selected from available donor trips. If no donor trip was available within the soft cell, the nearest available donor trip was selected within the hard boundary imputation cell (e.g., same trip purpose). The hot-deck imputation was run repeatedly with the specification that no donor trip be used more than once per run; a donor was used more than three times in less than 0.01% of trips. Given the lack of national probability surveys on non-household passengers and the availability of multiple trip and income characteristics for household passengers with non-household drivers, hot-deck imputation seemed the richest strategy to replace missing non-household passenger age and sex.

2.2.2. Relative risk of fatal crash involvement—Relative risk of fatal crash involvement with one passenger (1), compared to no passengers (0), was calculated for each driver/passenger condition. To calculate relative risk, defined as the fatal crash involvement rate ratio, the fatal crash involvement rate per 10 million VT and VMT were first obtained for each driver/passenger as well as the no passenger condition by dividing yearly average of fatal crash involvement (C) (see Table 2) by annual VT and VMT in 10-millions (V) (see Table 3). The fatal crash involvement rate with one passenger was then divided by the rate with no passengers. The procedure described by Rothman and Greenland (1998) was employed to calculate the corresponding 95% confidence intervals, which were used to determine statistical significance.

$$\text{Relative risk per 10 million VT or VMT: } (C_1/V_1)/(C_0/V_0)$$

3. Results

3.1. Fatal crashes

Table 2 presents young drivers' yearly average of fatal crash involvement from the FARS 1999–2003 by driver/passenger conditions. Percentage of crashes with one passenger is also shown for each driver/passenger condition. Results indicated that about 60% of the fatal crashes in which young drivers were involved occurred with no passengers, while most fatal crashes with one passenger occurred with 16–20-year-old passengers, particularly with passengers of the same sex as the drivers (44% vs. 32% for males and females respectively).

3.2. Estimation of driving exposure

Estimates of annual VT and VMT in 10-millions by driver/passenger conditions are shown in Table 3. Results with 16–20-year-old passengers indicate that teenage drivers took more VT with females than males (i.e., for male drivers: 210 million VT with female passengers vs. 190 million VT with males; for female drivers: 260 vs. 100 million VT). Similar results were found with VMT. Results also show that more VT and VMT were taken with passengers aged 35 years and older than with 16–20-year-old passengers.

3.3. Relative risk of fatal crash involvement

Table 4 presents young drivers' risk of fatal crash involvement with one passenger and for each driver/passenger condition, relative to no passengers, per 10 million VT and per 10 million VMT. For VT, the highest relative risk for young drivers was with 16–20-year-old male passengers. The other passenger age groups associated with increased risk for male drivers were, in descending order: 21–34-year-old males, 16–20-year-old females, and 13–15-year-old males or females. For female drivers, increased risk with other passenger subgroups was also found, in descending order, with 16–20-year-old females, 21–34-year-old males, 13–15-year-old females, and 21–34-year-old females. For VMT, comparable results to those found with VT were observed for male drivers. However, for females, relative risk was comparable with 16–20-year-old male and female passengers, and null effects were found with 21–34-year-old female passengers. With both VT and VMT, protective effects were found with passengers aged 35 years and older and a mix of protective and null effects was observed with passengers under 13 years old.

4. Discussion

The main aim of this study was to examine, using the NHTS, young male and female drivers' fatal crash risk by passenger age group and sex, specifically the effect of young male passengers, while accounting for driving exposure. While the presence of young passengers

has been associated with young drivers' increased crash risk, the relative risk imposed by young passengers can only be evaluated accurately by controlling for exposure. In the current study, the NHTS missing non-household passenger characteristics were imputed with hot deck, which allowed the estimation of young drivers' crash rate and relative risk of fatal crash involvement by passenger age and sex, using solo driving as the referent.

4.1. Main findings

The highest relative risk of fatal crash involvement per 10 million VT was found with young male passengers. The highest risk was also found with male passengers for male drivers per 10 million VMT, but similar values were found for female drivers with young male and female passengers. In terms of the direction of the results, these findings can be compared, though only indirectly, to the results of an observational study of drivers and passengers (Simons-Morton et al., 2005). This study indicated that compared with general traffic teenagers, especially males, drove at higher speeds and with smaller headways when carrying male teenagers. The results can also be compared indirectly to the fatalities per 1000 crashes by driver and passenger sex found by Chen et al. (2000) who did not disaggregate the data in that analysis by passenger age. For young male drivers, they found higher fatalities when one or more of the passengers were male. For young female drivers, they found an equivalent relative risk when carrying one male or one female passenger. By focussing on fatalities per 10 million trips as a function of the age and sex of both drivers and passengers, this study extends the work by Chen et al. (2000) on crash risk with one passenger, which calculated fatalities per 10 million trips by driver age and sex, irrespective of passenger characteristics. Our results shown in Table 4 for that analysis are similar to their results. However, the relative magnitude of the effects found in our study, which is the first to disaggregate data by young driver sex and passenger age and sex per 10 VT and VMT in the same analysis, is noteworthy.

High relative risk was also found for young drivers with other passengers, though generally lower than with 16–20-year-old passengers. In particular, the presence of 21–34-year-old male passengers was associated with increased risk for both male and female drivers. Other studies have found an elevated crash risk for young drivers carrying 20–29-year-old passengers (e.g., Bédard and Meyers, 2004; Chen et al., 2000; Lam, 2003; Preusser et al., 1998). Moreover, Chen et al. (2000) found that teenage drivers had a higher relative risk of fatality per 1000 crashes with 20–29-year-old passengers than with 13–19-year-old passengers. The general protective effect found with passengers under 13 and 35 years and older is in line with most findings in the literature.

4.2. Methodological issues and future research

One disadvantage associated with hot-deck imputation is that both the choice of variables from the selected donor database and data quality can affect the estimated values (Pérez et al., 2002). Regarding the former, it is possible that some trip characteristics, such as going home, which represented about a third of the driving exposure, were similar for different types of passengers (e.g., young and older passengers). This could explain why the hot-deck imputation assigned young drivers more trips with non-household passengers aged 35 years and older. With regards to data quality, the 2001 NHTS survey allowed a proxy to answer for participants under some circumstances, such as participant unavailability during the 6-day recall period or failed contact after 3 days (Hu and Reuscher, 2004). Analysis of this variable from the survey indicates that about half of young participants' responses were answered by a proxy. In contrast, for drivers 35 years and older, these numbers were below 15% for females and around 25% for males. This situation might have affected the NHTS data, especially for young participants. In a review of the literature, Moore (1988) concluded that research on self vs. proxy responses is inconclusive and that some research topics might be more affected than others by proxy responses. In the present study, it is probable that in most cases a parent served as a proxy.

While responses of young participants and their parents could be equivalent, it is possible that parents are better at estimating their children driving exposure. In contrast, parents may be in the dark about some of their children's behavior (Beck et al., 1999). Some teenage drivers may hide driving exposure information from their parents when carrying other teenagers and/or being a passenger in a teenager's vehicle. These possibilities may be more likely for young drivers in states that prohibited new drivers from having teenage passengers for a certain time period after licensing. In 2001, 19 states had some kind of passenger law (Insurance Institute for Highway Safety [IIHS], 2008). It is rather unclear how the potential impact of proxy measures could have been accounted for in the imputations conducted in this study. More research needs to be conducted on the effect of proxy vs. self response in relation to young drivers' exposure.

Other rate-based analyses, such as the quasi-induced crash exposure technique, have been employed as an alternative way to deal with missing driving exposure data (e.g., Aldridge et al., 1999; Padlo et al., 2005; Preusser et al., 1998). While the quasi-induced crash exposure technique has provided interesting results, some of its shortcomings might nevertheless impact on young drivers' crash risk estimation. This technique is based on crashes involving two or more vehicles in which one is determined to be at-fault. It also assumes that fault assignment is unbiased, the distribution of drivers in single-vehicle crashes is similar to the distribution of drivers in multiple crashes, and not-at-fault drivers represent the driver population (Jiang and Lyles, 2007; Stamatiadis and Deacon, 1997). Given that young drivers are overrepresented in single-vehicle crashes compared to multiple-vehicle crashes, Stamatiadis and Deacon (1997) suggested that policy making should not be based only on analyses conducted on multiple crashes. Moreover, the interpretation of studies' results will always be complicated by important methodological and conceptual differences between them. In line with this thinking, employing multiple techniques to address the numerous challenges in the assessment of risk would be advantageous.

This study focused on the impact of passenger age and sex on male and female teenage driver fatal crash risk involvement, resulting in the disaggregation of the data into 20 driver/passenger conditions. Results could have been different if our dependent variable had been or had included non-fatal crashes. Also, our approach limited the exploration of other factors that can increase crash risk with passengers, such as the presence of more than one passenger, time of the day, and vehicle or road types. It is therefore conceivable that a portion of the observed passenger age and sex effects may be better explained by the various dyads driving under different conditions, even if amount of driving is controlled for. While this study shows higher risk with certain types of passengers, potential causes of crashes (e.g., alcohol, speed) were not addressed, and psychosocial mechanisms underlying increased risk for various dyads remains undemonstrated and awaits further investigation. Research into these mechanisms, including social influence, peer pressure, and passenger-induced distraction, would improve our understanding of crash risk. Understanding the risks associated with passenger characteristics, as we did in this study, and the psychosocial mechanisms underlying passenger effects are key to our ability to better develop and target psychosocial interventions.

4.3. Conclusion

This study was the first to estimate relative risk of fatal crash involvement by young driver sex and passenger age and sex per 10 million VT and VMT. The high fatal crash involvement of 15–20-year-old drivers with 16–34-year-old passengers, especially for male drivers with male passengers, warrants further investigation. At the same time, a more precise assessment of risk by driver and passenger characteristics will not emerge until the U.S. national survey collects reliable information on non-household passenger age and sex.

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References

- Aldridge B, Himmler M, Aultman-Hall L, Stamatiadis N. Impact of passengers on young driver safety. *Transp Res Rec* 1999;1693:25–30.
- Beck KH, Shattuck T, Haynie D, Crump AD, Simons-Morton B. Associations between parent awareness, monitoring, enforcement and adolescent involvement with alcohol. *Health Educ Behav* 1999;14 (6): 765–775.
- Bédard M, Meyers JR. The influence of passengers on older drivers involved in fatal crashes. *Exp Aging Res* 2004;30 (2):205–215. [PubMed: 15204633]
- Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System (WISQARS): Leading Causes of Death Reports 1999–2005. 2008. [On-line] <http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html>
- Chang, D. Traffic Safety Facts Comparison of Crash Fatalities by Sex and Age Group. NHTSA's National Center for Statistics and Analysis; Washington, DC: 2008.
- Chen LH, Baker SP, Braver ER, Li G. Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. *JAMA* 2000;283:1578–1582. [PubMed: 10735394]
- Doherty ST, Andrey JC, MacGregor C. The situational risks of young drivers: the influence of passengers, time of day and day of week on accident rates. *Accid Anal Prev* 1998;30 (1):45–52. [PubMed: 9542543]
- Engstrom I, Gregersen NP, Granstrom K, Nyberg A. Young drivers - Reduced crash risk with passengers in the vehicle. *Accid Anal Prev* 2008;40 (1):341–348. [PubMed: 18215567]
- Fatality Analysis Reporting System. Fatality Analysis Reporting System (FARS). 2008. <http://www.nhtsa.dot.gov/people/ncsa/fars.html>
- Ford, BL. An overview of hot-deck procedures. In: Madow, WG.; Olkin, I., editors. *Incomplete Data in Sample Surveys*. Vol. II. Academic Press; New York: 1983. p. 185-207.
- Fu, H.; Wilmot, CG. Effect of passenger age and gender on young driver crash risk. Proceedings of the 87th Annual Meeting of the Transportation Research Board; Washington DC. 2008. <http://www.ltrc.lsu.edu/pdf/2008/08-0617.PDF>
- Hartup, W. Friendships and their developmental significance. In: McGurk, H., editor. *Childhood Social Development: Contemporary Perspectives*. Lawrence Erlbaum Associates; East Sussex: 1992. p. 175-205.
- Hu, PS.; Reuscher, TR. Summary of Travel Trends: 2001 National Household Travel Survey. U.S. Department of Transportation Federal Highway Administration; Washington, DC: 2004.
- Insurance Institute for Highway Safety [IIHS]. US licensing systems for young drivers - effective dates. IIHS; Arlington: 2008.
- Jiang X, Lyles RW. Difficulties with quasi-induced exposure when speed varies systematically by vehicle type. *Accid Anal Prev* 2007;39 (4):649–656. [PubMed: 17118322]
- Lam LT. Factors associated with young drivers' car crash injury: comparisons among learner, provisional, and full licensees. *Accid Anal Prev* 2003;35 (6):913–920. [PubMed: 12971926]
- Moore JC. Self/proxy response status and survey response quality. *J Off Stat* 1988;4 (2):155–172.
- Padlo P, Aultman-Hall L, Stamatiadis N. Passengers and other factors affecting the safety of young and older drivers. *Transp Res Rec* 2005;1937:7–13.
- Pérez A, Dennis RJ, Gil JFA, Rondon MA, Lopez A. Use of the mean, hot deck and multiple imputation techniques to predict outcome in intensive care unit patients in Columbia. *Stat Med* 2002;21:3885–3896. [PubMed: 12483773]
- Poulin F, Pedersen S. Developmental changes in gender composition of friendship networks in adolescent girls and boys. *Dev Psychol* 2007;43 (6):1484–1496. [PubMed: 18020826]
- Preusser DF, Ferguson SA, Williams AF. The effects of teenager passengers on the fatal crash risk of teenager drivers. *Accid Anal Prev* 1998;30 (2):217–222. [PubMed: 9450125]

- Reiss, JA.; Kruger, H. Accident risk modified by passengers. Proceedings of the 13th International Conference on Alcohol, Drugs, and Traffic Safety; Adelaide, Australia. 1995. p. 213-221.
- Rothman, KJ.; Greenland, S. Modern Epidemiology. 2. Lippincott-Raven; Philadelphia: 1998.
- Rueda-Domingo T, Lardelli-Claret P, Luna-del-Castillo JD, Jimenez-Moleon JJ, Garcia-Martin M, Bueno-Cavanillas A. The influence of passengers on the risk of the driver causing a car collision in Spain. Analysis of collisions from 1990 to 1999. *Accid Anal Prev* 2004;36 (3):481–489. [PubMed: 15003593]
- Senserrick TM, Kallan MJ, Winston FK. Child passenger injury risk in sibling versus non-sibling teen drive crashes: a US study. *Inj Prev* 2007;13 (3):207–210. [PubMed: 17567980]
- Simons-Morton BG, Lerner N, Singer J. The observed effects of teenage passengers on the risky driving behavior of teenage drivers. *Accid Anal Prev* 2005;37 (6):973–982. [PubMed: 15921652]
- Stamatiadis N, Deacon JA. Quasi-induced exposure: methodology and insight. *Accid Anal Prev* 1997;29 (1):37–52. [PubMed: 9110039]
- Williams AF, Karpf RS. Deaths of teenagers as passengers in motor vehicles. *Accid Anal Prev* 1983;15 (1):49–54.
- Williams AF, Shabanova V. Responsibility of drivers, by age and gender, for motor-vehicle crash deaths. *J Safety Res* 2003;34 (5):527–531. [PubMed: 14733986]
- Williams AF, Wells JK. Deaths of teenagers as motor-vehicle passengers. *J Safety Res* 1995;26 (3):161–167.
- Zimowski, M.; Tourangeau, R.; Ghadialy, R.; Pedlow, S. Nonresponse in Household Travel Surveys. Federal Highway Administration; Washington, DC: 1997.

Table 1
Trip characteristics from the 2001 National Household Travel Survey for driver and passenger types

	Number of Occupants (Number of Passengers)	Type of Driver	Type of Passenger	Number of Trips	Missing Passenger Age and Sex
a) 1 (0)		Household	-----	4464	-----
b) 2 (1)		Household	Household	788	no
c) 2 (1)		Household	Non-household	829	yes
d) 2 (1)		Non-household	Household	775	no

Note. Age and sex of non-household vehicle occupants were not collected in this survey. The hot-deck imputation used trip and income characteristics from line “d” to impute missing non-household characteristics of line “c.”

Table 2

Young drivers' yearly average of fatal crash involvement from the Fatality Analysis Reporting System (1999–2003) by driver/passenger condition (n = 5816), and percentages of fatal crash involvement with one passenger by condition

Passenger		Young Driver			
Number and Sex	Age Group	Male		Female	
		M	(%)	M	(%)
No Passengers	----	2449	----	1110	----
1 Passenger	All	1567	(100)	690	(100)
Male	≤12	23	(1)	38	(6)
	13–15	118	(8)	23	(3)
	16–20	697	(44)	136	(20)
	21–34	203	(13)	77	(11)
	≥35	66	(4)	18	(3)
Female	≤12	13	(1)	36	(5)
	13–15	66	(4)	66	(10)
	16–20	287	(8)	221	(32)
	21–34	55	(3)	36	(5)
	≥35	38	(3)	39	(6)

Note. From 1999–2003, there was a total of 29 077 fatal motor vehicle crashes in which young U.S. drivers were involved, but not necessarily as fatality victims. Frequencies and percentages for each subgroup are shown rounded to the closest unit; totals are calculated with decimals and then rounded to closest unit.

Table 3
Young drivers' estimated annual vehicle trips (VT) and vehicle-miles traveled (VMT) in 10-millions by driver/passenger condition

Passenger		Young Driver Exposure in 10-millions			
		VT		VMT	
Number and Sex	Age Group	Male	Female	Male	Female
No Passengers	----	533	458	3801	3637
1 Passenger	All	198	168	1622	1545
Male	≤12	7	18	63	145
	13–15	14	9	87	53
	16–20	19	10	109	110
	21–34	10	11	82	109
	≥35	36	16	321	325
Female	≤12	8	11	70	101
	13–15	11	13	79	66
	16–20	21	26	135	166
	21–34	14	9	128	123
	≥35	59	45	548	346

Note. Frequencies for each subgroup are shown rounded to the closest million unit and percentages to the closest unit; totals are calculated with decimals and then rounded to closest unit.

Table 4

Young drivers' relative risk of fatal crash involvement by driver/passenger condition per 10 million vehicle trips (VT) and 10 million vehicle-miles traveled (VMT)

Passenger		Young Driver Relative Risk and (Confidence Interval) per 10 million			
		VT		VMT	
Number and Sex	Age Group	Male	Female	Male	Female
No Passengers	-----	1.00	1.00	1.00	1.00
1 Passenger	All	1.71 (1.61–1.83)	1.69 (1.54–1.86)	1.50 (1.41–1.60)	1.46 (1.33–1.61)
Male	≤12	0.72 (0.47–1.08)	0.87 (0.63–1.20)	0.57 (0.38–0.86)	0.85 (0.62–1.18)
	13–15	1.83 (1.52–2.21)	1.05 (0.70–1.59)	2.10 (1.74–2.52)	1.42 (0.94–2.14)
	16–20	7.99 (7.34–8.69)	5.63 (4.71–6.72)	9.94 (9.13–10.81)	4.06 (3.40–4.85)
	21–34	4.41 (3.82–5.09)	2.88 (2.29–3.63)	3.84 (3.33–4.44)	2.30 (1.82–2.90)
	≥35	0.40 (0.31–0.51)	0.45 (0.28–0.73)	0.32 (0.25–0.41)	0.18 (0.11–0.28)
Female	≤12	0.35 (0.20–0.60)	1.37 (0.98–1.90)	0.28 (0.16–0.49)	1.18 (0.85–1.64)
	13–15	1.31 (1.03–1.68)	2.10 (1.64–2.69)	1.31 (1.03–1.67)	3.28 (2.56–4.20)
	16–20	2.97 (2.63–3.36)	3.50 (3.03–4.05)	3.29 (2.91–3.72)	4.36 (3.78–5.04)
	21–34	0.85 (0.65–1.11)	1.66 (1.19–2.31)	0.66 (0.51–0.87)	0.96 (0.69–1.34)
	≥35	0.14 (0.10–0.19)	0.35 (0.26–0.49)	0.11 (0.08–0.15)	0.37 (0.27–0.50)