The Effect of Passengers On Teen Driver Behavior

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16. Abstract

A number of studies have shown that passengers substantially increase the risk of crashes for young, novice drivers. This increased risk may result from distractions that young passengers create for drivers. Alternatively, the presence of passengers may increase the likelihood of teenage drivers engaging in explicitly risky behaviors, for example, by actively encouraging drivers to take risks. A better understanding of how transporting peers contributes to young driver increased crash risk will help develop strategies to reduce this risk. NHTSA analyzed data collected through an earlier naturalistic driving study (Goodwin, Foss, Margolis, & Waller, 2010). Over a 6-month study period, event-based data recorders collected 24,085 driving clips, of which 4,466 were selected for analysis. The sample included 52 drivers: 38 newly licensed teens and 14 high-school-age siblings.

Risky driving behaviors by teenage drivers were more common while they were driving in the presence of teenage peers. Teenage drivers were two-and-a-half times more likely to engage in one or more potentially risky behaviors when driving with one teenage peer compared to when driving alone. When driving with multiple teenage peers the likelihood increased to 3 times. Some of the mechanisms commonly thought to explain the increased crash risk when carrying passengers were rare, such as instances of deliberate encouragement for the drivers to take risks. Rather, helpful statements on the part of passengers were 10 times more common than statements encouraging risk-taking behavior. These findings suggest the mere presence of peers may have influenced risky driving behaviors more than deliberate encouragement.

Several potential distractions were common when teenage peers were present. Loud conversation was 5 times more likely and horseplay was 9 times more likely with multiple teenage passengers in the vehicle compared to when a parent/adult was present. Other distractions, such as loud music and electronic device use, were less common in the presence of passengers.

This study had several limitations. First, teens may have changed their driving behavior because of the presence of the data recorders. Second, the sample was small, included a disproportionate percentage of females, and was overrepresented by families with higher-level educations and higher incomes. These sample characteristics suggest caution in generalizing the findings to teenage drivers broadly.

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TABLE OF CONTENTS

TABLES AND FIGURES

Tables

Figures

EXECUTIVE SUMMARY

A number of studies have shown that passengers substantially increase the risk of a crash for young, novice drivers. However, little is known about the mechanisms by which passengers influence teen driver behavior. The increased risk of a crash may result from distractions that young passengers inevitably create for drivers. Alternately, the presence of passengers may increase the likelihood of explicitly risky driving behaviors. Whether passengers actively encourage the driver to take risks – or whether drivers simply behave differently in the presence of teen passengers – is currently unknown. A more thorough understanding of the processes that lead to the increased crash risk associated with transporting peers is essential to the development of policies and other strategies to reduce this risk.

The objective of this study was to investigate the nature of passengers' influence on teenage driving. This study was conducted to address the following research questions:

- How often do beginning teen drivers carry passengers and who are the passengers (peers, siblings, parents, etc.)?
- How often and in what ways do passengers distract the driver? How often do they encourage the driver to take risks or try to be helpful?
- Do interactions between teenage friends and siblings differ in meaningful ways?
- How often do teen drivers violate passenger restrictions? Are these violations and other risky actions, such as nighttime violations, seat belt nonuse, and cell phone use more common when teen passengers are present?
- How do teen driving behaviors differ in the presence of male passengers versus female passengers?

Methods

The data used to address these questions were collected during a previous investigation of 50 families of novice drivers (Goodwin, Foss, Margolis, & Waller, 2010). Event-based data recorders were placed in the vehicles of participating families at the outset of the learner stage so parent and teen behaviors during practice sessions could be directly observed. These data recorders, obtained from DriveCam, collected video, audio, and accelerometer data when a triggering "event" occurred, such as sudden braking or an abrupt turn. The data recorders were returned to the family vehicles during the initial 6 months of

unsupervised driving, a very high-risk time for new drivers. The data reported in the present study are from this initial period of independent driving. Because vehicles were sometimes shared, there is also data on some more experienced teen drivers – the siblings of the original target teen. In total, the sample for this study included 52 drivers: 38 newly licensed teens and 14 high-school-age siblings. It is important to note this was a "naturalistic" study of teen driving behavior. No interventions were conducted with participating families.

During the 6 months data recorders were installed in vehicles, 24,085 driving clips containing video, audio, and accelerometer information were recorded for the 52 teens in the study. A sample of 4,466 clips was selected for coding. Clips with passengers were oversampled to ensure a sufficient sample size for comparisons between different passenger combinations (e.g., driving with teenage peers versus siblings or parents). A coding system was developed to analyze the selected video clips. This system included detailed information about the vehicle occupants, as well as a number of driving behaviors, verbal behaviors, and nonverbal behaviors potentially related to the presence of passengers.

Results

Frequency of Carrying Passengers

Teens drove alone in two-thirds (65%) of all clips. Teenage peers were the most commonly carried passengers, present in 20% of clips. Siblings were present in 15% of clips, and parents (or other adults) were present in just 3% of clips. Males were more likely than females to carry multiple teenage peers.

Risky Driving, Distractions and Passengers

Drivers were two-and-a-half times as likely to engage in one or more potentially risky behaviors when driving with one teenage peer compared to driving with no passengers. They were 3 times as likely to engage in at least one risky behavior when driving with multiple teenage peers. Passengers encouraged the driver to take risks in only 1% of clips when passengers were present. In most of these cases, the "risky" suggestion by the passenger was related to speed (e.g., "Gun it!"). This suggests the mere presence of peers may have been the more important influence on risky driving behaviors than passengers actively encouraging the driver to take risks.

By contrast, helpful statements on the part of passengers were 10 times more common than statements encouraging risk-taking behavior. Teenage peers assisted the driver in approximately 12% of clips, usually by helping the driver to navigate, but occasionally by pointing out potential hazards or giving warnings. Moreover, teenage peers commented negatively on the driver's behavior in about 8% of clips.

In sum, there were many more instances of passengers assisting the driver – or admonishing the driver for "bad" behavior – than actively encouraging the driver to do something risky.

There were several indications in the present study that potential distractions were more common in the presence of teenage peers. Loud conversation was 5 times more common when multiple teenage peers were in the vehicle (in comparison to driving with a parent/adult); horseplay was 9 times more likely in the presence of multiple peers. These situations were not rare: loud conversation and horseplay were observed in 26% and 14% of clips, respectively, involving multiple teenage peers. Conversely, a number of potential distractions were seldom observed, such as dancing by drivers and passengers, communicating with someone outside the vehicle, and physical contact between the driver and passengers (each occurring in about 1% of all clips with passengers). Moreover, some potential distractions were *less* common in the presence of teenage peers, including music that was loud enough to be judged as a possible distraction and electronic device use by drivers. Thus, although teenage peers may create or increase certain types of potential distractions for drivers (e.g., rowdiness in the vehicle), they appear to decrease potential distractions in other ways.

Siblings Versus Peers

Although most U.S. States now have restrictions limiting the number of passengers a young driver may carry, most allow newly licensed drivers to carry family members. At present, little is known about whether these exemptions affect the safety of young drivers and their siblings. In general, the presence of siblings was unrelated to most of the driver and passenger behaviors we examined. For example, teen drivers were no more (or less) likely to engage in risky driving behaviors when carrying siblings than when driving alone. On the other hand, sibling presence *did* appear meaningful when combined with teenage peers. When teens transported both siblings and peers, loud conversation and horseplay were more prevalent than when teens were carrying parents/adults. These findings suggest exemptions for siblings from passenger restrictions may have little overall effect on teen driving behaviors. However, for States with a sibling exemption (and which allow one or more teenage peers), it may be important that teen drivers not be allowed to carry teenage peers if a sibling is also present.

Violations of License Restrictions

Overall, the vast majority of driving was in compliance with the passenger restriction. Violations were observed in just 7% of clips (usually because teens were carrying more than one teenage peer, rather than combinations of peers and siblings). Although most teens did violate the passenger restriction at some point, a sizeable proportion of the sample – about 30% – virtually never violated the restriction.

Violations of the 9 p.m. night restriction were also infrequent. Teens were observed violating the night restriction in 7% of clips. Nighttime violations were 3 times more common when teens were carrying multiple teenage peers than when they were driving alone. This is a concern given the synergistic effect of passengers and nighttime driving risk on young driver fatalities.

Male Versus Female Passengers

With male and female passengers, a relatively consistent pattern emerged. Potentially risky driving behaviors and horseplay by the vehicle occupants were noticeably more common when male drivers were carrying male (rather than female) teenage peers. Among female drivers, risky driving behaviors also appeared more common when male teenage peers were present.

Conclusions

The objective of this study was to investigate the nature of passengers' influence on teenage driving. Risky driving behaviors were more common in the presence of teenage peers. However, some of the mechanisms commonly thought to explain the increased crash risk when carrying passengers were rare, such as instances of deliberate encouragement for the driver to take risks. Several potential distractions were commonplace when teenage peers were present, including loud conversation and horseplay. Other distractions, such as electronic device use, were less common in the presence of passengers. Siblings appeared to have little effect on the behavior of teen drivers. Finally, the frequency of carrying passengers and observed violations of GDL restrictions were similar to findings from previous studies using different methods such as self-report or roadside observations.

BACKGROUND

A number of studies have shown that passengers substantially increase the risk of a crash for a young, novice driver. In a seminal study, Chen, Baker, Braver, and Li (2000) demonstrated how each additional passenger produces an increase in the risk of a driver fatality. A 16-year-old driver is 86% more likely to be killed in a crash when carrying two passengers, and 182% more likely to be killed when carrying three or more passengers. Both male and female young drivers experience this increased risk (Chen et al., 2000; Doherty, Andrey, & MacGregor, 1998). Although crash risk is elevated when teenage drivers carry same-age peers, adult passengers reduce the risk of a crash for young, beginning drivers (Aldridge et al., 1999; Ouimet et al., 2010; Rice, Peek-Asa, & Kraus, 2003). Passengers' sex also appears to be related to young drivers' crash risk. Male passengers increase the risk of a crash, especially for young male drivers (Chen et al., 2000; Ouimet et al., 2010). Crash risk is even greater when teenage drivers carry passengers at nighttime compared to daytime (Chen et al., 2000; Doherty et al., 1998).

To better understand the increased crash risk of teenagers when they are carrying passengers, a recent observational study examined the association of passengers' age and sex with the risky driving behavior of teenage drivers (Simons-Morton, Lerner, & Singer, 2005). The researchers recorded speed and headway distances of teen drivers as they departed from school. In general, teens drove faster and allowed shorter headways than other drivers, particularly when a teenage male passenger was present. Overall, the male driver/male passenger combination doubled the observed rate of high-risk driving (high speed and short headways) compared to general traffic (Simons-Morton et al., 2005).

Beyond the interaction of teenage passenger presence with age or experience of the driver, little is known about the mechanisms by which passengers affect the behavior of teenage drivers. The increased risk of a serious crash may result from distractions that young passengers inevitably create for novice drivers. These distractions can take many forms, from loud conversation, to horseplay, to physical contact between the driver and passengers. In self-report surveys, teens acknowledge that having passengers can be distracting (Allstate Insurance Company, 2005); however, the extent to which these potentially distracting situations and behaviors occur is not known.

The presence of passengers may also increase the likelihood of explicitly risky behaviors (Regan & Mitsopoulos, 2001; Rhodes, Brown, & Edison, 2005; Williams et al., 2007). For example, a survey of young drivers found that dangerous driving behaviors such as speeding, intentionally skidding, and

running a red light were strongly associated with the presence of teen passengers (Farrow, 1987). In an experimental study, Gardner and Steinberg (2005) had adolescent participants (age 13 to 16) play a computerized driving game by themselves or in groups of three. In the group condition, the teens that were not driving were allowed to talk with the driver and give advice. Compared to those who drove by themselves, teens who played the game in the presence of peers took more risks. When adults participated in the driving game, the presence of other adults had little effect on risk taking (Gardner & Steinberg, 2005). Whether passengers actively encourage the driver to take risks – or whether drivers simply behave differently in the presence of teen passengers – is currently unknown.

Conversely, passengers can assist the driver. For example, passengers can give directions and point out hazards the driver may have missed. They can also help with tasks such as answering a phone call or changing a CD. In addition, passengers might express disapproval of certain risky or dangerous driving behaviors. Little is known about the frequency with which teen passengers engage in these types of behaviors. To date, most of the studies investigating the effect of teen passengers have relied on crash data, while a smaller number have used self-report, observational, or laboratory techniques. Only recently have naturalistic studies begun to investigate how often teenage passengers appear to influence a teenage driver, either positively or negatively.

Because of the dramatic increased risk of crashes when passengers are present, 42 States and the District of Columbia now restrict carrying young passengers by drivers with an intermediate license (IIHS, 2010; see Table 1). The details of passenger restrictions vary widely. In a number of States the restriction is eased over time. For example, Colorado, Georgia, and West Virginia allow no passengers for the first 6 months of independent driving, then one passenger for the next 6 months. In addition, several States have exceptions that permit newly licensed drivers to carry family members. In a recent national survey, 86% of the general public said they favored restricting the number of teenage passengers that novice drivers may carry (Block & Walker, 2008). Similarly, support for passenger restrictions is strong among parents, though less so among teens (Williams, Nelson, & Leaf, 2002).

Table 1

Passenger Restrictions for Young Beginning Drivers in U.S. States

Restriction	Number of States
0 passengers	15
1 passenger	27
2 passengers	1
No restriction	7

Source: Insurance Institute for Highway Safety, August 2010

The limited available evidence suggests passenger restrictions appear to be effective in reducing crashes among novice drivers. In North Carolina, a teen passenger restriction was enacted independent of any other changes to the State's GDL system. Subsequent to this restriction, 16-year-old-driver crashes involving multiple passengers decreased by 32% (Foss, 2009). National studies of GDL also suggest passenger restrictions may contribute to fewer fatalities involving teenage passengers (Morrisey, Grabowski, Dee, & Campbell, 2006; Williams, Ferguson, & Wells, 2005). To date, no studies have examined whether exemptions for family members have any effect on safety. These exemptions have resulted from political expediency, and there is concern they may increase risks not only for young drivers, but their siblings as well.

In sum, several studies indicate teen passengers elevate the risk of a crash for novice, teen drivers. However, little is currently known about the mechanisms by which passengers influence teen driving behavior. A more thorough understanding of the processes that lead to the increased crash risk associated with transporting peers is essential to the development of policies and other strategies to reduce this risk.

The objective of this study was to investigate the nature of passengers' influence on teenage driving. It was designed to address a number of questions including:

- How often do beginning teen drivers carry passengers, and who are the passengers (peers, siblings, parents, etc.)?
- How often, and in what ways, do passengers distract the driver? How often do they encourage the driver to take risks or try to be helpful?
- Do interactions between teenage friends and siblings differ in meaningful ways?

- How often do teen drivers violate passenger restrictions? Are these violations and other risky actions, such as nighttime violations, seat belt nonuse, and cell phone use more common when teen passengers are present?
- How do teen driving behaviors differ in the presence of male passengers versus female passengers?

North Carolina's GDL System

The teenage drivers in this study were all licensed in North Carolina. Teens in North Carolina may obtain a learner permit as early as age 15. They must hold the permit for 12 months before they are eligible for an intermediate (restricted) license. Hence, the earliest age at which teens can obtain the intermediate license is 16. Newly licensed drivers may carry no more than one person younger than 21 unless a supervising driver is in the vehicle. There is an exception for young family members; however, if young family members are present, no other young passengers are permitted. In addition to the passenger restriction, newly licensed drivers may not drive without supervision from 9 p.m. until 5 a.m. (except when driving to or from work). Teens must hold the provisional license for 6 months before they are eligible for a full, largely unrestricted license. Finally, all drivers in North Carolina younger than 18 are prohibited from using a mobile telephone while driving. Exceptions are permitted for talking to a parent, legal guardian or spouse, and making a call regarding an emergency situation.

METHODS

The data used to address the research questions listed above were collected during a previous investigation of 50 families of novice drivers (Goodwin, Foss, Margolis, & Waller, 2010). Event-based data recorders were placed in the vehicles of participating families at the outset of the learner stage so parent and teen behaviors during practice sessions could be directly observed. The data recorders were returned to family's vehicles during the initial 6 months of unsupervised driving, a very high-risk time for new drivers (Masten & Foss 2010; Mayhew, Simpson, & Pak 2003). The data reported in the present study are from this initial period of independent driving. Because these vehicles were sometimes shared, there is also data on some more experienced teen drivers – the siblings of the original target teen. It is important to note this was a "naturalistic" study of teen driving behavior. No interventions were conducted with participating families. All aspects of the study were approved by the University of North Carolina Institutional Review Board.

Participating Teens

The 50 families were recruited through two Division of Motor Vehicles (DMV) offices in central North Carolina at the time teens applied for learner's permits. (For details on the recruitment procedure, see Goodwin et al. [2010].) Two of the families had twins; hence, 52 teens originally enrolled in the study. Of these, 38 families agreed to continue participating when the teen obtained an intermediate (restricted) license. These included the 38 newly licensed teens as well as 14 high-school-age siblings who shared the vehicle. Consequently, the total sample comprised 52 teenage drivers.

Event-Based Data Recorders

Event-based data recorders were installed in the family vehicle most often driven by the new teen driver, usually within one week of the date of licensure. They remained in the vehicle for 6 months. When the data recorder was installed, families gave permission to record everyone who drove the vehicle, not just the "target" teen.

The event-based data recorders were obtained from *DriveCam* (www.drivecam.com).[1] A DriveCam is a palm-sized camera that is mounted on the windshield behind the rearview mirror. The camera has a

[1] Although DriveCam offers a monitoring and feedback program for parents of teen drivers, the present study did not involve this program, using the data recorders only to study the natural behavior of teen drivers.

forward-facing lens that captures the scene in front of the vehicle; a second lens records activity inside the vehicle. The camera is also equipped with a microphone that records sounds inside the vehicle and an accelerometer to measure lateral and longitudinal g-forces. Although the camera runs continuously, it only saves information when a triggering "event" occurs such as sudden braking or abrupt turns. Once triggered, it saves the 10 seconds preceding and 10 seconds following the event. Thus, the cause of the triggering event, as well as occupants' responses, can be viewed. Although the cameras were equipped with a small red light that flashes when triggered, these lights were disabled for the present study. Our goal was to investigate the natural behavior of parents and teens; hence, anything that might draw attention to the camera was undesirable.

The sensitivity of the data recorder – that is, the change in g-forces required to trigger the unit to record – was adjustable. The thresholds employed for the present study were 0.40 for longitudinal (forward/rearward) g-forces and 0.45 for lateral (side-to-side) g-forces. This matched the sensitivity settings employed during the initial phase of the study (when teens had learner permits). The sensitivity levels were lower for this study than other studies that have employed similar event-based data recorders. For example, another recent study of newly licensed teen drivers used threshold settings of .50 and .55 for longitudinal and lateral g-forces, respectively (McGehee, Raby, Carney, Lee, & Reyes, 2007). The highly sensitive settings in the present study were used to capture essentially random moments of driving as well as serious incidents.

The data recorders were installed by local auto electronics dealers contracted to provide this service. The recorders were installed in the vehicle that the family anticipated the teen would drive most often. In some cases, this was a vehicle the teen "owned" or had unlimited access to. In other cases, the vehicle was shared with parents and/or siblings. Once per month during the 6-month period of data collection, a member of the research team met with the family to exchange the data recorder with a "fresh" one. The "used" data recorder was then returned to the research center where driving clips were downloaded.

Selection of Video Clips for Full Coding

During the 6 months in which data recorders were installed in vehicles, 29,920 individual driving clips were recorded. Reviewing and coding these clips is a labor-intensive, time-consuming process. Due to time and budgetary constraints, a sample of approximately 4,500 video clips of teen drivers was selected for coding. As an initial step in the selection process, we screened each clip to identify the driver and passengers. Because we tracked these families from the beginning of the learner stage, we could easily

identify whether the vehicle occupants were newly licensed teens (i.e., "target teens"), siblings, parents, or non-family members. Table 2 shows the driver and passenger categories used in the initial screening of the 29,920 driving clips.

Table 2

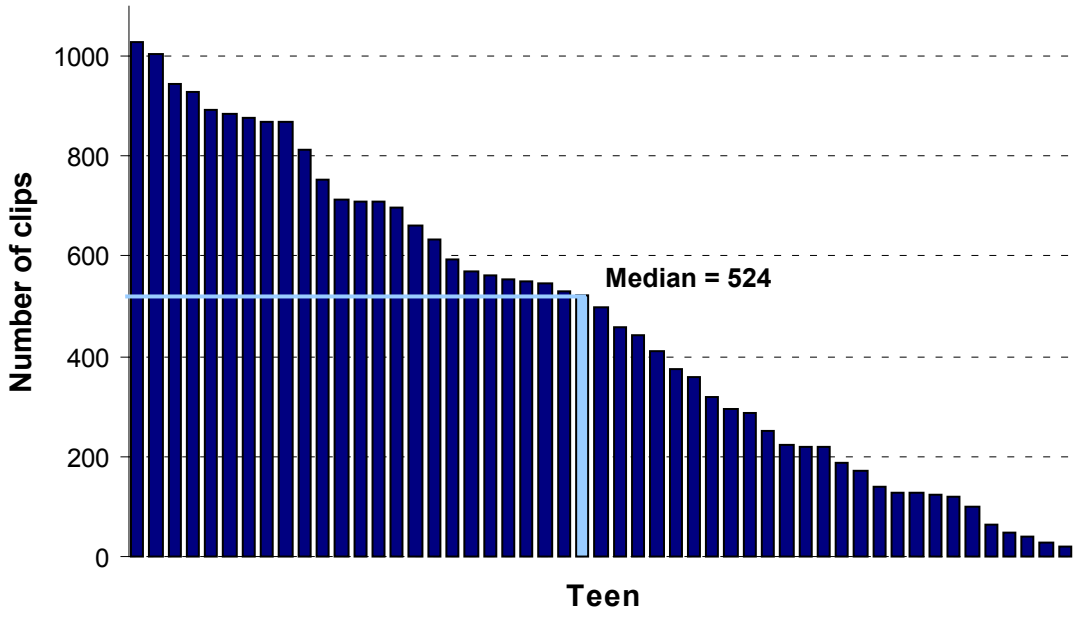
Driver and Passenger Categories Used in the Initial Screening of Driving Clips

Driver	Passenger combination
Target teen	None
Sibling	One sibling
Parent	One non-adult (non-sibling)
Other adult	Sibling(s) and non-adult(s)
Other non-adult	Two or more siblings
	Two or more non-adults
	Adult(s)*

*Adult(s) includes any clip where an adult passenger was present.

In total, 24,085 driving clips were recorded for the 52 teens in the study (19,384 from target teens; 4,701 from siblings). In the remaining clips, the driver was a parent, other adult, friend, or someone else. On average, there were 463 clips per teen driver, ranging from 17 to 1,028. The average number of clips recorded by target teens (510) was noticeably higher than the number of clips recorded by siblings (336). Figure 1 shows the distribution of driving clips for all 52 teens in the study.

Figure 1. Total Number of Clips Recorded for Each Teen



There were two primary issues to consider in selecting clips of teen drivers for full coding. First, more driving clips were recorded for some teens than others. To address this issue, we set a cap on the total number of clips selected for each of the 52 teen drivers. This helped to ensure the findings were not biased toward the teens who recorded the most clips. Second, initial screening of clips to identify the driver and passengers revealed that teens carried passengers in a minority of clips. Consequently, we oversampled clips with passengers to ensure a sufficient sample size for comparisons between different combinations of passengers (e.g., driving with teenage peers versus siblings or parents). Table 3 shows the maximum number of driving clips selected from any driver for coding based on the passenger combination.

Table 3

Maximum Number of Driving Clips per Driver Selected for Coding by Passenger Combination

None	25
One sibling	20
One non-adult (non-sibling)	20
Sibling(s) and non-adult(s)	50
Two or more siblings	50
Two or more non-adults	50
Adult(s)*	35

*Adult(s) includes any clip where an adult passenger was present.

For each teen, driving clips were randomly selected up to the pre-set maximum for each passenger combination. If a teen had less than the maximum number of clips for a certain passenger combination, then all clips with that combination were selected. For example, if the teen had only 12 clips with one sibling passenger, all 12 clips were selected for coding. Using this procedure, the median number of clips selected per teen was 87 (ranging from 17 to 208). In total, 4,466 driving clips were selected for the 52 teens.

Coding Scheme

A coding scheme was developed to analyze the selected video clips for information about the vehicle occupants:

- Total number of vehicle occupants,
- Driver sex,
- Driver belt use,
- Passenger seating position,

- Passenger sex,
- Passenger age and relationship to driver, and
- Passenger belt use.

A seating position chart was developed to code the exact position of each passenger. The chart included nontraditional seating positions such as the storage areas on SUVs or wagons and the beds of pick-up trucks. For passenger relation and age, the following categories were used: teenage peer, sibling, child non-sibling, child sibling, parent, other adult, and can't determine. "Teenage peer" was defined as passengers between the age of 13 and 20; "child" included anyone younger than 13. In many cases, the exact age of siblings was known. With peers, however, judgment was occasionally required in making age determinations. Finally, because it was sometimes difficult to determine the identity of a passenger due to darkness or other circumstances, a "can't determine" category was included for each of the passenger variables.

Researchers also coded a number of driver behaviors, including verbal and nonverbal behaviors that could potentially be related to the presence of passengers. Each of the coded variables, along with a definition or description of the variable and coded categories, is listed in Tables 4 through 6.

Data Weighting and Analysis

Clips with teen passengers were oversampled for analysis to ensure there would be enough cases (clips) to compare different passenger combinations. Because of this, it was necessary to weight the final dataset of coded clips for those analyses where the objective was to estimate characteristics of the full sample of clips. The case weights are simply the inverse of the probability of selection based on the known passenger distributions of the full sample of teen driver clips (N=24,085). For the comparison of measures as they relate to different passenger combinations, unweighted data were used. Because multiple clips were coded for each driver (ranging from 17 to more than 200 per driver), all analyses took this clustering of measures within driver into account, to ensure that standard errors (hence, confidence intervals) were correctly estimated.

Table 4

Coded Driver Behaviors

Variable name	Definition or description	Categories
Speeding – Faster than other moving vehicles	Driving faster than other moving vehicles.	No other moving vehicles No Yes – a little faster Yes – much faster
Speeding – Too fast for situation	Driving too fast for situation.	No Yes – a little too fast Yes – much too fast
Following too closely	Does not maintain a safe following distance.	No – Yes
Fails to yield	Pulls in front of another vehicle.	No – Yes
Weaving	Weaving through or around traffic. Trying to "get ahead."	No – Yes
Erratic driving	Inconsistent, abrupt, unpredictable driving indicating the driver seems clueless, lost, or confused.	No – Yes
Risky maneuver	Driving action that creates unnecessary danger.	No – Yes
Goofing or showing off	Driving action only.	No – Yes
Racing	Racing another vehicle. Clear indication of intent to race (not just starting fast).	No – Yes

Table 5

Coded Verbal Behaviors

Variable name	Definition or description	Categories
Loudness of conversation	Includes singing.	No conversation Normal Loud
Outside (driver)	Driver communicates with or toward someone outside vehicle.	No – Yes
Outside (passenger)	Passenger communicates with or toward someone outside vehicle.	No – Yes
Anger	Driver expresses anger, irritation, or impatience with another driver.	No – Yes
Take risk	Passenger tells driver to do something that is explicitly risky.	No – Yes
Helps navigate	Passenger assists driver by giving directions.	No – Yes
Points out something	Passenger assists driver by pointing out something on or about roadway or driving environment (e.g., stop sign).	No – Yes
Assists with task	Passenger assists driver with a task, such as answering phone for them, unscrewing soda cap, changing music.	No – Yes
Gives warning	Passenger points out immediate danger (e.g., “watch out!”).	No – Yes
Negative comment (passenger)	Passenger comment, not positive, on driving behavior. Direct or indirect (e.g., “whoa,” or “you should have stopped”).	No – Yes
Negative comment (driver)	Driver comments, not positively, on own driving behavior. Direct or indirect (e.g., “Sorry about that,” or “I should have stopped”).	No – Yes

Table 6

Coded Nonverbal Behaviors

Variable name	Definition or description	Categories
Horseplay	Rowdy, rough, or boisterous behavior by vehicle occupants.	None Mild Rough
Music	Music and volume level. "High" indicates loud enough to be a possible distraction	None Low (background – barely audible) Medium High
Dancing (driver)	Driver is dancing at any point during clip. Only coded if done while vehicle is moving.	No Yes – hands on wheel Yes – one hand off wheel Yes – both hands off wheel Yes – with passenger (not necessarily touching)
Dancing (passenger)	Passenger is dancing at any point during clip. Only coded if done while vehicle is moving.	No – Yes
Electronic device use (driver or passenger)	Electronic device use. Only coded if done while vehicle is moving.	No Holding cell phone to ear Talking on a hands-free phone Observed operating an electronic device (e.g., dialing, texting, GPS) Suspected operating an electronic device
Physical contact	Contact involving the driver (kissing, handholding, shoving, etc.)	None Affectionate – driver is active Affectionate – driver is passive recipient Non-affectionate – driver is active Non-affectionate – driver is passive recipient

RESULTS

Characteristics of Participating Teen Drivers

Table 7 shows the characteristics of the 52 teens whose driving is reported here.

Table 7

Characteristics of Participating Teen Drivers

	N	%
Age		
16	33	63%
17	9	17%
18	10	19%
Sex		
Male	16	31%
Female	36	69%
Type of vehicle driven most		
Passenger car	18	35%
SUV	9	17%
Minivan	9	17%
Pickup truck	6	12%
Number of siblings		
0	4	8%
1	24	46%
2	14	27%
3 or more	10	19%

Frequency of Carrying Passengers

For all 24,085 teen driver clips, researchers coded the presence and distribution of passengers. The findings are presented in Table 8.

Table 8

Observed Passenger Distribution

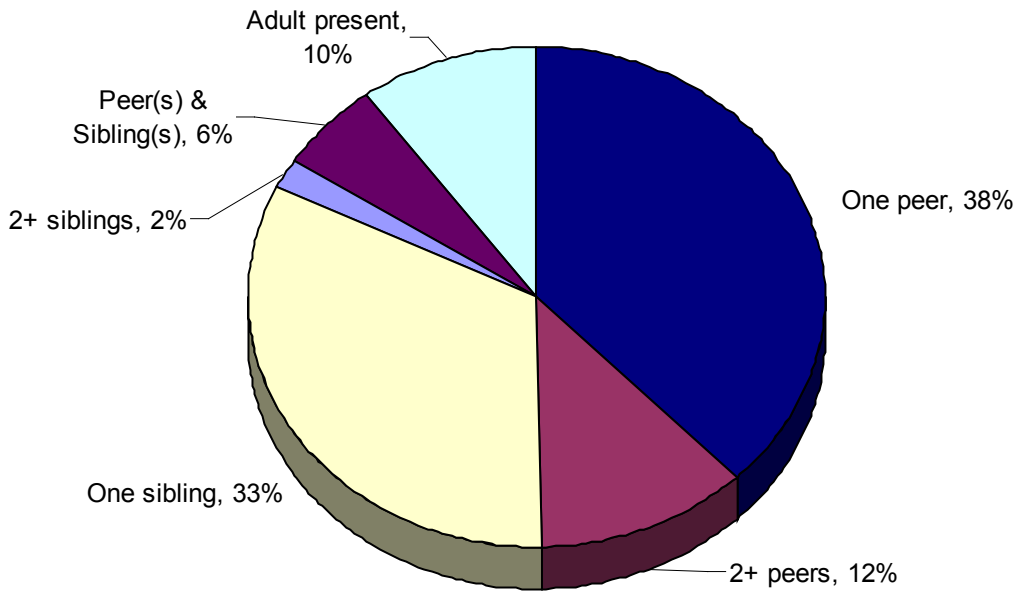
	N	%
No passengers	15,461	65%
One teenage peer	3,087	13%
Two or more teenage peers	968	4%
One sibling	2,661	11%
Two or more siblings	159	1%
Teenage peer(s) & sibling(s)	483	2%
Parent or other adult present	809	3%

Teen drivers were somewhat more likely to carry teenage peers (20% of clips) than siblings (15% of clips). An adult was present in only 3% of clips. The vast majority (90%) of adults in these clips were parents. Note that clips with an adult present may have also included various combinations of peers, siblings and other adults.

Teens transported a non-family member who was judged to be a child (under age 13) in only 9 clips. Because these passengers constituted such a small number of clips, they were removed from the remainder of the analyses.

Figure 2 displays the passenger distribution only for those clips when a passenger was present.

Figure 2. Distribution of Passengers (When a Passenger Was Present)



About 55% of the time when a passenger was present, at least one teenage peer (non-sibling) was involved. Roughly 40% of the time, there was a sibling passenger. A parent or other adult was present in only 1 out of 10 (10%) clips with passengers.

Sex of Passengers

For the teen driver clips that were fully coded (N=4,466), we examined the sex of passengers carried by teen drivers. Table 9 shows the distribution of teen passengers based on the sex of the driver.

Table 9

Passenger Distribution by Driver Sex

	Male Driver		Female Driver	
	N	%	N	%
No passengers	951	68%	1,972	64%
One teenage peer	163	12%	421	14%
Two or more teenage peers	77	6%	106	3%
One sibling	143	10%	360	12%
Two or more siblings	9	1%	21	1%
Teenage peer(s) & sibling(s)	14	1%	78	3%
Parent or other adult present	41	3%	112	4%

Males and females did not differ in their likelihood of carrying any passengers (31.9% versus 35.8%; OR=0.89, 95% CI=0.73, 1.09). Moreover, there was little difference in the distribution of passengers carried by male and female drivers.

Of particular interest is how the sex of passengers is related to the driver's sex. Table 10 shows the sex of passengers when teen drivers were transporting one or more teenage peers, but no siblings or adults were present.[2]

Table 10

Passengers Sex by Driver Sex

	Male Driver		Female Driver	
	N	%	N	%
One male teenage peer	133	56%	133	25%
One female teenage peer	28	12%	286	54%
Two or more male teenage peers	59	25%	12	2%
Two or more female teenage peers	3	1%	73	14%
Combination of male and female teenage peers	14	6%	21	4%

Not surprisingly, teen drivers were more likely to carry same-sex passengers than opposite-sex passengers. When a male driver was carrying teenage peers, 81% of the time all of the passengers were male. When a female driver was carrying teenage peers, all of the passengers were female 68% of the time. Males were somewhat more likely than females to carry multiple teenage peers (32% versus 20%; OR=1.60, 95% CI=1.01, 2.54).

Frequency of GDL and Seat Belt Violations

For GDL violations, the analysis was limited to those teens with intermediate (provisional) licenses who were subject to the restrictions – that is, the 38 "target" teens who had the cameras installed when they obtained their intermediate licenses. A total of 3,288 driving clips were fully coded for these 38 teens.

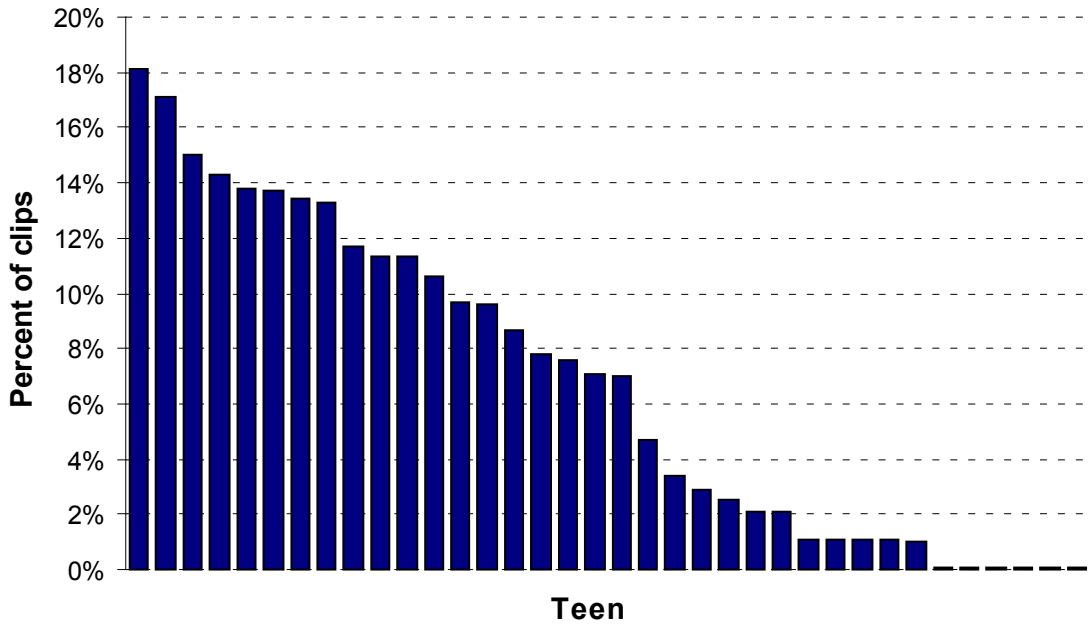
Passenger restriction. We first examined violations of the teen passenger restriction. In North Carolina, teens with intermediate licenses are limited to one teen passenger when driving without an adult supervisor. Although there is an exception for family members, teens are not permitted to carry friends

[2] Siblings were not included in this analysis because (1) not all teens had siblings, whereas all teens had the opportunity to transport peers, and (2) teens could not choose the sex of those siblings.

when also carrying family members. Teens were observed violating the passenger restriction in 7.4% of all clips. In 5.1% of clips, they were carrying more than one teen passenger without adult supervision. In 2.3% of clips, they had a combination of teen passengers and siblings (without an adult present). Violations of passenger restriction did not differ between male and female drivers (8.0% versus 7.2%; OR=1.12, 95% CI=0.66, 1.89).

Figure 3 shows the frequency of passenger violations for the 38 teens with intermediate licenses.

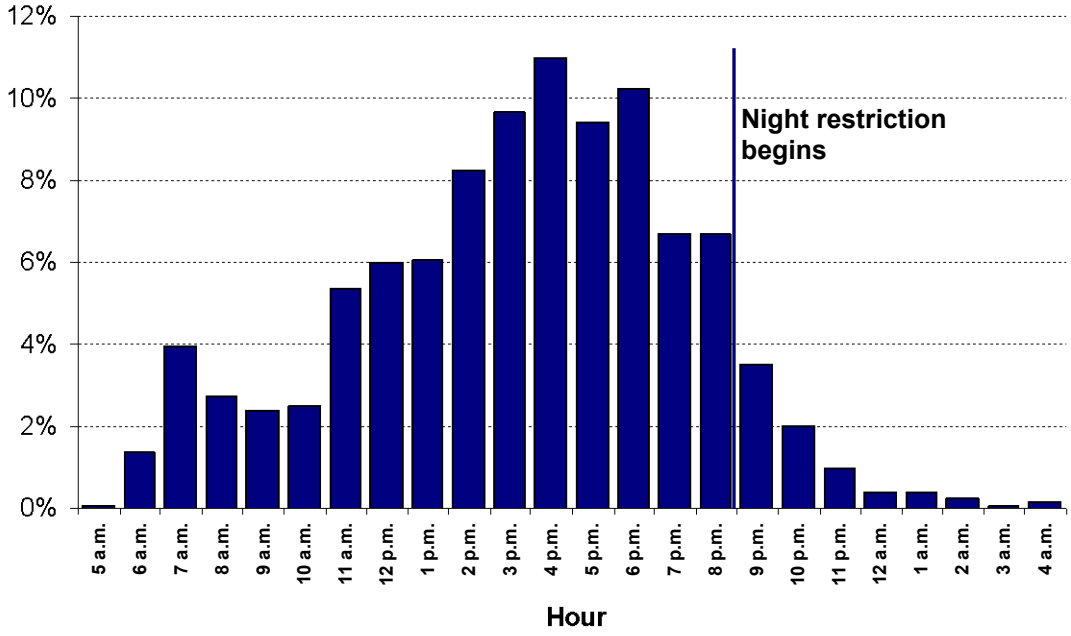
Figure 3. Percentage of Clips in Violation of the Passenger Restriction per Teen



There was noticeable variation between teens in how often violations of the passenger restriction occurred. Six of the teens (16%) did not violate the passenger restriction in any of their driving clips. Another 5 teens (13%) violated the restriction in only one clip each. By contrast, 3 teens (8%) violated the passenger restriction in at least 15% of their driving clips.

Night restriction. In North Carolina, newly licensed teens are not permitted to drive unsupervised from 9 p.m. until 5 a.m. Figure 4 shows the time of teen driver unsupervised clips recorded for the 38 teens with intermediate licenses (N = 3,173).

Figure 4. Time of Teen Driver Unsupervised Clips



In total, 7.4% of the recorded driving clips were in violation of the night restriction. Violations were about 60% more common among males than females (10.0% versus 6.2%; OR=1.62, 95% CI=0.99, 2.65). It should be noted that teens in North Carolina are allowed to drive after 9 p.m. if they are driving to or from work. Since trip purpose was unknown, it is possible that some of the trips after 9 p.m. were not violations.

Once again, violations varied considerably across teen drivers. Three teens (8%) did not violate the restriction in any of their clips, and 4 teens (11%) violated the restriction in just one clip each. At the other extreme, 2 teens (5%) violated the night restriction in about 25% of their driving clips.

Table 11 shows how violations of night restrictions were related to the presence of passengers.

Table 11

Association of Night Restriction Violations and Passengers

	%	Odds Ratio (95% CI)
No passengers	6.9%	1.00 (reference)
One teenage peer	10.7%	1.60 (0.96, 2.69)
Two or more teenage peers	17.7%	2.89 (1.58, 5.29)
One sibling	3.2%	0.45 (0.22, 0.93)
Two or more siblings	4.0%	0.56 (0.17, 1.90)
Teenage peer(s) & sibling(s)	10.2%	1.53 (0.76, 3.10)
Parent or other adult present*	0.0%	---

*Teens are permitted to drive after 9 p.m. when carrying an adult supervisor; hence, these instances of driving after 9 p.m. are not violations of the night restriction.

Drivers with intermediate licenses were almost three times more likely to violate the restriction when carrying multiple teenage peers than when they had no passengers. By contrast, they were approximately 50% *less* likely to violate the restriction when carrying one sibling. When carrying one teenage peer, violations of the night restriction were 60% more likely than when teens were driving alone. In sum, violations of the night restriction were more common when multiple teenage peers were present with no adult. It is important to keep in mind this does not imply causal association. Whether teenage peers encourage violations, or whether late night trips are simply more likely to include teenage peers, cannot be determined.

Seat belt use. Seat belt use by drivers and right front seat passengers was coded whenever possible. Seat belt use by rear seat passengers was often difficult to see and could not be reliably measured. Because all drivers and passengers in North Carolina are required to wear seat belts regardless of age, we report seat belt use for all drivers and passengers, not just those cases (clips) with intermediate license drivers. Teen drivers were properly wearing seat belts in 97% of clips. Seat belt use did not differ between males and females (94.4% versus 97.6%; OR=0.97, 95% CI=0.92, 1.02).

Belt use was also high among right front seat passengers (91%). Teenage peers (88%) had somewhat lower belt use than siblings (94%) or adult (94%) passengers. Among teenage peers, seat belt use once again did not differ between males than females (85% versus 91%; OR=0.94, 95% CI=0.86, 1.02).

Driver belt *nonuse* for different combinations of passengers is shown in Table 12.

Table 12

Association of Driver Seat Belt Nonuse and Passengers

	%	Odds Ratio (95% CI)
No passengers	3.6%	1.00 (reference)
One teenage peer	3.6%	0.99 (0.48, 2.06)
Two or more teenage peers	4.5%	1.25 (0.51, 3.08)
One sibling	2.1%	0.57 (0.26, 1.30)
Two or more siblings	10.1%	2.97 (1.14, 7.74)
Teenage peer(s) & sibling(s)	2.8%	0.77 (0.31, 1.96)
Parent or other adult present	1.3%	0.35 (0.15, 0.82)

Driver belt nonuse was higher in the presence of multiple siblings. As might be expected, belt nonuse was lower in the presence of parents or other adults.

Potentially Risky Driving Behaviors

We examined the frequency of a number of potentially risky driving behaviors, and whether these behaviors were more or less common in the presence of passengers than when teens were driving alone. Generally, risky driving behaviors were rare, as shown in Table 13.

Table 13

Frequency of Potentially Risky Driving Behaviors

	N	%
Speeding – Faster than other moving vehicles		
No other moving vehicles	1,518	33%
No	2,934	67%
Yes, a little faster	8	< 1%
Yes, much faster	1	< 1%
Speeding – Too fast for situation		
No	4,366	98%
Yes, a little too fast	86	2%
Yes, much too fast	9	< 1%
Following too closely		
No	4,455	99%
Yes	6	< 1%
Fails to yield		
No	4,554	99%
Yes	7	< 1%
Weaving		
No	4,440	99%
Yes	15	< 1%
Erratic driving		
No	4,209	95%
Yes, roadway	230	4%
Yes, parking lot	22	< 1%
Risky maneuver		
No	4,416	99%
Yes	44	1%
Goofing or showing off		
No	4,384	99%
Yes	77	1%
Racing		
No	4,452	99%
Yes	9	< 1%

Because the frequency of individual risky behaviors was low, a new variable was created based on whether the driver engaged in one or more of these behaviors. In total, teen drivers engaged in at least one of the potentially risky driving behaviors in 7.2% of all clips. Males did so somewhat more often than females (9.0 versus 6.5%; OR=1.39, 95% CI=0.95, 2.03).

Table 14 shows how the frequency of potentially risky driving behaviors was related to the presence of passengers.

Table 14

Association of Potentially Risky Driving Behaviors and Passengers

	%	Odds Ratio (95% CI)
No passengers	5.7%	1.00 (reference)
One teenage peer	13.0%	2.48 (1.61, 3.84)
Two or more teenage peers	15.5%	3.05 (1.98, 4.49)
One sibling	6.9%	1.24 (0.86, 1.79)
Two or more siblings	8.3%	1.51 (0.69, 3.31)
Teenage peer(s) & sibling(s)	8.5%	1.55 (1.01, 2.41)
Parent or other adult present	5.5%	0.92 (0.42, 2.04)

Teens were two and a half times as likely to engage in one or more potentially risky behaviors when driving with one teenage peer compared to driving with no passengers. Moreover, they were three times as likely to engage in at least one of the behaviors when driving with multiple teenage peers. Carrying teenage peers and siblings together was also related to potentially risky driving behaviors. Again it is important to bear in mind this does not necessarily indicate that passengers cause more risky driving; it may simply be that more risky drivers are also more likely to transport passengers.

Another question of interest was whether risky behaviors are more or less common with certain combinations of male and female drivers and passengers. Table 15 shows the frequency of engaging in one or more potentially risky driving behaviors for various combinations of driver and passenger sex. This only includes clips when teens were transporting one or more teenage peers, but no siblings or adults were present.

Table 15

Incidence of Potentially Risky Driving Behaviors by Passenger Sex and Driver Sex

	Male Driver		Female Driver	
	Clips with this configuration	% involving potentially risky driving	Clips with this configuration	% involving potentially risky driving
Configuration				
One same sex teenage peer	133	21%	286	7%
Two or more same sex teenage peers	59	24%	73	10%
One or more opposite sex teenage peers	31	13%	145	17%
Combination of male and female teenage peers	14	21%	22	9%

Among both male and female drivers, potentially risky behaviors appeared more common when a male teenage peer was present.

Verbal Behaviors

We next examined the frequency of a number of verbal behaviors – some that may be distracting and others potentially helpful – and whether these behaviors were more or less common with certain combinations of passengers. Table 16 summarizes the frequency of these driver and passenger verbal behaviors.

Table 16

Frequency of Verbal Behaviors

	N	%
Loudness of conversation*		
No conversation	286	16%
Normal	1,235	70%
Loud	234	13%
Driver communicates with someone outside vehicle		
No	4,372	98%
Yes	78	2%
Passenger communicates with someone outside vehicle*		
No	1,521	99%
Yes	20	1%
Driver expresses anger at another driver		
No	4,373	98%
Yes	74	2%
Passenger encourages driver to take risks*		
No	1,510	99%
Yes	18	1%
Passenger helps driver navigate*		
No	1,435	94%
Yes	92	6%
Passenger points out something on/about roadway*		
No	1,485	97%
Yes	42	3%
Passenger assists with task*		
No	1,503	98%
Yes	27	2%
Passenger gives warning*		
No	1,515	99%
Yes	12	1%
Passenger comments negatively on driving behavior*		
No	1,419	93%
Yes	109	7%
Driver comments negatively on own driving behavior*		
No	1,433	93%
Yes	102	7%

*Denotes a variable that was only coded if a passenger was present in the vehicle.

Most of the verbal behaviors we examined – both positive and negative – were relatively rare. For example, passengers encouraged the driver to take risks in only 1% of clips. Females were more likely than males to make negative comments on their own driving (8.0% versus 3.2%; OR=2.46, 95% CI=1.39, 4.37). No other differences were observed between male and female drivers on any of the verbal behaviors.

Table 17 shows how the frequency of verbal behaviors was related to the presence of passengers. Since many of these behaviors could only occur when passengers were present, we used cases where a parent or other adult was in the vehicle as the reference group. Also, since the various "helping" behaviors were relatively rare, a new variable was created based on whether passengers offered any assistance to the driver including: help with navigating, pointing out something on or about the roadway, assisting with a task, or giving a warning. In total, passengers assisted the driver in one or more of these ways in 10% of all clips. In the table below, loudness of conversation was dichotomized into loud versus normal or no conversation.

Table 17

Association of Verbal Behaviors and Passengers

	%	Odds Ratio (95% CI)
Loud conversation		
Parent or other adult present	6.6%	1.00 (reference)
One teenage peer	15.1%	2.53 (1.57, 4.08)
Two or more teenage peers	26.1%	5.01 (3.30, 7.60)
One sibling	5.3%	0.79 (0.47, 1.33)
Two or more siblings	9.1%	1.42 (0.59, 3.42)
Teenage peer(s) & sibling(s)	18.7%	3.27 (2.04, 5.24)
Passenger assists driver		
Parent or other adult present	19.5%	1.00 (reference)
One teenage peer	10.1%	0.46 (0.32, 0.67)
Two or more teenage peers	13.8%	0.66 (0.48, 0.92)
One sibling	5.7%	0.25 (0.14, 0.44)
Two or more siblings	8.3%	0.38 (0.17, 0.84)
Teenage peer(s) & sibling(s)	13.2%	0.63 (0.37, 1.07)
Passenger comments negatively on driving behavior		
Parent or other adult present	12.7%	1.00 (reference)
One teenage peer	8.1%	0.60 (0.42, 0.87)
Two or more teenage peers	8.0%	0.59 (0.42, 0.84)
One sibling	3.8%	0.27 (0.14, 0.52)
Two or more siblings	1.5%	0.11 (0.03, 0.39)
Teenage peer(s) & sibling(s)	9.8%	0.75 (0.42, 1.33)

In comparison to driving when a parent/adult was present, loud conversation was approximately three times more common when one teenage peer, or combinations of peers and siblings, were in the vehicle. Conversation was 5 times more likely to be loud when multiple teenage peers were in the vehicle. Generally, assisting the driver was more frequent when a parent/adult was present; however, critical comments were also more common. Siblings rarely assisted the driver or commented on his/her driving.

Table 18 shows the frequency of verbal behaviors for various combinations of driver and passenger sex. This only includes clips when teens were transporting one or more teenage peers, but no siblings or adults were present.

Table 18

Incidence of Verbal Behaviors by Passenger Sex and Driver Sex

	Male Driver		Female Driver	
	Clips with this configuration	% involving the verbal behavior	Clips with this configuration	% involving the verbal behavior
Loud conversation				
One same sex teenage peer	132	12%	286	15%
Two or more same sex teenage peers	59	27%	73	25%
One or more opposite sex teenage peers	28	21%	144	18%
Combination of male and female teenage peers	14	29%	21	33%
Passenger assists driver				
One same sex teenage peer	132	10%	286	10%
Two or more same sex teenage peers	59	10%	73	14%
One or more opposite sex teenage peers	28	11%	146	13%
Combination of male and female teenage peers	13	23%	21	14%

Carrying multiple teenage peers was associated with loud conversation, regardless of the sex of the driver and passengers. Passenger sex appeared unrelated to whether the passengers assisted the driver.

Nonverbal Behaviors

In addition to examining verbal behaviors, we also examined the frequency of a number of nonverbal behaviors, and whether these were more or less common depending on the combination of passengers. The frequency of various nonverbal behaviors is shown in Table 19.

Table 19

Frequency of Nonverbal Behaviors

	N	%
Horseplay*		
None	1,439	94%
Mild	85	6%
Rough	7	< 1%
Music		
None	816	18%
Low (background – barely audible)	708	16%
Medium	2,124	48%
High	783	18%
Dancing - driver		
No	4,323	99%
Yes – hands on wheel	39	1%
Yes – one hand off wheel	16	< 1%
Yes – both hands off wheel	1	< 1%
Yes – with passenger (not necessarily touching)	0	0%
Dancing – passenger*		
No	1,498	98%
Yes	27	2%
Electronic device use – driver		
No	4,080	92%
Holding cell phone to ear	107	2%
Talking on a hands-free phone	3	< 1%
Observed operating an electronic device	49	1%
Suspected operation of an electronic device	173	4%
Electronic device use – passenger*		
No	1,318	87%
Holding cell phone to ear	39	3%
Talking on a hands-free phone	0	0%
Observed operating an electronic device	60	4%
Suspected operation of an electronic device	101	7%
Physical contact*		
None	1,498	99%
Affectionate – driver is active	3	< 1%
Affectionate – driver is passive recipient	9	1%
Non-affectionate – driver is active	3	< 1%
Non-affectionate – driver is passive recipient	3	< 1%

*Denotes a variable that was only coded if a passenger was present in the vehicle.

Once again, most of the coded nonverbal behaviors were rare. This was especially the case for passenger behaviors often believed to explain increased teen driver crash rates when passengers are present, for

example, horseplay, dancing, and physical contact between passengers and the driver. Although music was frequently audible, the volume was judged to be high enough to be a possible distraction in only 18% of clips. Drivers were using (or suspected of using) an electronic device during 7.5% of driving clips. Females were somewhat more likely than males to be using some type of electronic device (8.7% versus 4.9%; OR=1.76, 95% CI=0.96, 3.23). By contrast, horseplay was somewhat more common among males than females (7.7% versus 5.4%; OR=1.44, 95% CI=0.99, 2.07). No other differences between males and females were observed.

Table 20 shows how the frequency of several nonverbal behaviors was related to the presence of passengers. The variables were dichotomized as follows: any horseplay versus none; music high (loud) versus low, medium or none; and any type of electronic device use versus none. Horseplay could only occur when passengers were present; hence, the reference group for this variable was having a parent or other adult in the vehicle. Otherwise the reference group was no passengers.

Table 20

Association of Nonverbal Behaviors and Passengers

	%	Odds Ratio (95% CI)
Horseplay (mild or rough)		
Parent or other adult present	1.8%	1.00 (reference)
One teenage peer	6.6%	3.88 (1.29, 11.60)
Two or more teenage peers	14.4%	9.19 (3.14, 26.90)
One sibling	2.7%	1.51 (0.43, 5.31)
Two or more siblings	7.6%	4.47 (1.06, 18.81)
Teenage peer(s) & sibling(s)	10.4%	6.35 (2.73, 14.77)
Loud music		
No passengers	20.9%	1.00 (reference)
One teenage peer	13.1%	0.57 (0.39, 0.83)
Two or more teenage peers	14.7%	0.65 (0.43, 0.99)
One sibling	10.7%	0.45 (0.29, 0.70)
Two or more siblings	9.9%	0.42 (0.16, 1.08)
Teenage peer(s) & sibling(s)	15.2%	0.68 (0.38, 1.20)
Parent or other adult present	2.4%	0.15 (0.05, 0.45)
Any electronic device use – driver		
No passengers	9.2%	1.00 (reference)
One teenage peer	4.0%	0.41 (0.26, 0.66)
Two or more teenage peers	4.9%	0.51 (0.33, 0.79)
One sibling	5.4%	0.57 (0.32, 0.99)
Two or more siblings	9.1%	0.99 (0.28, 3.51)
Teenage peer(s) & sibling(s)	4.1%	0.42 (0.26, 0.70)
Parent or other adult present	1.2%	0.12 (0.06, 0.26)

Not surprisingly, horseplay was substantially more common when teens were carrying teenage peers than when a parent or adult was present. Horseplay was also more frequent when peers were combined with siblings. Loud music was generally less common when teens were transporting passengers; this was particularly notable when a parent/adult was present. Finally, electronic device use by teen drivers tended to be lower when teens carried passengers, especially a parent/adult.

Table 21 shows the frequency of engaging in horseplay based on the sex of drivers and passengers. This only includes clips where teens were transporting one or more teenage peers, but no siblings or adults were present.

Table 21

Incidence of Horseplay by Passengers Sex and Driver Sex

	Male Driver		Female Driver	
	Clips with this configuration	% involving potentially risky driving	Clips with this configuration	% involving potentially risky driving
Configuration				
One same sex teenage peer	132	7%	133	8%
Two or more same sex teenage peers	59	19%	73	10%
One or more opposite sex teenage peers	5	6%	145	9%
Combination of male and female teenage peers	14	29%	21	14%

For male drivers, horseplay was noticeably more common in the presence of two or more males or combinations of male and female passengers. For female drivers, passenger sex was generally unrelated to horseplay.

Crashes and Near-crashes

Finally, we examined the frequency of crashes and near-crashes, and how this related to the presence of passengers. Among the coded clips, there were only 3 crashes involving teen drivers, all but one of which was relatively minor in nature. Consequently, a new variable was created that combined the following categories:

- Collision (n = 3),
- Near collision – evasive maneuver by teen (n = 22),
- Near collision – other driver avoids crash (n = 4), and
- Other serious incident, such as losing control or leaving the roadway (n = 9).

Only 0.8% of clips involved an incident that fell into one of these categories. Males and females did not differ in their likelihood of being involved in an incident (1.1% versus 0.7%; OR=1.66, 95% CI=0.54, 5.04). Table 22 shows the relationship of driving incidents to the combination of passengers.

Table 22

Association of Driving Incidents and Passengers

	%	Odds Ratio (95% CI)
Driving incidents		
No passengers	0.7%	1.00 (reference)
One teenage peer	1.4%	2.16 (0.79, 5.88)
Two or more teenage peers	1.9%	2.89 (1.07, 7.78)
One sibling	0.5%	0.71 (0.24, 2.14)
Two or more siblings	0.8%	1.13 (0.13, 9.88)
Teenage peer(s) & sibling(s)	0.2%	0.33 (0.05, 2.47)
Parent or other adult present	1.5%	2.26 (0.82, 6.23)

When carrying two or more teenage peers, teens were approximately three times more likely to be involved in a driving incident. None of the other passenger combinations were related to driving incidents.

Another potential indicator of the seriousness of an event is the g-forces that were involved. Specifically, we examined whether the frequency of higher g-force events varied by the presence of passengers. High g-force events were defined as those in the top 10% of the g-force distribution. This included clips above .53 for longitudinal (forward/rearward) events, and above .59 for lateral (side to side) events. (Recall the thresholds employed for the event data recorders were 0.40 for longitudinal g-forces and 0.45 for lateral g-forces.) Findings are shown in Table 23.

Table 23

Association of High G-force Events and Passengers

	%	Odds Ratio (95% CI)
Longitudinal events		
No passengers	8.2%	1.00 (reference)
One teenage peer	13.9%	1.81 (1.03, 3.16)
Two or more teenage peers	16.7%	2.24 (1.41, 3.55)
One sibling	10.0%	1.24 (0.55, 2.83)
Two or more siblings	14.3%	1.86 (0.87, 3.99)
Teenage peer(s) & sibling(s)	10.2%	1.27 (0.67, 2.39)
Parent or other adult present	11.7%	1.48 (0.86, 2.55)
Lateral events		
No passengers	10.8%	1.00 (reference)
One teenage peer	8.3%	0.74 (0.47, 1.18)
Two or more teenage peers	12.9%	1.22 (0.71, 2.11)
One sibling	9.8%	0.90 (0.56, 1.45)
Two or more siblings	12.0%	1.12 (0.41, 3.05)
Teenage peer(s) & sibling(s)	7.4%	0.66 (0.33, 1.33)
Parent or other adult present	7.1%	0.63 (0.37, 1.07)

Only two noteworthy findings were observed: longitudinal events involving high g-forces were approximately twice as common when one teenage peer or multiple teenage peers were present.

DISCUSSION

This was a naturalistic study of 52 teenage drivers to learn more about the influence of passengers on teenage driver crash rates. Event-data recorders were used to unobtrusively monitor the behavior of the driver and all vehicle occupants. The present study was designed to address the following questions:

- How often do beginning teen drivers carry passengers, and who are the passengers (peers, siblings, parents, etc.)?
- How often, and in what ways, do passengers distract the driver? How often do they encourage the driver to take risks or try to be helpful?
- Do interactions between teenage friends and siblings differ in meaningful ways?
- How often do teen drivers violate passenger restrictions? Are these violations and other risky actions, such as nighttime violations, seat belt nonuse and cell phone use more common when teen passengers are present?
- How do teen driving behaviors differ in the presence of male passengers versus female passengers?

Frequency of Carrying Passengers

Teens drove alone in two-thirds (65%) of all clips. Teenage peers were the most commonly carried passengers of teenage drivers, present in 20% of clips. Siblings were present in 15% of clips, and parents (or other adults) were present in just 3% of clips. Males were more likely than females to carry multiple teenage peers. These findings are consistent with those reported by Ehsani et al. (2010), who examined travel data for 16- and 17-year-old drivers from the statewide Michigan Travel Counts survey. Similar to the present study, they found teens drove substantially more miles, minutes, and trips alone than with passengers. Presently, few other sources of exposure data are available that supply information about passengers. For example, the National Household Travel Survey (FHWA, 2010) collects travel information from a representative sample of the U.S. population; however, the survey includes a relatively small number of young drivers, and it does not obtain information about non-household passengers. This lack of basic exposure data impedes researchers' efforts to understand teen driver risks related to passengers.

Because triggering the camera may have been associated with passenger load/type/combination, the findings should be taken with caution. However, the real value of these data is in our ability to look at what happens in the presence of various passenger combinations.

Risky Driving, Distractions, and Passengers

One possible reason for the heightened crash risk when teens carry passengers is that passengers may, advertently or inadvertently, distract the driver. Distractions include anything that takes the driver's attention away from driving, and can be physical, visual, or cognitive in nature (NHTSA, 2010). There were several indications in the present study that potential distractions were more common in the presence of teenage peers. In comparison to driving when a parent or adult was present, loud conversation was 5 times more common when multiple teenage peers were in the vehicle; horseplay was 9 times more likely in the presence of multiple peers. These situations were not rare: loud conversation and horseplay were observed in 26% and 14% of clips, respectively, involving multiple teenage peers. Both loud conversation and horseplay may indicate a general rowdiness or disorder in the vehicle. In such a setting, it is not difficult to see how a driver's concentration could be disturbed. By increasing the overall "cognitive load" on the driver, loud conversation or horseplay might reduce the likelihood a driver will perceive and react to situations that arise in the driving environment. Research suggests novice drivers must devote more of their attentional capacity to the multiple tasks involving in driving than experienced drivers, for whom driving tasks have become largely automatic during years of driving experience (Lansdown, 2002). As a consequence, novices may be more susceptible to a distraction-related crash, since they have less spare attentional capacity (Lee, 2007).

Conversely, a number of potential distractions were quite rare, including several that are sometimes cited to explain increased crash rates among young drivers when teenage passengers are present. These include dancing by drivers and passengers, communicating with someone outside the vehicle, and physical contact between the driver and passengers (each occurring in about 1% of all clips with passengers). Moreover, some potential distractions were *less* common in the presence of teenage peers, including music that was loud enough to be judged as a possible distraction and electronic device use by drivers. Thus, although teenage peers may create or increase certain types of potential distractions for drivers (e.g., rowdiness in the vehicle), they appear to decrease potential distractions in other ways.

Another common belief is that young passengers actively encourage teenage drivers to engage in risky behaviors. We found little direct evidence of this. Passengers encouraged the driver to take risks in only

1% of clips when passengers were present. In most of these cases, the "risky" suggestion by the passenger was related to speed. Many were statements such as "push it," "gun it," or "speed up." A few were specific directives, such as telling the driver to run a red light, knock over a garbage can, or stick her head out the window while driving. (In each of these cases, the driver complied.) On the other hand, helpful statements on the part of passengers were 10 times more common than statements encouraging risk-taking behavior. Teenage peers assisted the driver in approximately 12% of clips, usually by helping the driver to navigate, but occasionally by pointing out potential hazards or giving warnings. Moreover, teenage peers commented negatively on the driver's behavior in about 8% of clips. These varied from global (and probably unhelpful) comments such as, "You suck at driving," to comments that may place subtle pressure on the driver to change his or her behavior such as, "You take turns way too fast." In sum, there were many more instances of passengers assisting the driver – or admonishing the driver for "bad" behavior – than actively encouraging the driver to do something risky.

Previous research has suggested that risky behaviors among teen drivers are more common in the presence of passengers (Farrow, 1987; Gardner & Steinberg, 2005). The present study corroborates this: drivers were two-and-a-half times as likely to engage in one or more potentially risky behaviors when driving with one teenage peer compared to driving with no passengers. They were 3 times as likely to engage in at least one risky behavior when driving with multiple teenage peers. What prior research has been unable to determine is whether passengers actively encourage the driver to take risks, or whether drivers simply behave differently in the presence of teen passengers. The present study suggests the mere presence of peers may be the more important influence on risky behaviors among teen drivers. The relative infrequency with which peers encouraged drivers to take risks cannot explain the substantially higher frequency of risky behaviors when passengers were present.

It is important to keep in mind that, like previous observational research on passenger "influence," this study was only able to describe association, not cause. It is reasonable to assume that at least some of the association between passenger presence/number with risky behaviors is spurious. That is, teens that carry passengers may simply be more predisposed to engage in risky behaviors. This seems particularly reasonable for drivers observed carrying more than one teenage peer, which was a violation of one of the license restrictions for most study participants. Those who are willing to disregard a passenger limit – and perhaps their parents' wishes as well – might be expected to exhibit a less cautious orientation while driving. This explanation gains additional credence given the substantial absence of evidence of passengers doing things to encourage risky behaviors. It should be kept in mind, however, that the study

population here was largely composed of highly inexperienced drivers. Passengers of older, though still young, drivers may exhibit more hazardous behaviors.

Siblings Versus Peers

Although most U.S. States now have restrictions limiting the number of passengers young drivers may carry, most allow newly licensed drivers to carry family members. Such exemptions are often considered necessary for securing the endorsement of legislators. Moreover, there is often an assumption that parents favor such exemptions so newly licensed teens can assist with transporting younger siblings. At present, little is known about whether these exemptions affect the safety of young drivers and their siblings, but there is concern that teenage siblings may be equally as problematic as unrelated teenage peers for young drivers. Drivers in our sample carried siblings nearly as often as peers. Consequently, it is important to understand whether, and if so how, siblings influence the behavior of young drivers.

In general, the presence of siblings was unrelated to most of the driver and passenger behaviors we examined. For example, teen drivers were no more (or less) likely to engage in risky driving behaviors when carrying siblings than when driving alone. That is, siblings did not appear to increase potential risks for teen drivers, nor did they have a protective effect. On the other hand, sibling presence *did* appear meaningful when combined with teenage peers. When teens transported both siblings and peers, loud conversation and horseplay were more prevalent than when teens were carrying parents/adults. These findings suggest exemptions for siblings from passenger restrictions may have little overall effect on teen driving behaviors. However, for States with a sibling exemption, it may be important that teen drivers not be allowed to carry teenage peers if a sibling is also present. This provision was included when a one passenger limit was added to the North Carolina GDL system, thereby protecting against the risk of multiple young passengers while accommodating a political reality. Such a provision would not be relevant in States that prohibit carrying any non-family passengers.

Because of the relatively small sample size, we were unable to disaggregate siblings into teenagers and younger children. It may be that teenage siblings pose different risks than their younger counterparts. In any case, more research of the type reported here, but including larger samples, is needed to understand whether, and how, siblings of varying ages influence teen driver behaviors.

Violations of License Restrictions

Several studies have examined the frequency of GDL violations among young drivers. These studies have typically relied on self-report (Begg et al., 1995; Goodwin & Foss, 2004; Mayhew et al., 1998; Williams, Nelson, & Leaf, 2002), although some have directly observed young drivers (Goodwin, Wells, Foss, & Williams, 2006). To date, no studies have used in-vehicle technology to unobtrusively measure the frequency of GDL violations.

Overall, the vast majority of driving was in compliance with the passenger restriction. Violations were observed in just 7% of clips (usually because teens were carrying more than one teen passenger, rather than combinations of peers and siblings). Although most teens did violate the passenger restriction at some point, a sizeable proportion of the sample – about 30% – virtually never violated the restriction. These findings are generally consistent with previous studies, which have found 70% to 80% of teen drivers acknowledge having ever violated this restriction (Begg et al., 1995; Williams et al., 2002). In earlier interviews with 900 licensed teenagers in North Carolina, we found 34% of teen drivers reported having ever violated the passenger restriction (Goodwin & Foss, 2004). The higher rate of violations in the present study might reflect the accuracy of unobtrusive observations over self-report. In sum, even though many teens appear to violate passenger restriction at some point in time, for most teens this is a relatively uncommon behavior. Teens seem to largely comply, at least with restrictions that allow one teen passenger.

Violations of the night restriction were also infrequent. In North Carolina, newly licensed teens are not permitted to drive unsupervised from 9 p.m. until 5 a.m. Teens were observed violating this restriction in 7% of clips. These violations were three times more common when teens were carrying multiple teenage peers than when they were driving alone. It seems unlikely that having multiple teen passengers "caused" the violation of the night restriction. It may simply be that some teens are more inclined to disregard GDL restrictions, whether they limit passengers or nighttime driving. However, it is also possible late night trips are simply more likely to include passengers. Neither the direction of effect, nor whether it is causal, can be determined from the present evidence. Although it was rare that either nighttime restrictions or passenger limits were disregarded, when a nighttime violation occurred, it was accompanied by a passenger restriction with some frequency. This is a concern given the synergistic effect of passengers and nighttime driving risk on young driver fatalities. Chen et al. (2000) found that night driving roughly doubles the risk and carrying passengers nearly triples it. The combination of both is associated with nearly a 6-fold increased risk of a 16- or 17-year-old driver fatality.

Seat belt use was nearly universal in our sample. Not surprisingly, it was particularly high when teen drivers carried parents or adults. Drivers were observed (or suspected of) using an electronic device in 8% of clips. This is slightly below the figure of about 10% that has been reported in other studies (Foss et al., 2009; Pickrell & Ye, 2009). Consistent with previous research, electronic device use among teen drivers was lower when a teenage peer or parent/adult was present (Foss et al., 2009). The mechanism behind this is not known. Teenage peers can potentially answer (or place) a call for the driver. A few instances of this were evident in the driving clips (coded as "assists driver with task"). With regard to parents, it seems likely the presence of an authority figure suppresses this illegal behavior.

GDL violations may be underestimated in these findings because the data recorders were visible in the vehicles, which may have resulted in a reluctance to carry multiple passengers, drive after 9 p.m., not wear seat belts, or use cell phones. There are two factors we believe lessen this concern. First, most teens were acclimated to the data recorders. The "target teens" in this study had driven periodically with the data recorders in their vehicle since first obtaining learner permits. We seldom saw evidence of drivers paying attention to the recorders (either by looking at or talking to them). Second, no feedback regarding anything recorded was provided to teens or their parents during the study. If teens had concerns their misbehavior would be reported, these concerns should have been alleviated quickly when they discovered no reporting took place. Nonetheless, it is certainly feasible some participating teens may have deliberately altered their driving choices because of the data recorders. A late night trip or carrying multiple passengers may have been avoided in the instrumented vehicle because of the recorder's presence. More spontaneous actions/reactions to situations seem less likely to have been influenced. Violations may also be underestimated if teens altered their driving style when committing violations. One study found most teens reported driving more carefully when violating passenger and nighttime restrictions so police would not notice their violating behavior (Goodwin & Foss, 2004). To the extent teens drove more slowly or carefully in these situations, they may have been less likely to trigger the data recorders.

Male Versus Female Passengers

With male and female passengers, a relatively consistent pattern emerged. Potentially risky driving behaviors and horseplay by the vehicle occupants were noticeably more common when male drivers were carrying male rather than female teenage peers. Among female drivers, risky driving behaviors also appeared more common when male teenage peers were present. Simons-Morton et al. (2005) obtained similar results when observing teen drivers departing from high schools. Males drove faster and with

shorter headways when they had male passengers. Male passengers had the same type, though smaller, effect on female drivers. Studies of crashes among young drivers also point to the increased risk of the male driver-male passenger combination. Young drivers' risk of fatal crash involvement is generally highest when male drivers are carrying male passengers (Chen et al., 2000; Ouimet et al., 2010).

Limitations

Several limitations of this study have already been noted, such as the fact that some teens may have changed their driving behavior because of the presence of the data recorders. However, other limitations of the study should be recognized. Perhaps the foremost concern is the small sample size (52 teens). The sample included a disproportionate percentage of females, and families with higher education and incomes were overrepresented (see Goodwin et al., 2010). This raises concerns about the representativeness of the sample and the generalizeability of the findings. The central concern here is whether teens who participated in the study are more or less likely to carry passengers – and whether they behave differently when carrying passengers – than the broader population of teen drivers. Unfortunately this question is impossible to answer. However, the frequency of carrying passengers and GDL passenger violations in the present study were consistent with findings from other studies. In any case, additional research on the effect of carrying passengers is needed to expand the present findings and ensure they characterize teens more generally.

It is important to note that individual teen drivers contributed unequal numbers of cases (clips) to the various combinations of passengers. For example, only 50% of teens provided the maximum number of cases with siblings (20), whereas 17% accounted for no cases. Teens without siblings obviously had no opportunity to drive in that setting. For clips involving multiple peers, only 12% provided the maximum number of clips (50), while 38% provided virtually no clips. By comparison, equal numbers of cases were obtained for most teens for the no passenger condition – all but 3 of the 52 teens provided the maximum number of 25 cases. In sum, the less common passenger combinations (e.g., multiple peers or siblings) represent a somewhat smaller subset of teens than the no passenger condition. We tried to minimize unequal contribution by individual drivers by limiting the number of coded clips per teen for each passenger combination. We also accounted for clustering of multiple observations within individual drivers and the unequal number of clips analyzed for each participant in the analyses.

Finally, the findings on how frequently teens drive with various combinations of passengers should be interpreted with some caution. The event data recorders were triggered by changes in g-forces, such as

turns or stops. The number of driving clips recorded for an individual was a function of how much a person drove, and also his or her "driving style." A person with a rough style of driving may have triggered the recorder more often than someone who drives smoothly. Of most interest in the present study is whether teens may drive differently in the presence of passengers, or different passenger combinations, which could influence the number of clips recorded. For example, we found a global measure of potentially risky driving behavior was more common when one or more teenage peers were present. This measure included behaviors such as speeding, weaving, or driving erratically. As a consequence, the present findings may *overestimate* how often teens carry peers to the extent that drivers are more likely to trigger the recorders when passengers are present. It should be noted that many of the behaviors we examined, including risky driving, were generally rare events even in the presence of teenage peers. Therefore, any differences in "driving styles" when teens were carrying passengers likely had only a small effect on the overall number of driving clips recorded.

Conclusions

The objective of this study was to investigate the nature of passengers' influence on teenage driving. Risky driving behaviors were more common in the presence of teenage peers. However, some of the mechanisms commonly thought to explain the increased crash risk when carrying passengers were rare, such as instances of deliberate encouragement for the driver to take risks. Several potential distractions were commonplace when teenage peers were present, including loud conversation and horseplay. Other distractions, such as electronic device use, were less common in the presence of passengers. Siblings appeared to have little effect on the behavior of teen drivers. Finally, the frequency of carrying passengers and observed violations of GDL restrictions were similar to findings from previous studies using different methods (e.g., self-report or roadside observations).

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