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Accident Analysis and Prevention xxx (2005) xxx–xxx
ACCIDENT ANALYSIS & PREVENTION
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The observed effects of teenage passengers on the risky driving behavior of teenage drivers

Bruce Simons-Morton [a,*], Neil Lerner [b], Jeremiah Singer [b]

[a] *Prevention Research Branch, Division of Epidemiology, Statistics, and Prevention Research, National Institute of Child Health and Human Development, National Institutes of Health, 6100 Executive Blvd RM#7B13M, Bethesda, MD 20892-7510, USA*
[b] *Westat, 1650 Research Boulevard, Rockville, MD 20850, USA*

Received 28 January 2005; received in revised form 20 April 2005; accepted 20 April 2005

Abstract

The association between teenage passengers and crash risks among young drivers may be due to risky driving behavior. We investigated the effect on two measures of risky driving in the presence of young male and female passengers. Vehicles exiting from parking lots at 10 high schools were observed and the occupants were identified by gender and age (teen or adult). At a nearby site, the speed and headway of passing traffic were recorded using video and LIDAR technology. Teenage drivers drove faster than the general traffic and allowed shorter headways, particularly in the presence of a male teenage passenger. Both male and female teenage drivers allowed shorter headways (relative to no passenger or a female passenger) in the presence of a male teenage passenger, while the presence of a female teenage passenger resulted in longer headways for male teenage drivers. Overall, the observed rate of high risk driving (defined as speed ≥15 mph or more above the posted speed limit and/or headway of ≤1.0 s) for the teen male driver/male passenger condition was about double that of general traffic. In conclusion, the presence of male teenage passengers was associated with risky driving behavior among teenage drivers.
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Keywords: Motor vehicles; Adolescents; Risk taking; Social influences; Speeding; Passengers

1. Introduction

Crash involvement rates per mile driven are several times greater for teenage than that for middle-age drivers (NHTSA, 2000). Fatal and non-fatal crash rates for 16- or 17-year-old drivers are particularly elevated in the presence of teen passengers (Chen et al., 2000; Doherty et al., 1998; Preusser et al., 1998; Regan and Mitsopoulos, 2001; Ulmer et al., 1997; Williams and Ferguson, 2002), particularly for speed-related fatal crashes (Williams, 2001). While the increased risk of teen passengers on crash rates among teen drivers is well documented, the underlying reasons that teen passengers increase teen driving risk are not well understood. One possibility is that the presence of teen passengers may alter teenage driving behavior.

Teen passengers may cause actual distraction by their actions in the vehicle, such as talking, altering the radio or CD player, moving about, or touching the driver. In studies of adolescent risk behaviors, it is indicated that teens are an important source of social influence (Ennett and Bauman, 1994; Jaccard et al., 2005; Simons-Morton et al., 2004) and peer influence may also be a factor in driving. Peer influences may include direct and intentional encouragement of risky driving behavior, for example, by urging the driver to drive fast, catch up with, or pass another vehicle. Peer influences may also be indirect and unintended. Accordingly, a teenage driver may be inclined to drive in a more or less aggressive, risky, or careless way because he or she perceives that the teen passenger(s) would view such driving behavior as desirable or expected. Although it is clear that the presence of teenage passengers is an independent risk factor for crashes among teenage drivers

* Corresponding author. Tel.: +1 301 496 674; fax: +1 301 402 2084.
E-mail addresses: Mortonb@mail.nih.gov (B. Simons-Morton), LERNER1@westat.coom (N. Lerner), jeremiahsinger@westat.com (J. Singer).

0001-4575/$ – see front matter. Published by Elsevier Ltd.
doi:10.1016/j.aap.2005.04.014

this relationship could be due in part to time of day, trip location and purpose, alcohol use, or other factor common to both teenage passengers and crashes by teenage drivers (Doherty et al., 1998). Although there has been considerable study of the statistical association between passenger characteristics and teenage driver crash risk, there has been relatively little research on the effects of passengers on teenage driver behavior and only one study has been reported in which an effect of passengers on young driver behavior was actually observed.

McKenna et al. (1998) provided the only data so far reported on the observed effect of young passengers on the driving behavior of young drivers in a natural driving environment. Specifically, McKenna et al. conducted a set of observational studies to assess the effects of young passenger presence on young driver behaviors, including speed, following distance, and gap acceptance. Accordingly, relative to young drivers with no young passenger, mean speed was greater for both male and female drivers when a male passenger was present. However, with a female passenger present, mean speed was greater for male drivers, but not female drivers. Gap distance was less for both young male and female drivers in the presence of young male passengers and greater in the presence of a young female passenger. Overall, McKenna et al. provided the first data showing that in the presence of male young passengers, risky driving behavior was greater for both young male and young female drivers, while in the presence of young female passengers, risky driving among young male drivers was less.

The study by McKenna et al., however, was limited in several ways. Importantly, determinations of driver and passenger age were based on the judgment of a remote, hidden observer viewing into a moving vehicle that they were less than 25 or greater than 25 years of age. In pilot efforts related to the present project, observers were unable to confidently classify passengers according to age and sex using both direct observation and video recordings from distances as close as 15 ft from moving vehicles. Windshield glare, shadows, tinted windows, varying vehicle heights and configurations, and other variable real-world conditions prevented observers from making confident judgments about occupant age and sex in moving vehicles. We concluded that only proximal observation of occupants in stationery vehicles would provide accurate assessments. The “gap acceptance” experiment of McKenna et al. might also be improved upon. For McKenna, gap acceptance was recorded as vehicles were turning from a “junction, which gave access to a 30 mph urban road.” The time that the merging vehicle’s rear bumper reached a criterion point on the main road and the time the following vehicle’s front bumper reached the criterion point were recorded, and the time between vehicles was considered the “gap” that the driver accepted. Actually, the gap (available time to make the maneuver) is not known. The measure is really a safety clearance interval that reflects both gap size and the speed with which the driver completed the merging maneuver. Finally, the study was conducted in England, where drivers are licensed at older ages and may in other ways be different from drivers in the United States.

The purpose of the present study was to examine driving behavior of teenage drivers in the presence of teenage passengers. Vehicles were observed exiting from high school parking lots at dismissal time and an observer was stationed within a few yards of the exit such that he or she could easily determine the number, sex, and relative age of the passengers. Complete information (presence, age, gender) for all vehicle occupants was recorded for more than 97% of vehicles exiting the lots and partial information (age or gender unknown, rear seat passenger presence unknown) was recorded for more than 99% of vehicles. In this way, the study was able to capture a large number of drivers with very high confidence that those who appeared to be youthful were indeed teenagers. Vehicle speeds and headways were then recorded at nearby locations, where roadway conditions allowed meaningful opportunities for speeding or tailgating. Vehicles at these measurement sites were then matched with information about the vehicles previously obtained as they exited the school lot. The behavior of teenage drivers could then be compared with the behavior of general traffic, and the effects of passenger presence could be assessed. The experiment provides an opportunity to confirm the passenger effects on risky driving behavior observed by McKenna et al. (1998) with a US population of high school students.

2. Method

2.1. Design

Field observations of vehicle traffic in the vicinity of public high schools were conducted and data on speed and frontal headway were obtained from relatively unobtrusive roadside recording equipment. Observers standing within a few feet of the exit from each school parking lot recorded the descriptions of exiting vehicles and the characteristics (age, sex) of drivers and passengers. At a site some distance from the school (½ to 3/4 mile), passing traffic was assessed using a roadside recording system, including a video camcorder and LIDAR. LIDAR is a laser device that measures the speed of vehicles and their distance and is commonly used in police speed enforcement. The manufacturer-certified accuracy of the system used in this study is ± 1 mph for speed and ± 1 ft for distance. From this recording, the speed and headway (distance from front of preceding vehicle to front of target vehicle) of each vehicle could be derived. By matching the vehicle information from the school exit to the vehicles recorded on the roadway, each vehicle could be categorized as having a teenage driver, an adult driver, or as “general traffic” (not from the school). These data permit an analysis of two measures of risky or aggressive driving – speed and headway – as a function of driver and passenger characteristics.

Data were collected at 13 roadway sites in the vicinity of 10 different public schools (two different sites meeting the criteria were used at three of the schools on different days) in the greater Washington, DC suburban area. High schools were selected for observation if school officials provided approval and if the school and a nearby road site met the following criteria: two-lane undivided road near the school; moderate, moderate traffic volume; no nearby traffic control devices that could impede traffic flow; substantial number of teenage drivers entering the traffic stream; safe roadside locations for researchers; dry road and no precipitation at time of observation.

2.2. Procedure

The data collection team of three observers set up prior to school dismissal. Observer #1 was located within a few yards from the parking lot exit to verbally record (via a wireless microphone transmitter) the age and sex of the driver and passenger and vehicle type and color. Observer #2 was located across from the lot with the video camera to record the vehicle for future identification. Observer #3 was located on a nearby road segment operating a LIDAR unit and 8 mm video camcorder. The data recording system was comprised of a Stalker LIDAR unit, a camcorder, a PC, a videocassette recorder, and a gas-powered generator. The LIDAR unit and camcorder were mounted to a tripod and set up to observe vehicles as they traveled away from the school at speed. The system was positioned well off the roadway and aimed toward traffic approaching from the direction of the high school. LIDAR data were output to the PC, where a custom software program corrected distance and speed measurements to reflect the road offset. The corrected data were fed to a videotitler unit, which stamped time, speed, and range data onto the video feed from the camcorder. The video and speed data were recorded to a VHS cassette in the VCR unit. During data recording, Observer three monitored the system and also audio recorded notes on vehicle color and type, partial license plate numbers of passing vehicles to aid in later matching vehicles at the LIDAR site to those exiting the school, and any unusual events that might affect the quality or interpretation of data.

2.3. Measures

2.3.1. Dependent measures

The risk-related driving measures used in this study were vehicle speed and headway. Speed was observed using a LIDAR unit. The spot speed recording was typically made at a distance of 150–300 ft from the LIDAR unit. Vehicle headway was derived from the video recording of traffic. The time that the front of each vehicle reached a criterion location was recorded. Vehicle headway was defined as the temporal latency (in seconds) between successive vehicles as they passed this fixed point on the roadway. Using this method, headway was recorded as the latency from the front of a lead vehicle to the front of a following vehicle. Note that this is not the same as following distance (distance from rear of lead vehicle to front of target vehicle) or following headway (time from arrival of rear of lead vehicle to front of target vehicle), although the measures are highly related.

2.3.2. Independent measures

The observer recorded the following independent variables on each vehicle exiting the parking lots: driver age (teen or adult); driver sex (male or female); teen passenger presence (none, front seat, rear seat), age (teen or adult), and sex; vehicle category (car, SUV, van, pickup truck, other).

2.4. Data management and analyses

After completion of the field observation, coders reviewed the video and audio (Observer #1 commentary) portions of the videotape of vehicles exiting the school parking lots and entered the data on each vehicle into a Microsoft Access database so that these vehicles could be matched to those passing the LIDAR site. Next, this information was combined with that from the LIDAR site video and vehicles that had exited from the parking lot were matched. Thus, each vehicle was classified as having a teen driver, an adult driver, or as being part of the general traffic at the site (driver age not known). Overall, about 63% of vehicles observed exiting the schools were also observed at the LIDAR sites. Although efforts were made to select sites where traffic dilution would be minimal, some vehicles left the observed road before reaching the LIDAR site. Because of the varying traffic patterns at the different sites, the matching rates varied substantially between sites. It is also possible that a very small percentage of unmatched vehicles did pass the LIDAR site but were not detected during the video review, due to obscuration (e.g., by a pedestrian passing the camera) or other viewing problems.

Non-passenger vehicles, such as trucks, buses, motorcycles, or commercial vehicles, were excluded from the database, along with aberrant data, such as LIDAR beam obstructed by a pedestrian. Vehicles were categorized as “teenage drivers” observed at the school exit, “adult drivers” observed at the school exit, and “general traffic” that did not match vehicles exiting from the school lot. “General traffic” includes some unknown number of teenage drivers. To the extent teenage drivers were also represented in the general traffic, this would weaken observed driver group effects, since the characteristics of the teen drivers (e.g., higher speeds) would contribute to the mean of the general traffic group as well. The complete database was then screened to identify erroneous data (e.g., by searching for extreme outliers and other suspicious values), which were then corrected by reviewing the original video data.

To allow for meaningful analyses across the various sites, which differed in terms of posted speed, general traffic speed, and other aspects, the data for each vehicle were transformed based on mean data for the site. Thus, for speed, the mean speed of general traffic was computed for the particular site. This mean was then subtracted from the speed for each individual vehicle, so that individual vehicle speed was expressed as a difference from the mean of general traffic. For example, if the mean speed of general traffic for a given site was 35.3 mph, and a particular vehicle was traveling at 37.8 mph, the transformed speed for that vehicle would be +2.5 mph. A similar transform was done for headway. The mean headway of general traffic was computed for each site, and each individual vehicle's headway was then transformed by subtracting this value. Therefore, the transformed speed and headway data are actually expressed as deviations from site general traffic means.

In actual traffic, some vehicles will be grouped together in a platoon and some vehicles will be relatively distant from other vehicles. Drivers in a platoon do not have full discretion regarding their speed; they cannot go faster than the vehicle ahead. A criterion headway value of 3 s was used to dichotomize individual vehicles into a platoon or non-platoon situation. Three seconds was selected as a reasonable criterion based on both general driver behavior and data from this study. Headways less than 2 s are generally considered to be "close car following." Also, a scatter plot of raw speed versus headway data from this study indicated that speeds were relatively constant at headways from 3 s on and there was also a clustering of headways in the 1–2.5 s range (suggesting platoons). Therefore, a value of 3 s appears as a reasonable criterion level for classifying platooning. If the headway was >3 s, the vehicle was considered to be non-platoon and could be used for speed analysis. If the headway was ≤3 s, the vehicle was considered to be car-following and could be used for headway analysis. With traffic speeds averaging approximately 40 mph, a nose-to-nose headway of 3 s is equivalent to about 176 ft. Assuming a typical vehicle length of about 16 ft, this translates into a tail-to-nose following distance of about 160 ft, or roughly 10 vehicle lengths of following distance.

Analyses of variance were based on these transformed speed and headway scores. Various other means of conducting these analyses were evaluated, to address concerns of non-normal distributions, high variance, unbalanced design, and other assumptions of the analysis model. These included raw and log-transformed speed and headway data and the inclusion of site as a covariate. None of these approaches substantially or systematically changed the observed test outcomes. Since the transformation of speed and headway based on the mean of general traffic at each site provides a simple and intuitive way to describe the findings, this was used for the primary analyses. Chi square tests were used to test bivariate comparisons of proportions.

3. Results

The posted speeds across the 13 sites ranged from 25 to 50 mph. Combining all sites, over 3000 passing vehicles were recorded, of which 2251 were qualifying vehicles in general traffic and 471 were teen drivers (245 male and 226 female). There was no passenger present in 232 of the teen vehicles and one or more passengers present in 239 of the teen vehicles. Among teenagers, over 80% drove cars, 14% vans or SUVs, and 3.4% pickups, while 60% of general traffic drove passenger cars, 33.8% vans or SUVs, and 5.3% pickups. Forty-six percent of observed vehicles had headways of less than or equal to 3 s and therefore were studied in analyses of headway. Fifty-four percent of observed vehicles had headways of greater than 3 s and therefore were studied in analyses of speed. On average,

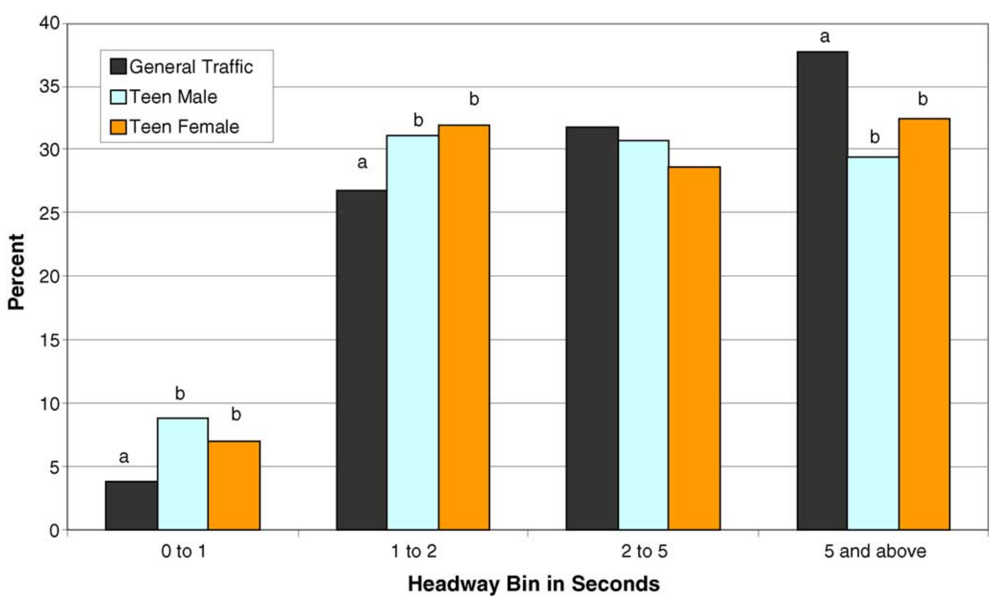

Fig. 1. Distribution of nose-to-nose headways for general traffic, teenage male and female drivers. *Note*: Percentages with different letters (a, b, c) are significantly different ($p < 0.05$) from each other (comparisons within each headway bin, not between headway bins).

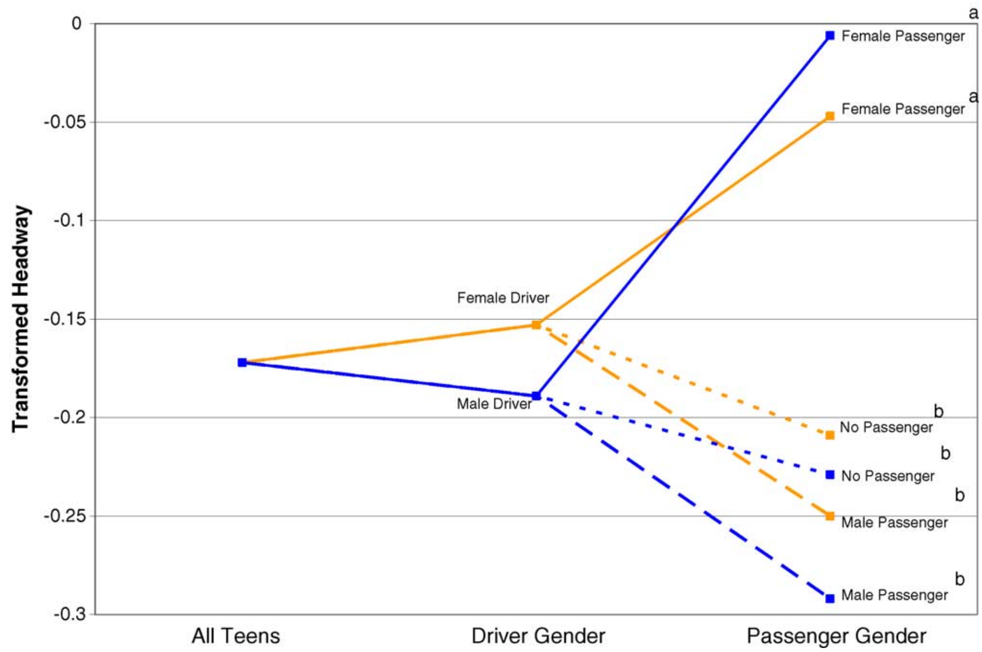

Fig. 2. Teen driver transformed headway by driver type and passenger type. *Note*: Driver-passenger category percentages with different letters (a, b) are significantly different from each other ($p < 0.05$).

vehicle headways were smaller at sites with greater traffic volumes.

3.1. Headway comparisons among driver groups

Shown in Fig. 1 are the distributions of vehicles with very short (≤1 s), short (≤2 s), moderate (2–5 s), or long (>5 s) headways by driver category. Teenagers represent fewer cases in the long headway category and more cases in the short headway (chi square = 14.92, d.f. = 4; $p < 0.01$) and very short headway (chi square = 15.08, d.f. = 2; $p < 0.001$) (differences between male and female teens were not significant). A 1 s nose-to-nose headway is equivalent to a tail-to-nose following gap of only about 0.73 s (assuming a speed of about 40 mph and a vehicle length of about 16 ft).

ANOVA techniques were used to examine the effects of driver and passenger type on headway among vehicles with a headway of <3 s. The experimental hypothesis is, given that the subject vehicle is in relative proximity to the lead vehicle, do driver and passenger characteristics relate to the choice of headway? An initial ANOVA on raw headway measures indicated main effects for driver (teen versus general traffic) and site, but no site-by-driver interaction. Given that there was no interaction between driver category and site, the subsequent analyses of teenage passenger effects were conducted using the pooled transformed headways for all sites.

The effect of teenage passengers on transformed headway for vehicles with <3 s headway is shown in Fig. 2. Accordingly, each driver's headway is a signed difference, in seconds, from the site mean (represented by zero value in Fig. 2) of general traffic. As shown, the mean headway for all teenage drivers is about 0.17 s shorter (about 10 ft at 40 mph) than that for general traffic. There is little difference in the headways of male and female teenage drivers, except in the presence of teenage passengers, where the presence of a female passenger is associated with longer headways and the presence of a male passenger is associated with shorter headways ($F = 3.19$, d.f. = 2234, $p < 0.05$). The presence of a female passenger for both male and female teen drivers resulted in significantly greater headway compared with all other driver/passenger conditions, as indicated in Fig. 2.

3.2. Speed comparisons among driver groups

Because short headways are likely to be associated with more congested traffic, and long headways with light traffic and increased opportunity to set one's own speed, it was anticipated that speed would increase with longer headways. Fig. 3 shows the mean transformed speed for vehicles at different headways from the preceding vehicle, where the zero line indicates the mean speed of general traffic and vehicle speed is expressed as the mean difference. As the figure suggests, the main effects of driver type ($F = 3.08$, d.f. = 2, 2618, $p < 0.05$), headway ($F = 47.06$, d.f. = 2, 2618, $p < 0.0001$), and their interaction ($F = 5.87$, d.f. = 4, 2618, $p = 0.0001$) were all statistically significant. Accordingly, mean speeds for all groups increase sharply as headways lengthen from 1–2 up to 3–4 s, and then flatten. The increase for teenagers is significantly higher than that for general traffic from 2–3 to 4–5 s and is particularly elevated for teenage females up to 5-s headways.

Mean transformed speed for teenage driver and passenger combinations is presented in Fig. 4. As shown, the mean transformed speed for all teenage drivers is about

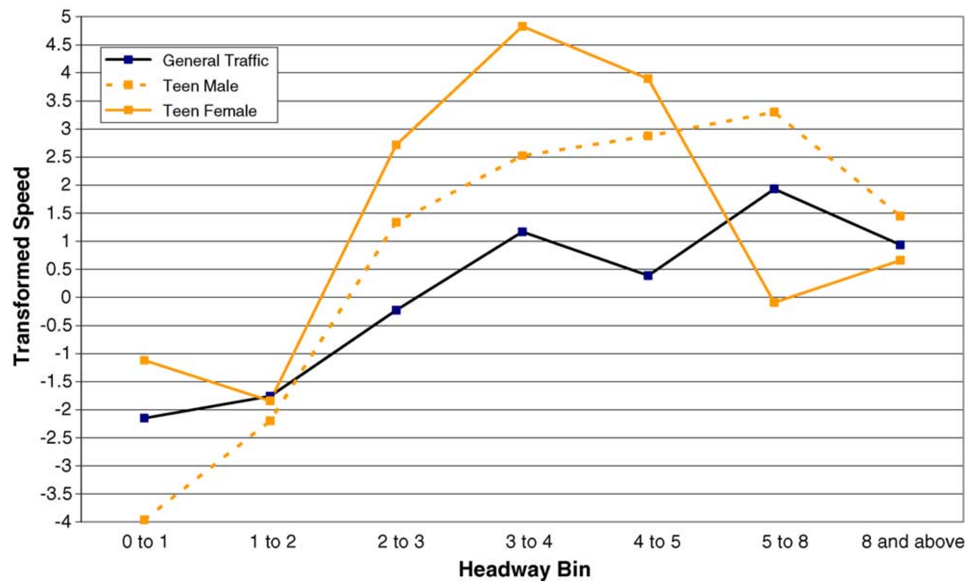

Fig. 3. Mean transformed speed as a function of headway, for driver groups (general traffic, teen males, teen females). *Note*: The increase in speed for teen males and females is significantly greater than that for general traffic for 2–5 s headway ($p < 0.05$).

1.3 mph faster than that for general traffic and teenage males drove slightly faster than teen females (+1.81 mph versus +0.77 mph), though this difference was not significant ($F = 0.90$, d.f. = 1192, $p = 0.34$). Compared to the no passenger condition, speeds were much higher when there was a male teenage passenger and somewhat slower when there was a female front seat teenage passenger present. While substantial, due to the small sample sizes and large variances, the effect of passenger type fell short of the conventional $p < 0.05$ significance level ($F = 2.90$, d.f. = 2192, $p = 0.057$).

The percentages of passenger vehicles with headway of >3 s and speeding by group, where speeding was defined as exceeding the posted speed limit by ≥15 mph, are shown in Fig. 5. As indicated, there was little difference between the general population and teenage drivers or between male and female teenage drivers, except in the presence of male teenage passengers (chi square = 11.58, d.f. = 2, $p < 0.01$). Subsequent tests found that the rate of such speeding for the teenage drivers with teenage male passengers differed significantly from the rate for teenage drivers with female

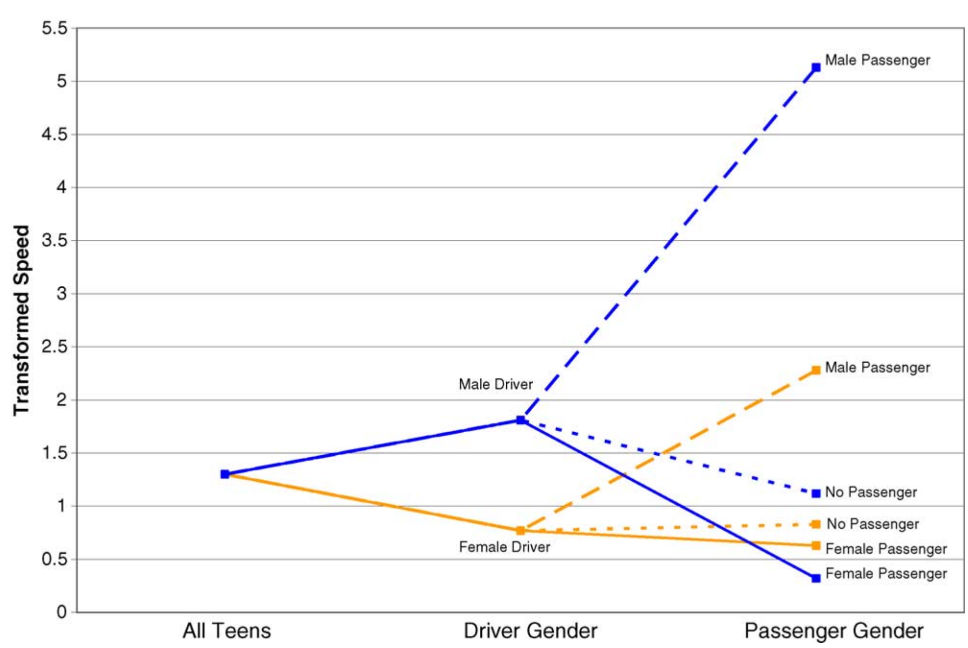

Fig. 4. Teen driver transformed speed by driver type and passenger type. *Note*: Comparison between male driver/male passenger and male driver/female passenger ($F = 2.90$, d.f. = 2, $p = 0.057$).

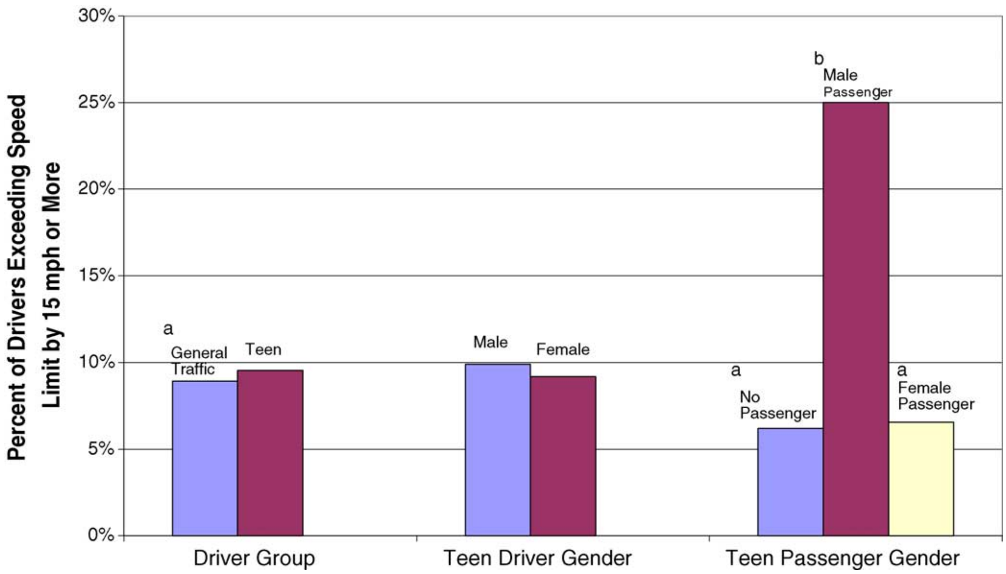

Fig. 5. Percent of cases where speed was at least 15 mph above the posted speed limit. *Note*: Different letters (a, b) indicate significant differences ($p < 0.05$).

teenage passengers (chi square = 5.14, d.f. = 1, $p < 0.05$), teenage drivers with no passengers (chi square = 7.50, d.f. = 1, $p < 0.01$), and general traffic (chi square = 8.75, d.f. = 1, $p < 0.01$).

In related analyses, teenagers drove faster when more than one teenage passenger was in the vehicle, except for the case where a male driver was accompanied by a female front seat passenger. However, given the small number of such cases, these differences were not statistically significant. Interestingly, among adult drivers leaving high school parking lots with teenage passengers speeds were faster with teenage male passengers than with teenage female passengers, +0.5 mph for adult female drivers and over 2.5 mph for the small sample of adult male drivers, although this effect was not statistically significant, given the small sample size.

3.3. Overall incidence of risky behavior

The findings for headway and speed just presented were analyzed independently, although they may not be independent. Close following headways may constrain speed; fast driving may result in close following. Since risky driving may be expressed in either high speed or short headway, it is of interest to ask how frequently some form of risky driving was observed. Criterion values for risky driving were taken as nose-to-nose headways of $\leq$1.0 s and speeds 15 mph or more over the posted speed limit. Table 1 presents the frequency of risky driving behavior for various driver and passenger groups. By this definition, slightly less than 10% of general traffic showed some risky driving behavior, compared with 14.9% of teenage male drivers and 13.1% of teenage female drivers (chi square = 8.21, d.f. = 2, $p < 0.02$). Compared with general traffic, the rate of risky driving was higher for male teenage drivers for both the no passenger (chi square = 5.15, d.f. = 1, $p < 0.05$) and the male passenger subgroup (chi square = 8.20, d.f. = 1, $p < 0.01$). For teenage male drivers, there was a significant effect of passenger presence with higher risky driving in the presence of a male passenger than in the presence of a female passenger (chi square = 5.02, d.f. = 1, $p < 0.05$). Risky driving among teenage female drivers was significantly higher in the presence of a female passenger.

4. Discussion

The effect of teenage passengers on teen driver crash risk is well established from analyses of crash statistics, but the reasons for this effect are less clear. In this study, we investigated the effect of teenage passengers on teenage risky

Table 1
Percent of vehicles showing high speed and/or short headway for driver and passenger groups

Driver/passenger group	*N*	% Showing risky driving behavior
General traffic	2186	9.6
Teen drivers		
No passenger	215	14.4*
Teen male passenger	91	18.7**
Teen female passenger	126	11.1
Teen male driver	228	14.9*
No passenger	107	16.8*
Male passenger	60	21.7**
Female passenger	55	5.5
Teen female driver	213	13.1*
No passenger	108	12.0
Male passenger	31	12.9
Female passenger	71	15.5*

* $p < .05$ in chi square comparisons with general traffic.
** $p < .01$ in chi square comparisons with general traffic.

driving behavior. The findings indicate that teenage drivers engaged in greater risky driving behavior than general traffic, particularly in the presence of a male teenage passenger. The findings show that teenage drivers tended to allow somewhat shorter headways and drive at somewhat higher speeds than general traffic, and these effects were greater in the presence of a male teenage passenger.

The presence of a male teenage passenger resulted in shorter headways (relative to no passenger or a female passenger), while the presence of a female teenage passenger resulted in longer headways for both male and female teenage drivers. This difference in headway of 0.3 s for male and about 0.15 s for female teenage drivers is substantial. At typical driving speeds of around 40 mph, a 0.3 s difference is equivalent to traveling slightly more than one car length closer to the vehicle ahead. Given that the analysis of headway data was confined to vehicles with nose-to-nose headways of 3.0 s or less, this is a potentially meaningful difference in safety performance.

Speed, like headway, was influenced most strongly by passenger gender. Teenagers, as a group, drove slightly faster than general traffic, and male teenagers drove slightly faster than female teenagers, but much faster in the presence of a male teenage passenger. Among male teenage drivers, the difference in speed between the male passenger and female passenger conditions was almost 5 mph, a large shift in average speed. The interpretation of speed findings is complicated because speed is related to following distance. Those drivers who choose to drive particularly fast may be most likely to come upon a leading vehicle and hence find themselves in a "platoon" situation where their speed is constrained. Thus, it may be the fastest drivers who are unable to express their desired speed and earlier we reported that teenage drivers were more likely than general traffic to be in short headway situations. To the extent, this reflects faster vehicles running up on slower vehicles, this would have weakened the observed differences in speed that might otherwise appear in unconstrained travel.

Neither close following nor speed is a "pure" measure of risky driving behavior because their occurrence is dependent to some extent on the presence and actions of other traffic. When the rate of "short" nose-to-nose headways was examined for vehicles within 3.0 s (thus having an opportunity to tailgate), about 40% of teenage drivers adopted headways of less than 2.0 s and about 7–8% adopted headways of less than 1.0 s (about double the rate for general traffic). When speeding (>15 mph over the posted speed limit) was examined for those vehicles assumed to have the opportunity to choose their speed (headway >3 s), teenagers showed higher rates of speeding only when there was a male teenaged passenger present. With a male passenger present, one-fourth of teenage drivers exceeded the speed limit by at least 15 mph (versus less than 10% of general traffic). Furthermore, teenage drivers were more likely to be within 3 s of the vehicle ahead. While these "platoon" drivers were excluded from the speed analysis, it is quite possible that the propensity to greater speed is what made them more likely to be in proximity to vehicles ahead.

When the occurrence of either speeding or tailgating was considered, a higher frequency of risky driving behavior was seen for teenage drivers. The teenage male driver/male passenger condition had a rate of risky driving behavior that was greater than double the rate of the general traffic group. The remaining teenage drivers had a rate about one-third higher than the general traffic group.

Our study sought to improve on the methodology employed by McKenna et al. (1998) in the only previous study to observe speed and headway behavior as a function of young driver gender and passengers. While McKenna et al. relied on remote judgments of "young drivers" (judged to be age <25 or >25 by remote roadside observers), the design of our study allowed greater assurance that the drivers were ≤18 years old, allowing for specific comparisons of teenage and older drivers. Also, McKenna et al. did not compare young driver groups with general traffic. Moreover, our measure of close following is a refinement on the method employed by McKenna et al. Nonetheless, given that both are observational, naturalistic studies of young drivers, it is of interest to compare the findings. Fig. 6a and b plot the observed effects for each condition. Fig. 6a shows that both studies observed longer headways for male drivers when a young female passenger was present and shorter headways in the presence of a young male passenger. Fig. 6b shows that both studies observed increased speeds when a male passenger was present, for both young male drivers and female drivers (i.e., speed in the male driver/male passenger condition was higher than that in the male driver/no passenger condition, by the amount shown in the bar chart). McKenna et al. observed a substantially lower speed when a young female passenger was present with a young male driver, while the present study observed very minimal difference. Both studies observed minimal difference when a young female driver was in the presence of a young female passenger. While the passenger effects in McKenna et al. and the present study were not entirely consistent, they both provide evidence that male passengers increase risky driving while female passengers decrease risky driving among young drivers.

The naturalistic observational design employed in the present study allowed for comparisons among driver groups under real-world conditions. However, this design has possible limitations, the most important of which are confounding and selection. A given dependent variable in the study may be correlated with other important but unmeasured or uncontrolled variables, thus confounding the results. For example, driver gender or passenger presence may be correlated with factors, such as the vehicle characteristics, proximity to school, time of day, and extent of driving experience. Also, the study subjects may not be representative of the general population. For example, teenage drivers most likely to transport male passengers may be different from other teenage drivers in ways that would alter driving behavior regardless of the actual presence of teenage passengers. Measurement

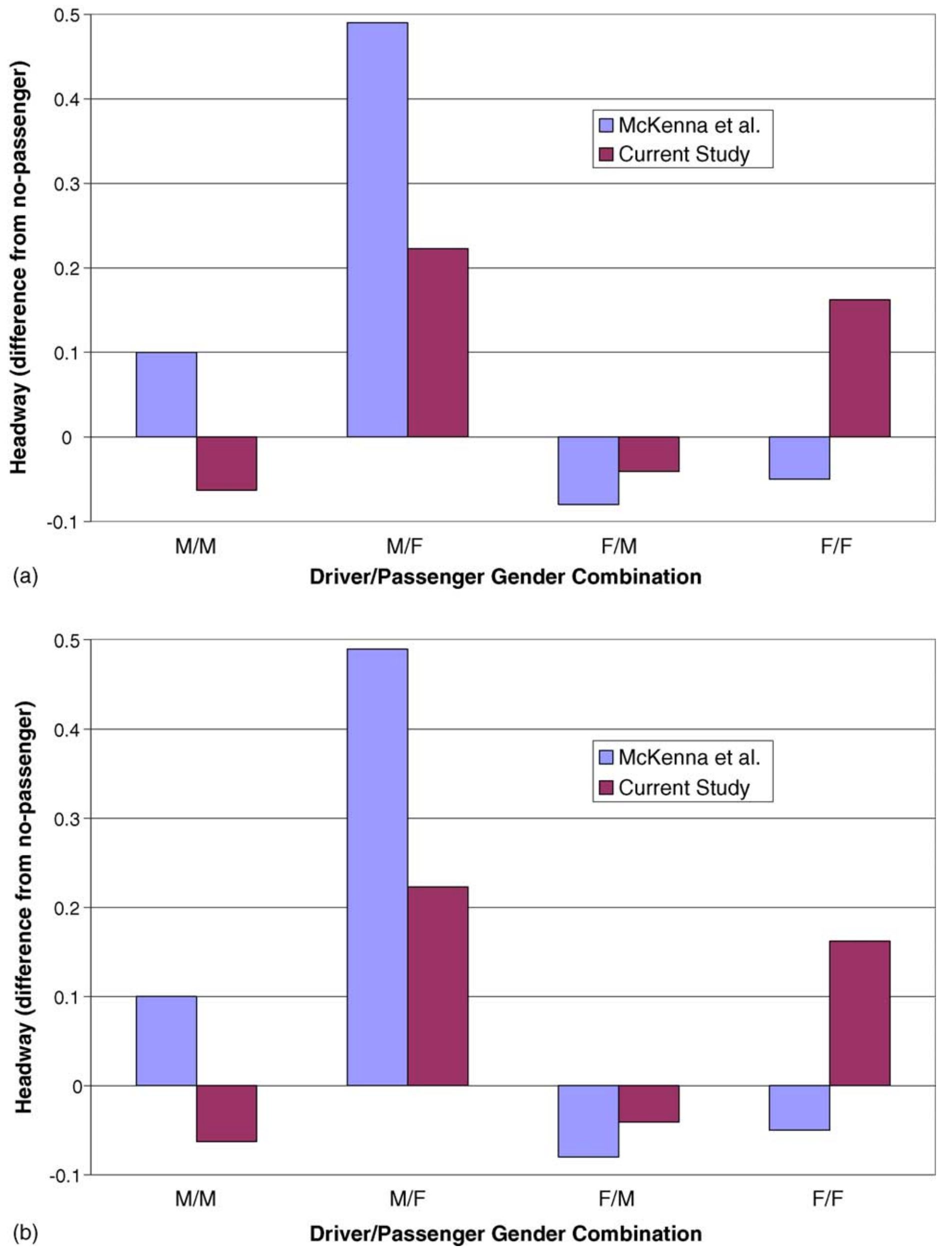

Fig. 6. (a) Comparison of findings from McKenna et al. (1998) and current study for teen driver and passenger effects on headway. (b) Comparison of findings from McKenna et al. (1998) and current study for teen driver and passenger effects on speed. *Note*: M, male; F, female.

reliability is always a research concern. The use of LIDAR permitted accurate speed measurement (within about 1 mph) and the use of frame-by-frame video analysis permitted accurate time headway estimates. Judgments of vehicle occupant type (teen or non-teen, male or female), while subjective, were facilitated by close-up observation while the vehicle was stopped or moving slowly at the school exit. Also, the design allowed only for the observation of effects of teenage passengers on teenage risky driving behavior, but did not allow for examination of what about teenage passengers, other than gender, may have influenced driving behavior. Finally, because remote observations can be unreliable, we did not attempt to observe the presence, age, or sex, of passengers in vehicles in the general traffic condition. Therefore, we were not able to determine if there may have been an effect of teen passengers on the driving behavior of adult drivers.

To gain a better understanding of the extent to which the findings can be generalized, additional research is needed that includes a larger sample, a wider range of driving conditions over more extended driving periods, a wider range of measures of risky driving behavior, and information on the characteristics of the driver, such as amount of driving experience. Given the variability of speeds and headways observed in the study, and the fact that these measures can be constrained by traffic conditions, substantial numbers of teens must be observed to provide adequate statistical power. Although teenage drivers, as a group, had higher mean speeds and shorter mean headways under certain conditions, speeding and tailgating were not typical of the entire group and it would be useful to learn more about which teenagers are susceptible to the influence of teenage passengers. Future research might consider the individual driver factors, social factors, and parental involvement, as well as driving situational factors that may be associated with the risky driving measures, particularly in the presence of passengers. Moreover, additional research is needed to determine the nature of the effect of teenage passengers on teen risky driving behavior.

In summary, this study demonstrated the frequency and magnitude of risky driving behavior among teenage driver subgroups, particularly in the presence of teenage male passengers. The influence of peer passengers was not simply a fixed negative factor on teenage drivers. Depending on driver and passenger gender and the particular driving measure, the presence of a passenger might have a risk-inducing effect, a risk-reducing effect, or no effect, relative to the no passenger condition. The magnitude and complexity of the effects of passengers confirms previous analyses of crash data showing an effect of teenage passengers and emphasizing the unique influences of male and female teenage passengers. These findings point to the need for a better understanding of how passengers modify teenage driving behaviors and suggest the importance of addressing teenage passenger influences in education and policy initiatives. The findings may have implications for graduated licensing program strategies, driver training, public education, and parental oversight.

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