Use of Video Feedback in Urban Teen Drivers

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ABSTRACT

Context: Fatal crashes of teens, especially newly licensed teens, are higher than for any other segment of the population. Technology can enhance the ability of parents to manage teen's driving beyond the supervised learning phase. Implementing such technology during the first six months of independent driving may enhance teen driver safety by curtailing risk-taking behavior and enhancing hazard awareness.

Objective: To determine whether feedback from an event-triggered video system can reduce the number of safety-relevant driving errors made by newly licensed teens.

Design, Setting, and Subjects: A one-group pretest-posttest quasi-experimental design was used to evaluate thirty-six newly licensed sixteen-year-old drivers. Participants were recruited from a suburban high school in Eagan, Minnesota. Of the teens recruited, 18 completed the entire 12-month study.

Intervention: Participants' vehicles were equipped with an event-triggered video recorder. During the first phase of the project, baseline driving data were obtained. The second phase employed the event-triggered video system, providing drivers with immediate feedback regarding unsafe driving behaviors. In addition, weekly feedback regarding these behaviors was sent to both teen drivers and their parents. In the final phase, additional baseline data were collected to determine whether the removal of feedback affected driving behaviors.

Main Outcome Measures: Number of safety-relevant events triggered per 1000 miles driven.

Results: The intervention reduced the number of safety-relevant events by 61% overall. The greatest reduction was seen in the category of improper turns and curves—the scenarios most represented in fatal car crashes. Overall reduction in safety-relevant events continued even after the intervention ended.

Conclusions: This study showed that immediate and cumulative video feedback shared with parents during early licensure can have a dramatic influence on the rate of safety-relevant driving events. To the extent that such events are a proxy for crash risk, this study suggests that feedback might enhance teen driving safety.

INTRODUCTION

Motor vehicle crashes have long been the leading cause of death for teenagers (16-19 years old). Data from the National Center for Injury Prevention and Control (2004) revealed that 38% of all deaths among 16-19 year olds were related to motor vehicle crashes. The fact is that there is likely no *single* reason for the elevated crash risk for teen drivers. Contributing factors include imperfectly learned vehicle control skills (Patten, Kircher, Ostlund, Nilsson, & Svenson, 2006; Shinar, Meir, & Ben-Shoham, 1998); poor ability to anticipate and identify hazards (Fisher, Pollatsek, & Pradhan, 2006; McKenna, Horswill, & Alexander, 2006; Pollatsek, Fisher, & Pradhan, 2006); willingness to take risks, such as shorter following distances and higher speeds (Evans & Wasielewski, 1983; Laapotti, Keskinen, Hatakka, & Katila, 2001); poor calibration of abilities relative to driving demands (Horswill, Waylen, &Tofield, 2004; Ivancic & Hesketh, 2000; Matthews & Moran, 1986); and sensitivity to peer influences in adopting inappropriate norms (Lin & Fearn, 2003; Simons-Morton, Lerner, & Singer, 2005).

A multitude of on-road and simulator experiments have been done to date examining these contributing factors and their impact on the young driver problem. However, the question has been raised as to whether the environment in which we are examining young drivers is representative of their natural environment. Is there a “disconnect between the research and the real-world safety problem” of teen drivers (Lerner, 2001)? Lerner argues that most empirical research has been conducted with teens driving alone (or with only an experimenter), on road types that are not typical of their driving, and without the everyday distractions (e.g., CD players, cell phones, and passengers) that are representative of most teens’ driving, which can lead to data that may be incomplete or misleading. Consequently, a year-long naturalistic study was conducted collecting driving data for newly licensed teen drivers. During this study, we were provided a glimpse into the everyday driving behaviors of newly licensed 16-year old drivers.

Currently, there are several different devices that can provide us with this window into the world of teen driving (Brovold et al., 2007). Video cameras, data recorders and global positioning systems have been developed to allow parents to keep track of what is happening in the vehicle, even while they are not physically present (e.g., SignalTrac, SmartDriver, or DriveCam).The hope is that these technologies will be used to inform both teens and their parents of the types of driving errors being made and give parents the opportunity to mentor and intervene in a way that can effectively reduce unsafe driving behaviors. While there is little data to support many of the technologies currently available, some studies have shown they may have the potential to improve driving safety among teens (Lee, 2007; McGehee et al., 2007a; McGehee et al., 2007b).

Crash risks are highest for novice teen drivers under certain conditions, and limiting their exposure to these conditions is the most effective way to reduce crash risk. Therefore, parents of teenage drivers play a significant role in limiting their teen's exposure to these risk factors. They are responsible for enforcing the graduated driver licensing policies and driving restrictions by controlling access to their teen's vehicle (Simons-Morton, Hartos, & Beck, 2003). However, research has shown that most parents place only modest restrictions on their newly licensed teens, and that these restrictions tend not to be very firm or lasting. In interviews conducted by McCartt et al. (2003), parents reported placing more trip limits (those involving where and when they were going) on their teens, but fewer and not as strict limits on driving conditions (those more related to teen crash risk, such as night driving, number of passengers, and high speed roads). These results indicate that parents are unsure of the conditions which lead to the highest crash risk and are managing their teens with little or no guidance.

In addition to this, it seems that parent-teen communication regarding any rules and limits is lacking. Beck et al. (2001) interviewed parents and teens one month after licensure regarding driving limits and consequences for breaking driving rules and found that there is a great deal of discord and this discord leads to poor compliance. Therefore, one advantage of any type of feedback intervention would be that it provides, if nothing else, the opportunity for parent-teen interaction and communication regarding driving behaviors that have the potential to be unsafe, rules regarding these behaviors, and the consequences for breaking these rules.

This research focuses on:

1. Describing the driving characteristics of a group of newly licensed urban teen drivers, including; driving records, vehicles driven, miles driven, time of day, types of trips, most common distractions, and risky driving behaviors engaged in.
2. Determining whether providing feedback regarding potentially unsafe driving behaviors will reduce the number of safety-relevant errors made by teen drivers. In particular:
    - How does the intervention affect teen driver safety?
    - Is the effect of the intervention lasting?
    - What types of unsafe behaviors can be most influenced by this type of intervention?
    - What types of drivers receive the most benefit from this intervention?
    - Can seatbelt use be increased using a feedback intervention?
    - Does an intervention like this have the potential to reduce the risks associated with newly licensed teen drivers?

3. The importance of parent-teen interaction in the success of the feedback intervention.

METHODS

Participants

Eagan High School in Eagan, Minnesota was chosen to be the location for the follow-up to a rural teen driving study (McGehee et al., 2007b) due to its proximity to a major urban area. The city of Eagan is a suburb of the Twin Cities, centrally located between Minneapolis and St. Paul, in close proximity to several interstates and highways. Therefore, day to day driving was more likely to occur on multi-lane city roads, highways, and intra-city freeways.

In order to recruit newly licensed 16-year old drivers, several group presentations were offered at Eagan High School to the approximately 300 teens that were eligible for participation in the study at that time. Eligible participants were those who turned 16 within six months of the start of data collection. From that pool of eligible participants, thirty-six 16-year old drivers (19 males and 17 females) were consented. Two male participants were dropped prior to the beginning of the study due to problems with their driver's licenses and one female participant was dropped during the course of the study after losing her vehicle to a flood. All participants had received their license within 6 months of enrollment in the study (see Figure 1) and reported having been driving unsupervised anywhere from 5 months to 1 week before beginning their participation in the study. Ninety-four percent of the participants reported having 4 months or less experience driving unsupervised and 48% reported two months or less. Participants were paid $25/month and a $75 bonus for completing all 12 months.

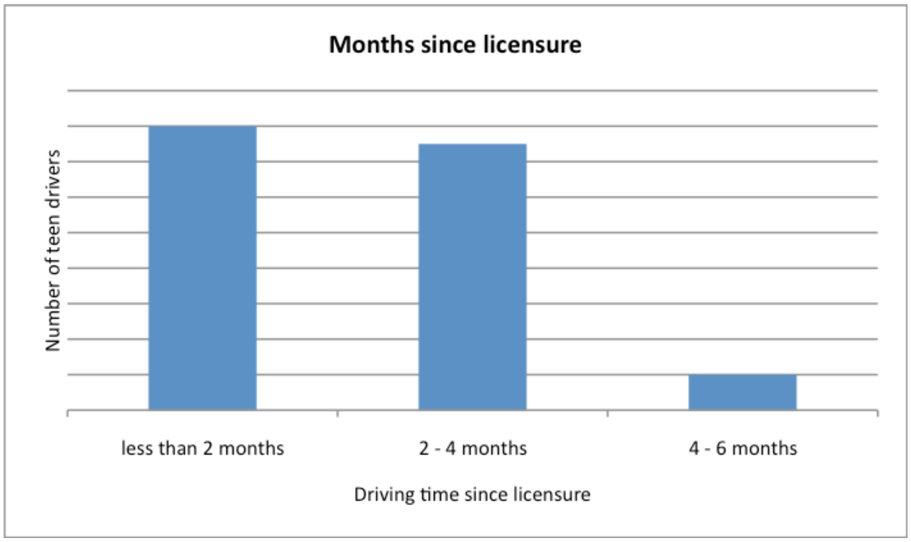

Figure 1. Months since licensure for Eagan teen participants.

Apparatus

Each participant's vehicle was equipped with an event-triggered video recording system made by DriveCam (Figure 2). The system is a palm-sized device that integrates two video cameras (forward and interior view) (Figure 3), a two-axis accelerometer, a 20-second data buffer, an infrared illuminator for lighting the vehicle's interior at night and a wireless transmitter. The device is mounted on the windshield behind the rearview mirror. It captures video from both inside and outside the vehicle as well as audio. Data is continuously buffered 24 hours/day but only writes to internal memory when an acceleration threshold is exceeded. Each video clip captures the 10 seconds preceding and the 10 seconds following the threshold exceedance.

Figure 2. DriveCam event-triggered video system.

Figure 3. Exterior and interior video view

DriveCam uses thresholds that roughly correspond to g-forces (+/- 10 percent). These thresholds refer to accelerometer readings that reflect changes in vehicle velocity or the lateral forces acting on the vehicle when cornering. If the acceleration exceeds the threshold value, then an event is triggered.   The trigger thresholds for this research project were:

- *Shock trigger threshold*: This setting defines the force level for a “shock trigger” from any direction. Shock triggers are most often caused by severe impacts. The threshold setting for this study was 1.50g.
- *Longitudinal trigger threshold:* This setting defines the force level required to trigger the system with a positive or negative acceleration. Longitudinal triggers are most often caused by hard braking. The threshold setting used for this study was 0.50g.
- *Lateral trigger threshold:* This setting defines the force level required to trigger the system with a lateral acceleration. Lateral triggers are most often caused by hard cornering or swerves. The threshold setting used for this study was 0.55g.

Settings were determined based on the guidance and experience of the manufacturer, as well as from other relevant studies. In the 100-car study, Dingus et al. (2006) used 0.5g as the threshold for defining hard braking and 0.4g as the threshold for defining rapid steering maneuvers. Our goal was to maximize the number of truly safety-relevant events captured, while reducing the number of invalid triggers to be analyzed.

When the video event recorder is triggered, an LED light blinks to alert the driver. This is intentional so the driver knows what he/she did to activate the video event recorder and can adjust their driving to avoid repeating that behavior. The unit can also be manually activated to record a video clip. Throughout the entire study, the teens were asked to manually activate the system and provide a weekly odometer reading. On several occasions this was not done. Analysts handled this by calculating cumulative averages for those subjects with missing data points and interpolating where necessary.

All data were automatically downloaded from the device via a secure wireless network whenever the participant parked in the high school parking lot. Once downloaded, the encrypted data were compiled for coding.

Procedure

The installation of the DriveCam system took approximately 30–45 minutes per vehicle. During installation, stickers were placed inside the vehicle (i.e., on the dashboard in front of the passenger's seat and on the back of the headrests) in an effort to notify all occupants that there was a possibility they could be recorded.

Data collection began in June of 2007. Data were first collected for a 6-week period to establish a baseline estimate of driver behavior. No feedback of any kind was provided during the baseline period.

During the next sixteen weeks, teens were provided with two types of feedback. The first was real-time and consisted of an LED on the recording unit blinking immediately after an event was triggered. This informed the driver that the maneuver just completed exceeded the safety limits defined by lateral and longitudinal acceleration thresholds. The second type of feedback was a weekly report card accompanied by a CD containing all safety-relevant video clips for that week. The report showed the driver's weekly and cumulative performance regarding unsafe behaviors and seatbelt use relative to the other participants. It should be noted that, after 16 weeks of participation, the teens were asked to continue the intervention for an additional 24 weeks. Eight of the teen participants decided not to continue and proceeded on to the next (final) phase of the project, the second baseline.

Participants were supplied proprietary software for viewing the videos to ensure confidentiality and that videos could not be shared. Parents of the teen drivers were encouraged to review the videos and report card with their teen each week.

During the final six weeks of the project, no feedback of any kind was provided. This second baseline phase assessed whether the effect of the feedback persisted.

Participants were asked to complete questionnaires regarding their driving and their experiences with the program at the end of each of the three phases of the project. They were also asked to complete a separate questionnaire related to sensation seeking, reckless driving, and parent as well as peer interactions.

Data Analysis

Every event captured by the system was reviewed to determine its cause and then classified into one of the following categories:

- Incident: a threshold exceedance in which the driver's action, either intentional or unintentional, was responsible for a safety-relevant event.
- Near-crash: a threshold exceedance in which an evasive maneuver was performed in order to avoid a collision.
- Crash: a collision with an object or vehicle occurred.
- Good response: a threshold exceedance in which the driver's action occurred in response to an external event.
- Invalid trigger: a threshold exceedance caused by the vehicle hitting a bump/pothole in the roadway.
- Invalid with feedback: an invalid trigger (see above), however, as the video was reviewed there emerged a safety-relevant concern (e.g., video contained evidence of driver/passenger unbelted, cell phone use, or traffic violations such as failing to stop for traffic signs/ signals, etc.).

- Manual: a trigger caused by the driver or passenger pressing a button on the device. This happened for a variety of reasons (e.g., weekly odometer readings, capturing the actions of other vehicles, recording passengers, etc.).
- Non-participant: a threshold exceedance or manual activation that occurred while someone other than the participant was driving the vehicle. These video events were not reviewed.

Once the causes of the events were determined, those requiring feedback were analyzed further. The events were scored to populate a database containing the nature of the event, its cause, the number of vehicles involved, and the action of the driver that caused the event. Safety-relevant data were also recorded, including information about safety belt use, the presence of loud music, and aggressive or reckless driving. Information about the number, location, and age of passengers and whether or not they were belted was also entered into the database. Environmental factors such as weather, light, road conditions, road geometry, and road type were also recorded. Driver-related factors such as distraction, fatigue, and social influence of passengers were also coded, if present.

Further analyses were done on those events deemed to be ‘coachable events’. Coachable events are comprised of both incidents or true triggers *and* invalid triggers where safety concerns are present. It should be noted that true triggers are less likely to be affected by characteristics of the driving environment while invalid triggers are directly related to the prevalence of things like rough roads. However, in either case, they provide an additional window into driving behavior and address potentially dangerous safety concerns. Therefore, invalid triggers that contained safety-relevant behaviors were included in the analyses of coachable events.

RESULTS

Of the 33 teen participants, 10 had 20% or more of their total events triggered while someone else was driving their vehicle. While it could be that the other driver(s) of the vehicle drove infrequently, but accumulated a greater proportion of the triggers, it could also be that the other driver(s) simply drove more frequently than the teen participant. Since we were examining the number of events triggered per 1000 miles driven, and we were unable to determine with any reasonable certainty the number of miles that were driven by those ten participants, their data was not included in the analysis.

The remaining 23 participants had less than 10% of their events generated by someone else, while 16 participants had less than 5% of their events generated by someone else. It was unclear where the cutoff should be made to determine whether or not the teen participant was the primary driver of the vehicle, allowing us to assume that the majority of the miles on the vehicle could be attributed to them. An analysis was done using both sets of data (16 participants and 23 participants). Results showed that there were no statistical differences between the two groups.

Of the 23 remaining subjects, five did not agree to continue their participation in the project for the full year of data collection. Their intervention lasted for 16 weeks instead of the 40 weeks completed by the rest of the group, which introduces variance related to the weather, maturation, system acclimation, etc. Therefore, only the data from the 18 subjects that were considered primary drivers *and* completed the entire year of data collection was used for the subsequent analyses.

Characteristics of Newly Licensed Urban Teen Drivers

It is important to mention the self-selection bias associated with this study. While it is critical, it is also an unavoidable limit of this and other types of experimental intervention. The teenager who would willingly agree to have a camera in their vehicle would most likely fall within a certain demographic group. The statistics that describe the eighteen participants reflect this.

The eighteen participants in this study were all 16 year old juniors at Eagan High School. All participants were newly licensed teens, with 6 months or less of solo driving experience. Ninety percent of the teens reported receiving mostly A's or B's in school. Ninety-three percent reported living with a biological mother or father. Fifty-five percent of the participants come from a home in which one or both parents have a bachelor's or advanced degree. Eighty percent of the teens live in a household that reported having an income of over $100,000.00 per year.

<u>Driving Record</u>

At the beginning of the study, only two of the eighteen participants reported that they had been given a ticket since they started driving independently. One had received a speeding ticket and the other received some other type of citation (not indicated). Not one of the eighteen participants had been involved in a crash. However, by the end of the year-long study, six out of the 18 teen drivers had received a written citation. Three participants were given a ticket for speeding- one of those teens received two tickets (on separate occasions). One participant was given a ticket for a stop sign/light violation. Two other participants received another type of citation (not indicated). Five teens reported having been involved in a crash where they were the driver at fault. One of these participants reported that they had been involved in three at fault crashes since they had started driving on their own.

Types of Vehicles Driven

Of the vehicles driven by the Eagan teens during their year of participation, the majority (69%) were smaller, lighter vehicles (i.e., compact to mid-size sedans). Additionally, 48% of the vehicles driven were 10 years old or older. Table 1 represents the types and sizes of the vehicles driven by the Eagan teens in this study.

Table 1. Vehicle types driven by Eagan teens.

Year	Make	Model	Body Type	Class
1993	Chrysler	LeBaron GTC	Coupe	Mid-size
1993	Chevy	Corsica	Sedan	Mid-size
1993	Ford	Taurus	Sedan	Mid-size
1994	Pontiac	Firebird	Coupe	Pony/Muscle car
1994	Cadillac	Concourse	Sedan	Full-size luxury
1996	Mercury	Grand Marquis	Sedan	Full-size
1997	Saturn	S-series	Sedan	Compact
1998	Hyundai	Tiburon	Coupe	Sport compact
1998	Honda	Civic	Sedan	Compact
1998	Honda	Civic	Sedan	Compact
1998	Dodge	Durango	SUV	Mid-size SUV
1999	Volkswagen	Passat	Family car	Mid-size
1999	Honda	Civic	Sedan	Compact
1999	Toyota	Corolla	Sedan	Compact
1999	Geo	Prizm		Compact
2000	Nissan	Maxima	Sedan	Mid-size executive
2000	Acura	TL	Sedan	Mid-size luxury
2001	Mitsubishi	Eclipse	Coupe	Compact
2001	Ford	E-350	Van	Full-size van
2002	Toyota	Camry	Sedan	Mid-size
2003	Nissan	Sentra GXE	Sedan	Compact
2003	Mitsubishi	Outlander	SUV	Compact crossover
2004	Nissan	Sentra	Sedan	Compact

Mileage

Data available regarding mileage, obtained from the 2001 National Household Travel Survey, showed that teens 16 – 19 years old drove 7,331 miles annually (males 8,228 and females 6106; Hu & Reuscher, 2003) or an average of 20.1 miles daily. The 18 teen drivers from Eagan averaged 6,904 miles annually. Their mileage remained relatively constant throughout the year ranging on average from 17-26 miles daily, with the lowest miles being driven during the months of January and February when weather conditions in Minnesota were not as favorable. Interestingly enough, when asked to estimate their mileage, the teens were surprisingly accurate, reporting an average of 140 miles per week or 20 miles per day.

Time of Day

The distribution of coachable events during the week (Figure 4) indicates that a greater percentage of coachable or "safety-relevant" events are occurring during the hours of 6 and 8am and 3 and 6pm. This would be during the teens' commutes to and from school, and not during the evening hours as might be expected. This graph is nearly identical to a graph of national data (Figure 5) showing the distribution of crash-involved 16-17 year old drivers (McCartt, 2007). According to that data, the majority of crashes involving 16 and 17 year old drivers occurred during the morning hours of 6 and 8am and the evening commute home between 2 and 6pm.

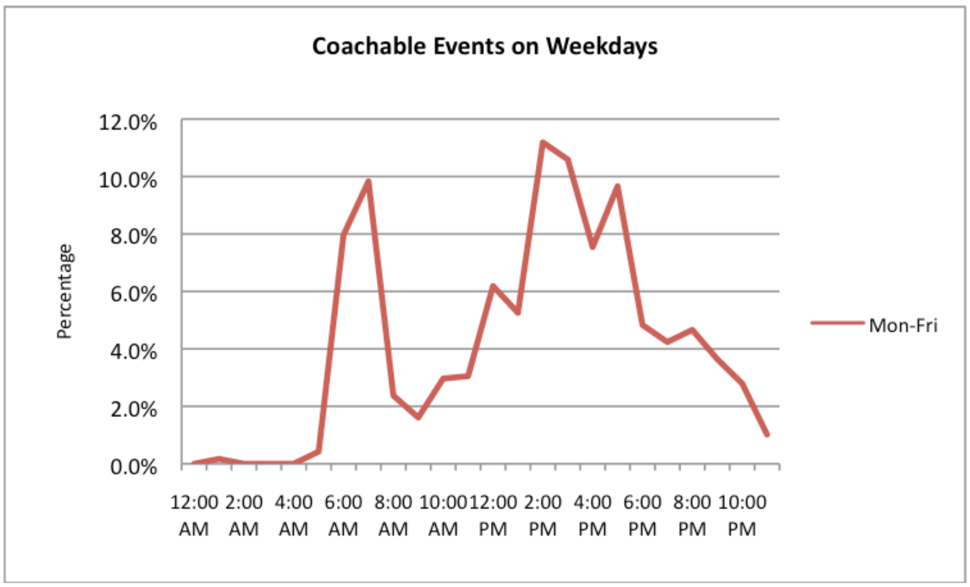

Figure 4. Distribution of coachable events during weekdays by time of day.

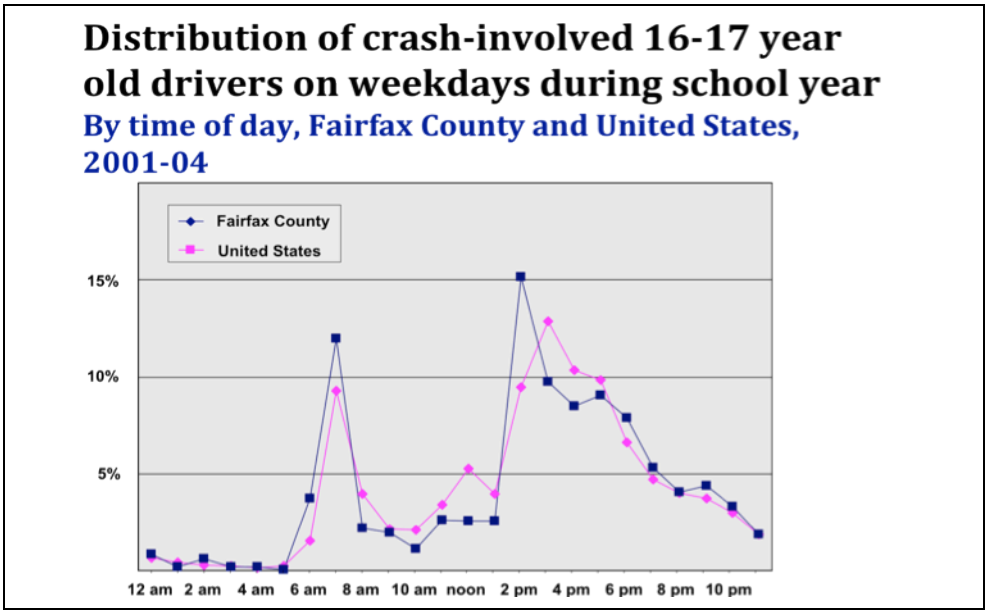

Figure 5. Distribution of crash-involved teens during weekdays by time of day. (from McCartt, 2007)

For the weekends, a different pattern emerges (Figure 6). The percentage of coachable events remains relatively consistent beginning around 8am until 5pm. Then, there is a spike in the percentage of coachable events around 6pm, which occurs for both Saturday and Sunday. Saturday driving shows an additional peak in the percentage of coachable events at 8pm and again around mid-night.

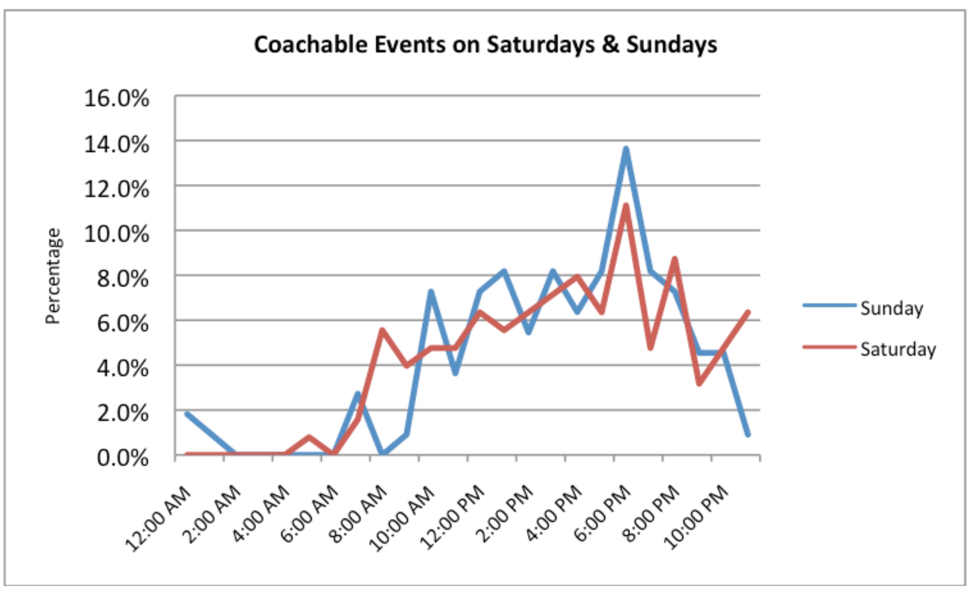

Figure 6. Distribution of coachable events on weekends by time of day.

Data from this study as well as McCartt (2007) and the 1990 National Personal Transportation Study indicated that teen drivers, ages 16-17, acquire only about 14% of their total miles driven during the hours of 9pm and 6am. However, when *fatal* crashes occur, 39% occur during these hours (Williams & Pruesser, 1997).

<u>Types of Trips</u>

Eagan teens reported that most of their driving is back and forth from work, friends' houses and extra-curricular activities (Figure 7). Surprisingly, 58% of teens from Eagan reported driving to and from school less than once a week. This is different than what was seen in the rural teen study (McGehee et al., 2007a; 2007b), where nearly 100% of the teens drove to and from school daily. In a suburban school district, the close proximity of the students to the high school, the large number of students attending relative to the limited amount of parking available, and the amount of vehicle sharing are most likely the causes of this trend. Eagan teens also reported that they rarely drive around without a destination. Eighty-three percent said that they do this less than once a week.

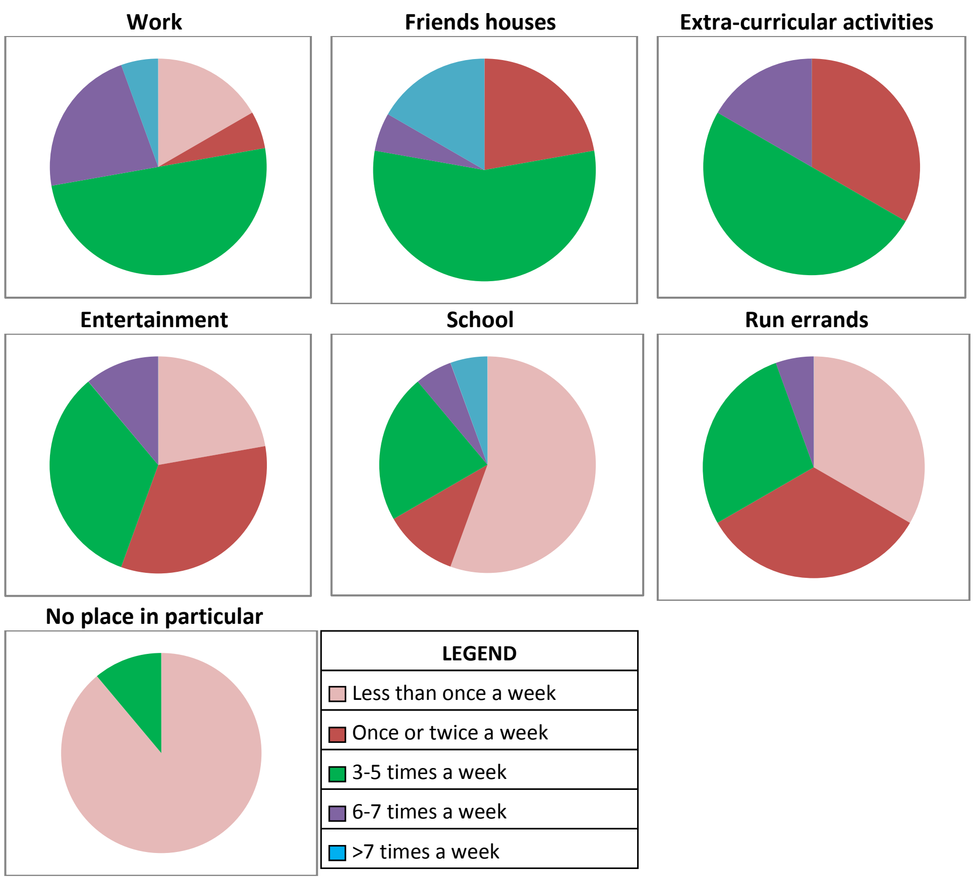

Figure 7. Breakdown of reported trip types.

Effectiveness of the Feedback Intervention

<u>Coachable Events</u>

The mean number of coachable events per 1,000 miles was calculated for each subject in order to standardize the data. This was important due to the variance in mileage obtained from one subject to another. For instance, a subject may have triggered a higher number of events each week because the amount of driving they were doing was greater. Or, it could have been that they drove in such a way that they triggered the system at a higher frequency. It is impossible to know which is true without first standardizing the data.

Results of the initial data analysis showed that the intervention was successful in reducing the number of coachable events by 61%, from an average of 21 per 1,000 miles to 8 (see Figure 8). And perhaps more importantly, the number of coachable events did not increase significantly when the intervention was stopped.

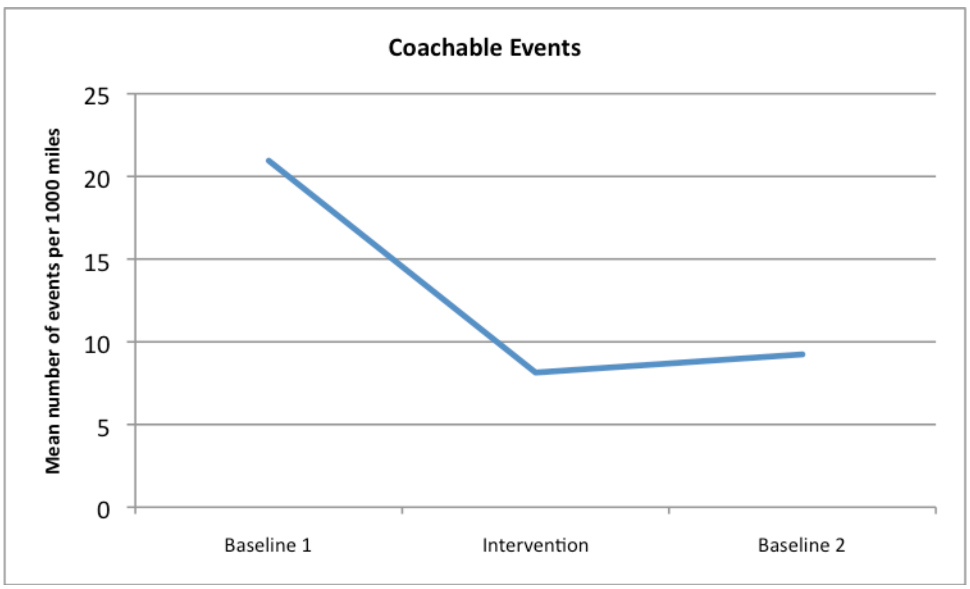

Figure 8. Effectiveness of intervention in reducing the number of coachable events.

Figure 9 breaks each of the three phases down and looks purely at the average number of coachable events triggered per week. Results show that there was approximately a two week period at the beginning of the study where, even though the teens were not getting any feedback regarding their driving, they had fewer safety-relevant events. Most likely, this was simply due to the novelty of the system and having it present in their vehicle. One could argue that those two weeks included, in essence, an intervention and should be removed from the baseline data. This would increase the average number of events triggered per 1,000 miles for the baseline period and make the effect of the intervention even larger.

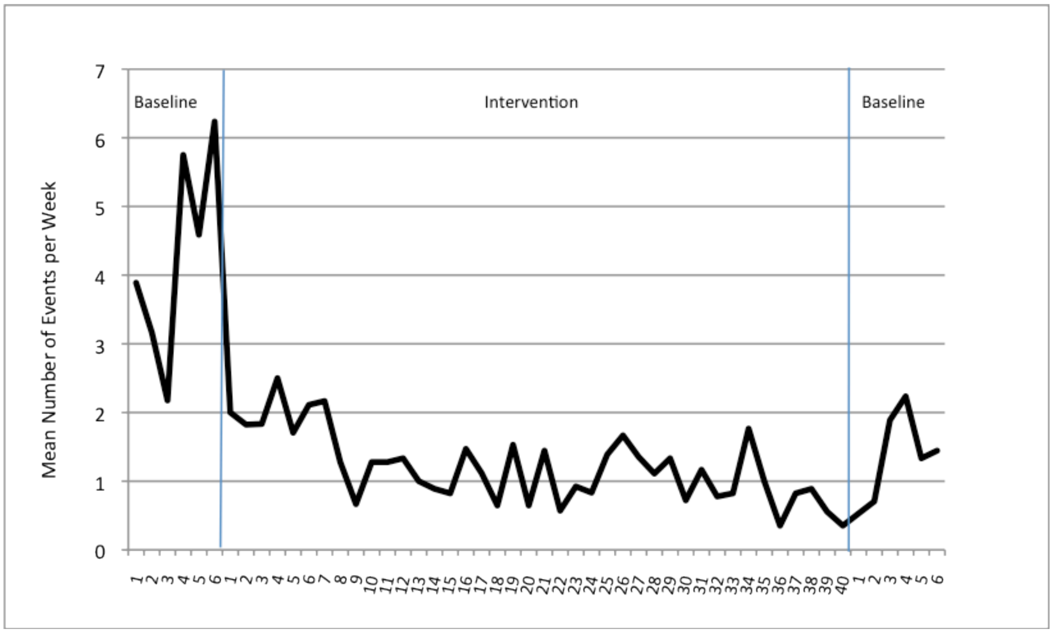

Figure 9. Mean number of events per week during each of the three phases.

The effect of the intervention was impressive and immediate. Introducing feedback regarding unsafe driving behaviors helped to significantly reduce the average number of events seen per week from 4.2during the initial baseline to 1.2 during the intervention. In addition, the number of events remained consistently low throughout the entire 40 weeks.

Drivers' Actions

Those events that were deemed "coachable" or safety-relevant were further analyzed in order to determine a cause or a "driver's action" that led to this event. The coding system offered 39 possible driver's actions. For the analyses these were grouped into 5 distinct categories.

1. Improper turns and curves (e.g., too fast, too wide, cutting the corner)
2. Abrupt braking (e.g., braking hard to stop for traffic sign or light)
3. Abrupt acceleration
4. Neglecting vehicle control (e.g., drifting or swerving due to inattention to roadway)
5. Other(e.g., tailgating, illegal passing

Out of these, the majority (90%) were improper turns and curves, abrupt braking, or abrupt acceleration. This reflects the nature of the DriverCam system. Because the system is only triggered when lateral and longitudinal g-forces have been exceeded, the majority of the events seen are going to be due to braking or turning. However, on the occasion that a bump was hit or a railroad track was driven over, an additional glimpse into the vehicle allowed us to code additional driver actions that might not otherwise have been seen. Figure 10 shows how the main three categories of driver action were affected by the intervention.

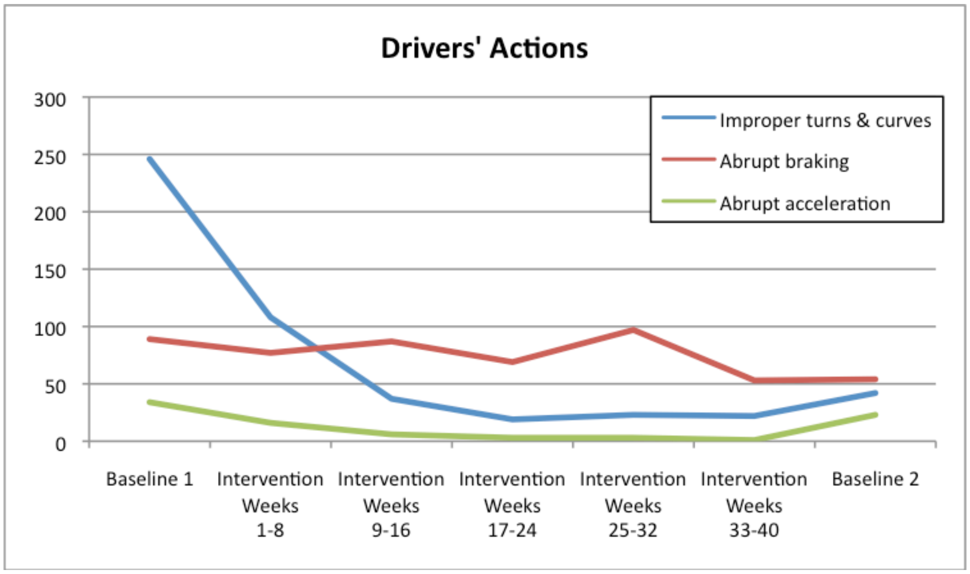

Figure 10. Effect of intervention on the three main drivers' actions.

Of particular interest is the difference in how the intervention affected improper turns/curves and abrupt braking. The intervention had an immediate effect on the way in which drivers took their turns and curves. They had to reduce their speed ahead of time and take the turns/curves slower to avoid triggering the camera. There was a 56% reduction in the number of improper turns and curves from the initial baseline to the first eight week period of the intervention. In contrast, drivers took the entire intervention period to reduce the frequency of abrupt braking. This required looking further ahead, anticipating the actions of others, and thinking about the potential hazards in the environment that may require an immediate response.

High vs. Low Event Drivers

Two groups were formed from the eighteen participants, a group of the three highest event drivers (the 85th percentile and above) and a group of the 3 lowest event drivers (the 15th percentile and below). During the initial baseline driving, the high event drivers triggered more than 40 coachable events per 1,000 miles while the low event getters triggered less than 5 coachable events per 1,000 miles. In addition, during the course of the entire study, the three highest event getters triggered 44.5% of all coachable events captured.

While there was a quite significant decline in the number of events triggered by the high event group during the intervention phase, their mean number of events never approached that of the low event group. However, their pattern of triggering events was identical to the low event getters once the intervention phase began (Figure 11).

The teens in the “high event” group tended to accumulate events related to more aggressive driving, such as taking the turns and curves too fast (46%) and abrupt acceleration (13%). The teens in the “low event” group tended to have driving errors that were more skill-based. Seventy percent of their events were coded as “hard braking”, suggesting that they simply may not have acquired the skills and/or experience necessary to judge how far ahead and where they should be looking for potential hazards.

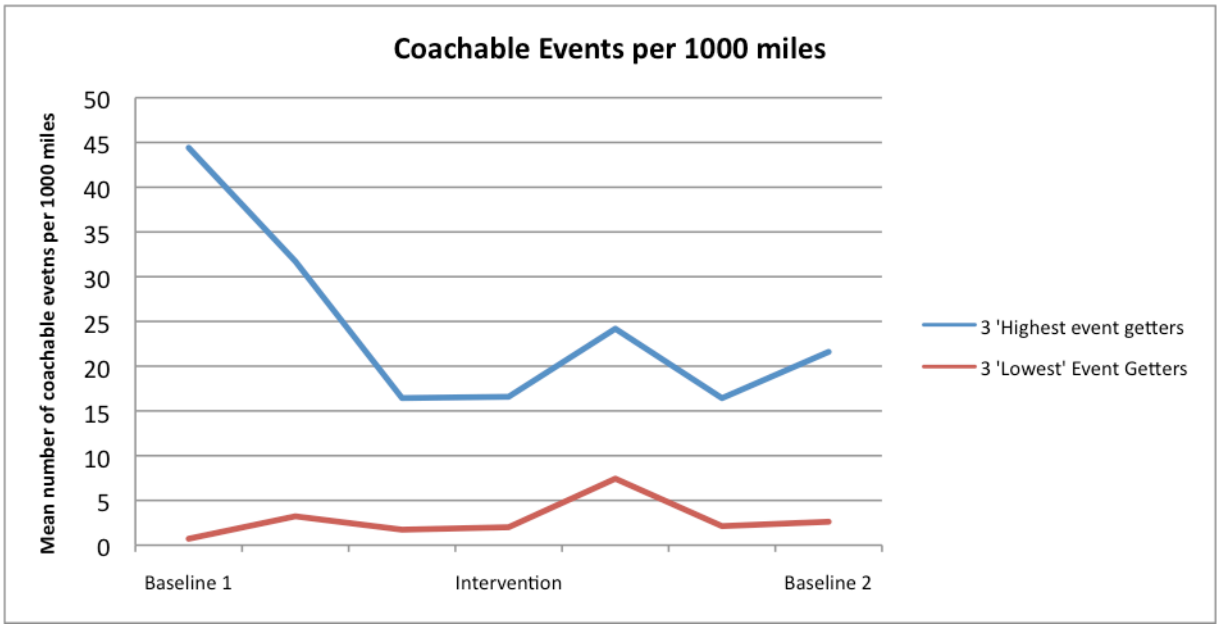

Figure 11. Coachable events for high and low event drivers

<u>Near-Crashes and Crashes</u>

Nine subjects were responsible for the 16 near-crashes that occurred during the year of data collection. One subject had 4 near-crashes, two subjects had 3 near-crashes and six subjects had 1 near-crash. Thirty-eight percent of the near-crashes were due to the participant’s late response to an external event (see Figure 12). In six of the 16 events, the driver was required to brake abruptly in order to avoid a collision. In 31% of the near-crashes, the driver committed some type of right-of-way error. All of the drivers were belted during the near-crashes.   Only two near-crashes occurred when passengers were present and in each event they were also belted. During 8 out of 16 near-crashes, drivers were distracted.   Distractions varied from cell phone or radio to looking outside the vehicle or simply inattention, with no one distraction type being more prevalent than another.

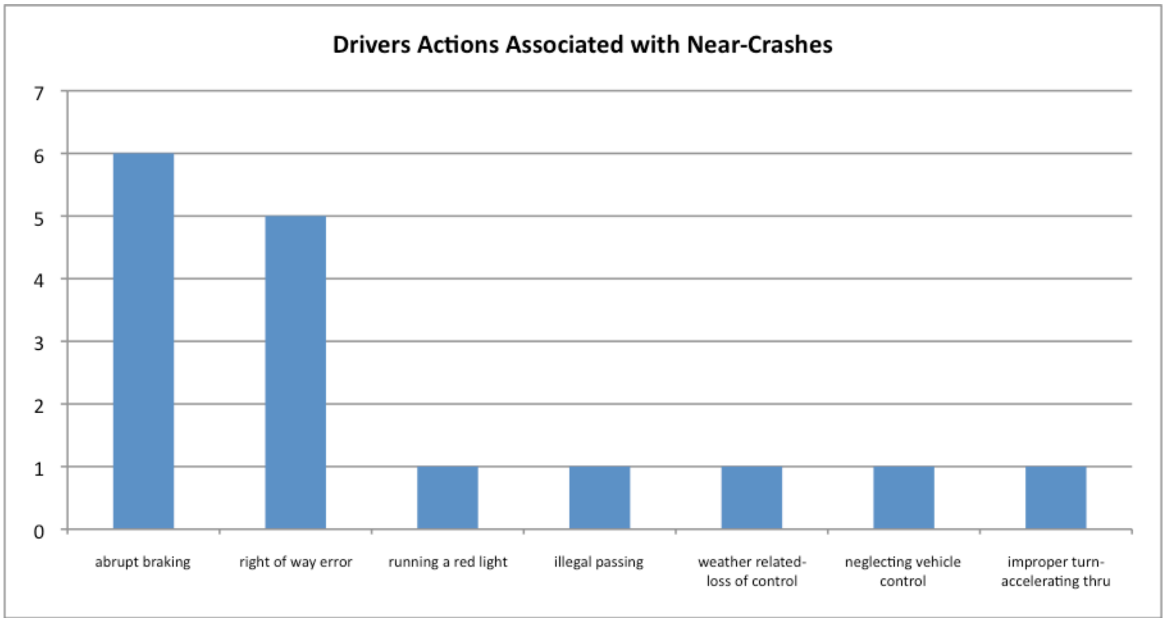

Figure 12. Drivers' actions associated with near-crashes.

Four subjects were involved in the six crashes that occurred during the course of the year. There were no injuries reported during any of the crashes. In addition, none of the crashes resulted in enough property damage to cause the vehicle to be out of commission for any period of time.

One participant was actually responsible for three of the crashes. Even more astonishing is that this participant's three crashes took place on the same day and within a ten-minute period of time. They were determined to be weather related, in that the vehicle's tire got caught in heavier snow, causing the vehicle to swerve and hit the guardrail on the side of the roadway.

Two rear-end crashes occurred when the participants failed to see the cars ahead of them were slowed/stopped and their braking did not occur in time to avoid the collision. The last crash was caused by a participant failing to sufficiently scan the area behind the vehicle before backing up in a parking lot.

It is important to note that due to the acceleration based triggering of the system used in this study, drivers' actions such as right of way errors, running red lights, illegal passing are only seen when they are associated with some type of abrupt maneuver (hard braking or steering) that will trigger the camera. For this reason, it is not possible to do a parallel analysis of the non-crash related events in order to see if these types of drivers' actions decreased as a result of the intervention. We can, however, examine abrupt braking, the leading drivers' action determined to be associated with near-crashes. When we do, we see that abrupt braking does decrease significantly as a result of the intervention. From this we can predict that the intervention would have an impact on teen driving safety, possibly reducing the potential for near-crashes and crashes.

Safety Belt Use

Safety belt data was coded for the driver as well as for the front and rear passengers present in the vehicle. If more than one passenger was present in the front or rear seat, both passengers in that location would be required to be wearing their safety belt for the data to be coded as such. In addition, if the analyst was unable to verify that a passenger was wearing a safety belt the data was coded as "unknown". These data were left out of the analysis of the safety belt data. Only a relatively small, 13%, of the events analyzed were coded as "unknown" and a majority of these can be attributed to our inability to view the entire rear seat.

Data regarding seatbelt use is usually gathered one of two ways, self-reports using survey data or spot sampling from observational data. This study was different in that we were able to collect longitudinal seatbelt compliance data throughout the year of data collection. In addition, the activation of the camera due to bumps, potholes, or inadvertent activation by passengers allowed for a quasi-random sampling regarding seatbelt use.

The data showed that the rate of safety belt use was high. All 18 of the participants had seatbelt compliance rates greater than 84% over the course of the study (see Figure 13). Seven of the teen drivers were never seen unbelted and ten had greater than 98% seatbelt compliance.

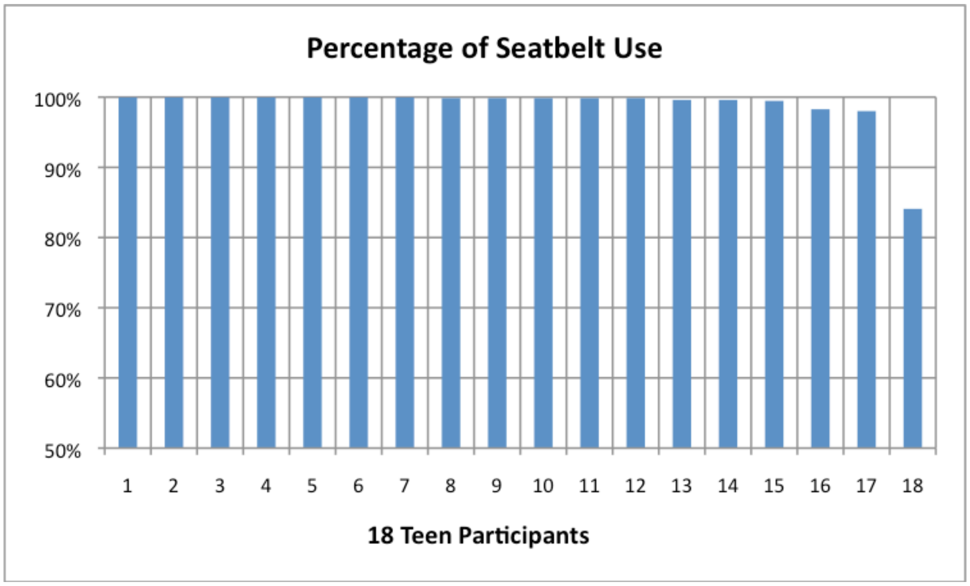

Figure 13. Seatbelt use for all subjects across the entire study

Overall, when events were captured where the driver was not wearing a safety belt, 78% of the time the driver was a male, versus 22% of the time the driver was female. During the intervention, we saw a slight increase in the driver's safety belt use (see Figure 14), due entirely to the increase in compliance of female drivers. Safety belt use for males actually declined slightly during the intervention. It is important to note, however, that even through the second baseline period when all feedback was removed, teen participants continued to increase their rate of safety belt compliance to nearly 98%.

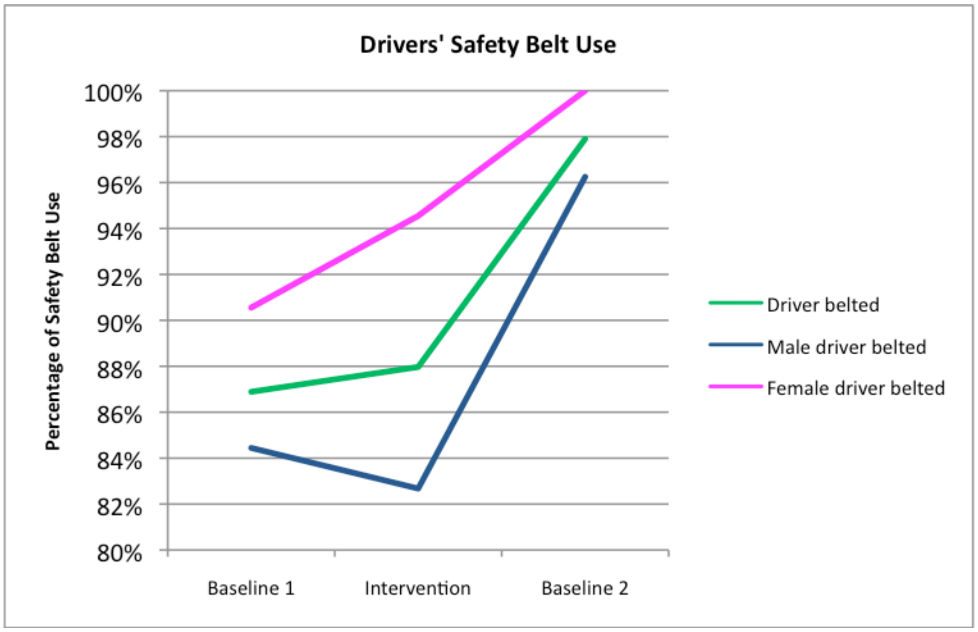

Figure 14. Percent of events with the driver unbelted by gender and phase.

As we would expect, passenger safety belt use was lower than that of the drivers (see Figure 15). During the initial baseline, drivers were belted 87% of the time, whereas their passengers were belted only 65% of the time. The intervention did increase passenger safety belt use to 75%. However, once the intervention was over and the drivers no longer received feedback, the passenger safety belt use started to decline again.

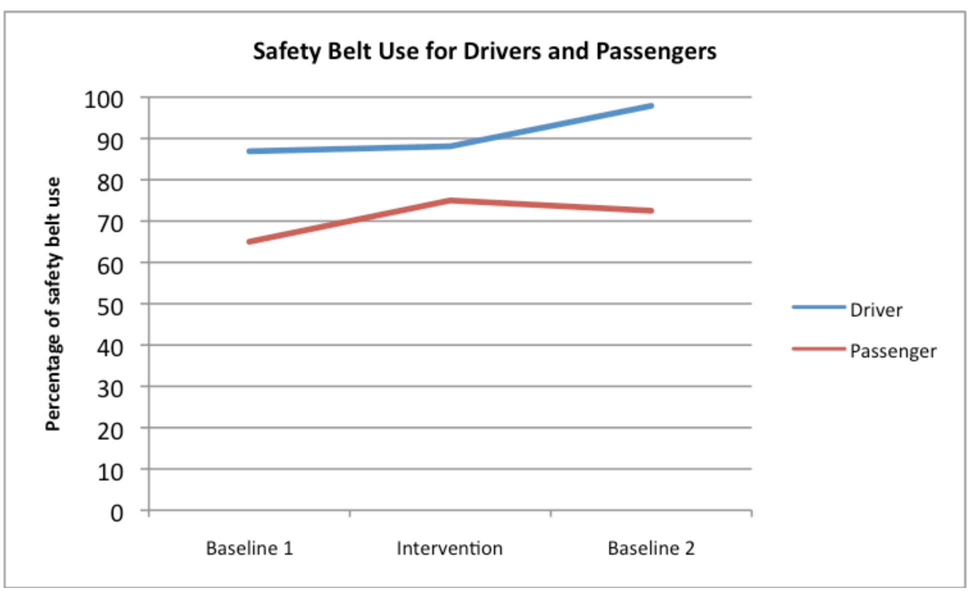

Figure 15. Percentage of safety belt use for drivers and passengers by project phase.

When we break down the passenger safety belt usage, we find that overall, rear passengers were less likely to wear their safety belt (49%seatbelt use) than front passengers (71% seatbelt use). This is in line with the latest seat belt data that shows a significantly lower usage for passengers age 16 – 24 when they are seated in the back seat versus the front seat (Glassbrenner, 2005). Womak et.al. (1997) collected data from teens seeking to identify the conditions for belt use among 16-19 year olds. Teens stated that, as a passenger, they were more likely to wear their seatbelts on a conditional basis, depending on who was driving and where they were riding in the vehicle. Even teens that reported they always wore their seatbelts, often said “except in the back seat”.

According to FARS data (1995 – 2000), lower belt usage is associated with an increasing number of passengers. Data from the current study showed that passenger safety belt use decreased as the number of teens present in the vehicle increased. Seventy-nine percent of the time, passengers used their safety belt when they were the only passenger in the vehicle, compared to 49% when there were 2 or more passengers and 23% of the time when there were 3 or more passengers present.

Also interesting to note is that the use of safety belts by the driver of the vehicle had a significant effect on passenger safety belt use. When the driver was wearing a safety belt, 68% of the time the passengers in the vehicle were also buckled. In contrast, when the driver was *not* wearing a safety belt, only 36% of the time where the passengers buckled.

If we examine the three teens who had the lowest safety belt use during the initial baseline (<90%), it is encouraging to see that the percentage of events recorded with the driver wearing their safety belt increased during the intervention phase and continued to increase even further during the second baseline period (see Figure 5). This suggests that, if nothing else, the intervention may have influenced the safety belt use of those teens who had not been belting up prior to this study.

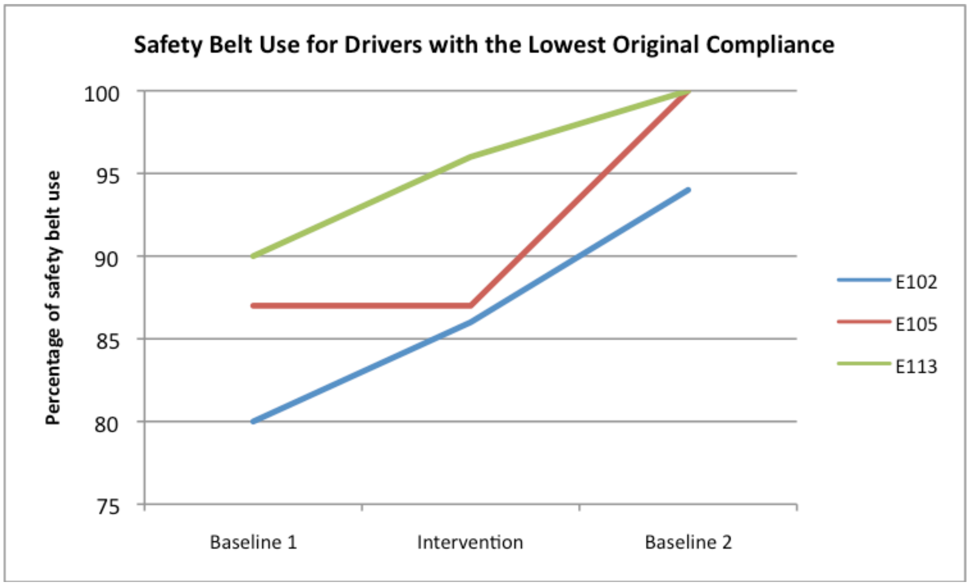

Figure 16. Percentage of events with the driver unbelted for the teens with the lowest original compliance.

<u>Distraction</u>

Driver distraction is an important safety problem. The results of a study that tracked 100 vehicles for one year indicated that nearly 80% of crashes and 65% of near-crashes involved some form of driver inattention within three seconds of the events (Liang and Lee, in press). For the Eagan teen drivers, 50% of the near-crashes and crashes were associated with some form of distraction (Figure 17).

During the 322 events for which distraction was present, 63% of the time the driver engaged in abrupt braking and 22% of the time the driver performed an improper curve or turn. In most of these instances, the distracted action resulted in the driver “looking but not seeing”. Due to the distraction, the driver failed to look far enough ahead and prepare in advance for situations that required some type of action on their part.

In approximately 10% of the events, the distraction caused behaviors that were considered to be aggressive, such as abrupt accelerations and neglecting vehicle control (i.e., “peeling out”, racing, “doing donuts”). In these instances the distraction was most likely a passenger who was socially influencing the driver, encouraging the driver to engage in behaviors that were triggering the system.

The three categories of driver distractions that occurred with the highest frequency included; cell phone distractions, cognitive distractions, and passenger distractions.

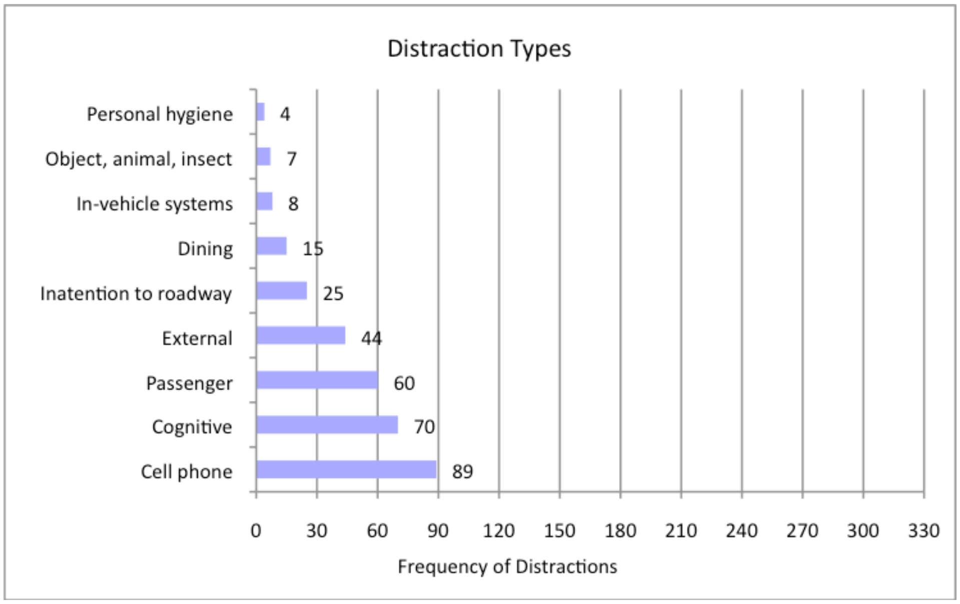

Figure 17. Frequency of driver distraction by type.

Cell Phones. The category accounting for the most driver distractions was cell phone use. This category combined talking and listening, locating, reaching, answering or putting away the phone, and texting (regardless of whether the phone was hands held or hands free). According to a 2005 Allstate Foundation Survey conducted of 1000 people between the ages of 15 and 17, 56 percent of young drivers reported that they use cell phones while driving. One on-road study conducted by Lerner and Boyd (2005) reported that younger drivers were more willing to use cell phones and other in-vehicle technologies during various driving situations and considered them to be less risky than did their older counterparts.

Cognitive. Cognitive distractions were harder to define and determine, simply due to their nature. The drivers' eyes may or may not be on the roadway and their hands may or may not be on the steering wheel, however their mind or attention was somewhere else. For this study, cognitive distractions were defined as reading, talking, singing, dancing, route planning, and simply looking but not seeing (e.g., lost in thought).

Passengers. Driving with teen passengers present in the vehicle increases the crash risk of the unsupervised teen driver and that risk increases substantially as the number of teen passengers increases (Chen, 2000; Doherty et al., 1998). According to a March 2008 NHTSA report, the crash risk is 3 to 5 times greater for teens driving with teenage passengers than when driving alone (Insurance Information Institute, 2008). It is not known whether distraction or social influence causes the associated changes in teen driving behavior when teen passengers are present. Just having someone present talking and moving about inside the vehicle could create enough of a distraction for the inexperienced driver that it would impair performance. In fact, in an on-line survey of

1,000 15-17 year olds conducted by Allstate Insurance Company (2005), 47% of teenagers admitted that they were distracted by having other people in the vehicle with them. And, 44% of the teens said that they were safer drivers when they drove without their friends.

University of California researchers surveyed 2,144 seniors from 13 high schools regarding driver distractions. More than a third of the teenage drivers said that they had been distracted by other teens in the vehicle while they were driving. The most common distraction was talking, yelling, arguing or being loud. Twenty-two percent of the drivers said that passengers distracted them by “being stupid” or “fooling around”. A passenger deliberately distracting the driver by punching or tickling them was mentioned by nearly 8 percent of the teen drivers. “Other deliberate distractions were attempts by passengers to control the car, such as "mess around with mirrors," "messed with my seat adjustments," and "messing with things in the car, such as radio or hazard lights."(Heck et al., 2007)

Risky Driving

When teens are asked to assess their own driving, they have the tendency to overestimate their abilities and skills (Matthews & Moran, 1986; McCormick et al., 1986). In addition, these same teen drivers tend to underestimate the risk of potentially dangerous driving situations (Finn and Bragg, 1986). Both of these beliefs together tend to factor into the high crash rates of newly licensed teen drivers (Gregersen, 1996).

Studies have shown that young drivers choose to behave more dangerously. They are more likely to speed, have shorter following distances, accelerate abruptly, and change lanes rapidly (Simons-Morton, 2005; Jonah, 1986; 1990; Preusser, Ferguson, & Williams, 1988). In essence, they drive faster and in ways that increase their probability of incidents with other drivers. During interviews conducted by Hartos, Eitel, and Simons-Morton (2002), more than 60% of teens reported that they committed the following risky driving behaviors at least once in the last six weeks: exceed the speed limit in residential and school zones (92%), drive through stop signs without completely stopping (69%), engage in distracting activities while driving (69%), and switch lanes to weave through slower traffic (67%).

When asked whether or not they had engaged in particular risky types of driving behavior, Eagan teens reported that the most common risky behaviors were associated with speeding and allowing themselves to be distracted by talking and texting on their cell phones (see Figure 18). Seventy-eight percent of the teens reported that they have disregarded the speed limit on a highway, and 67% said that they have disregarded the speed limit on a residential road. More specifically, seventy-eight percent reported that they have driven more than 10 mph over the speed limit, with 17% reporting that they do so somewhat frequently.

Eighty-nine percent of teens reported having talked on their cell phones while driving within the last year, 17% saying that they do so frequently. Seventy-two percent have texted while driving, again 17% saying that they do so frequently. Interestingly, the teens that reported frequently talking on the cell phone were NOT the same teens who reported frequently texting while driving. It is not known whether this is because there is a misperception that one is safer than the other, or they feel as though they are less likely to be caught texting.

Some behaviors were seen as too risky to engage in- driving when drunk above the legal limit and driving with young children unsecured in the vehicle. None of the Eagan teens reported having engaged in these behaviors within the last year.

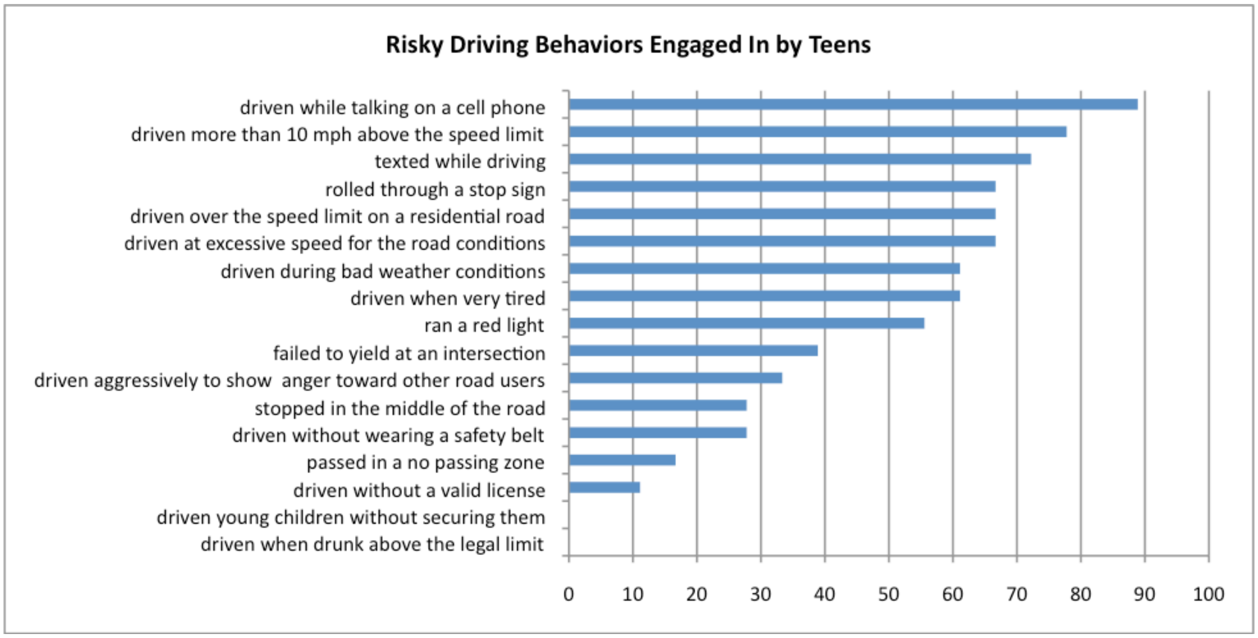

Figure 18. Percentage of teen drivers who reported engaging in risky driving behaviors within the last year.

Parent-Teen Interactions

Several studies have shown that parents place more emphasis on things like having permission and knowing what time to be home than they do on dangerous driving (i.e., having teen passengers and driving at night). McCartt et al. (2003) surveyed 2854 teens from 11 schools in four different states and then followed up with telephone surveys at six-month intervals through their senior year. Teens reported having on average, four types of restrictions. The most common restrictions were no drinking and driving (90%), no driving without a seatbelt (73%), and nighttime curfew (71%). Only 38% of teens said that their parents placed a limit on the number of teen passengers they were allowed to have.

Figure 19 reports the percentage of Eagan teens who reported having particular rules or restrictions placed on their driving. Interestingly, 80 to 90% of the teens reported that their parents had required them to be home before midnight, tell parents where they were going and call if their plans changed. However, more safety relevant restrictions regarding the time of day, weather, traffic, and number of passengers were imposed by only about 30% or less of the parents.

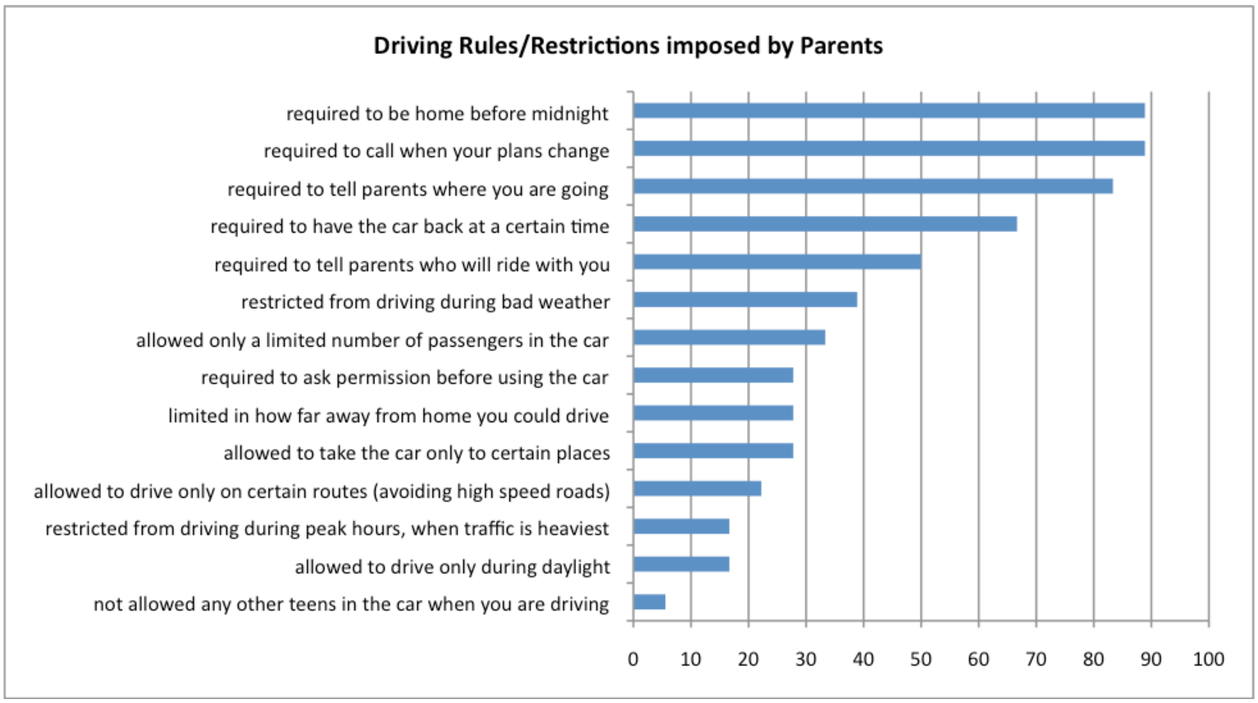

Figure 19. Percentage of parents who impose rules/restrictions on their newly licensed teens (teen reported).

More importantly however, was the discord between what parents thought the rules were and what the teens understood the rules to be. Hartos et al. (2004) found that when parents and teens were both asked to report three specific rules related to driving; only a little over 50% were in agreement. And, even when they did match on the rule, just under half matched in terms of the consequences for violating the rule.

Figures 20 and 21 compare the responses of Eagan parents and teens regarding driving rules or restrictions concerning the presence of passengers, cell phone use, time of day driven, road types driven on, or locations driven to. Around 90% of both teens and their parents reported that they have rules regarding cell phone use. That is not to say that they are in agreement about what the rule is or what the consequences are for violating the rule. It is, however,

There was disagreement between some parents and teens regarding rules about where and when they were allowed to drive. However, the biggest difference between what the parents reported and the teens reported was in the case of passengers being present in the vehicle. While about 88% of parents reported that they have a rule regarding the number of passengers their teen is allowed to have in the vehicle, only 27% of teens report having such a rule. This is a huge discrepancy surrounding an issue that has been found to be paramount to teen driving safety.

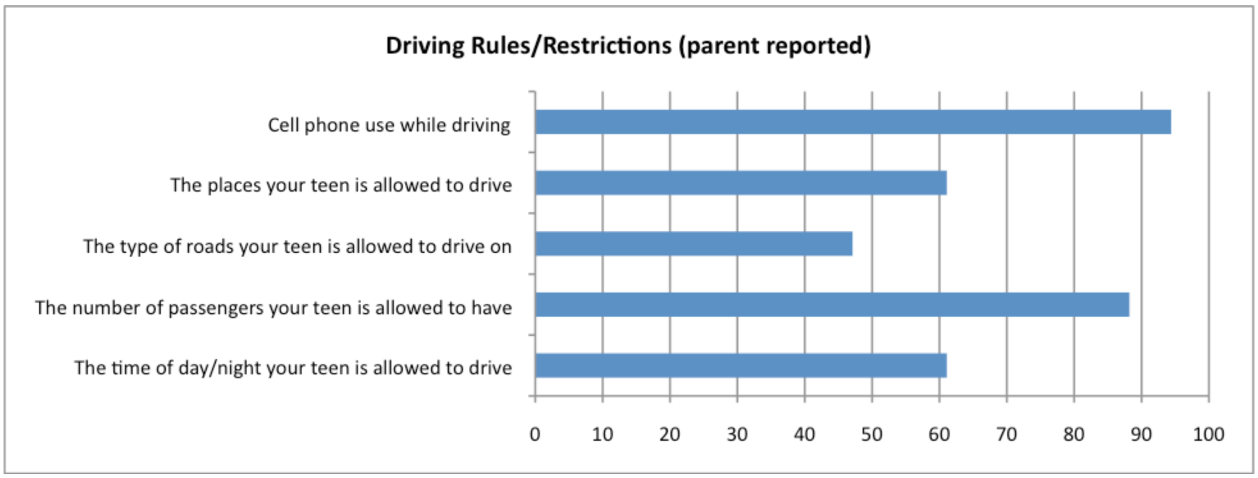

Figure 20. Percentage of parents who impose rules/restrictions on their newly licensed teens (as reported by parents)

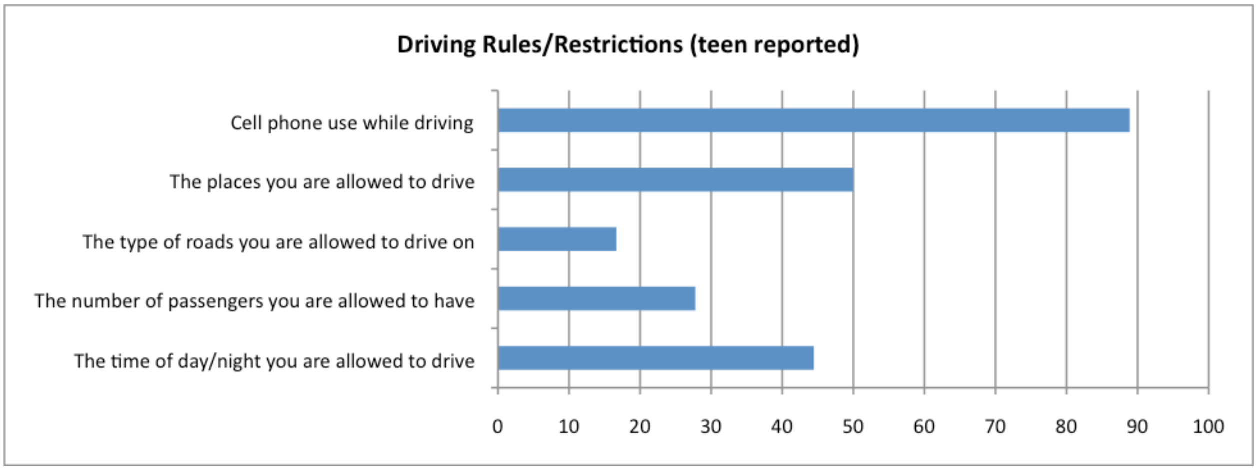

Figure 21. Percentage of parents who impose rules/restrictions on their newly licensed teens (as reported by teens)

The results show that there appears to be a lack of communication regarding driving rules and restrictions between parents and their teens. This discord can lead to poor compliance. Teens who are not informed of the rules cannot be expected to follow them. In addition, it seems as though parents have not been given the information necessary to make the most practical and safety-relevant rules necessary for keeping their teens as safe as they can be.

<u>System Acceptance</u>

While active monitoring of teen driving allows for the opportunity to assess the young driver's abilities, maturity, and judgment several parents dismiss the idea saying it "shows a lack of trust" or is "an invasion of privacy". Others argue that feedback from parents as well as the in-vehicle systems can help young drivers hone some of their skills regarding safe speeds, following distances, and in-vehicle distractions.

After participating in the study for 1 year, 78% of Eagan teens reported feeling more confident in their driving abilities and 83% felt as though they were safer drivers. Perhaps surprising is the fact that 83% of the teens reported that they did not feel as though the camera were an invasion of their privacy. Ninety-four percent were glad that they chose to participate in the study and 100% said that they would recommend it to other teens. Some comments made by the teens include:

> "It made me slow down."
> "It let me see my mistakes so I could try to avoid them the next time."
> "It affected my cell phone use."
> "It made me less aggressive."
> "It let me see how I was taking turns too fast and just getting to know my driving better."

Parents also reported feeling that their teens were safer and more confident drivers. One hundred percent of parents reported that after completing the program, they believed their teen to be a safer driver. The entire group reported being glad that they chose to participate and that they would recommend the program to other parents. One Eagan parent wrote,

> "I feel the program really allowed a dialogue with my daughter regarding safe driving. I think it is very important to be thinking of good and safe driving habits right away. There are far too many accidents for new drivers and I think this program was very beneficial to concretely see where improvement is needed and ultimately could save their lives and others."

DISCUSSION

The video intervention was successful in reducing the number of coachable events triggered by novice teen drivers by 61%. Overall, the number of events was reduced from an average of 21 times per 1000 miles during Baseline 1 to an average of eight times per 1000 miles averaged across the intervention segments. A similar effect was demonstrated in a cohort study of rural teen drivers (McGehee et al., 2007a, 2007b).

The intervention was most successful in reducing the frequency of improper turns. Teens went from triggering the system an average of 12 times per 1000 miles in the initial baseline to less than two in the second baseline, a 78% reduction. The importance of these results is highlighted by previous data indicating that 22% of all fatal crashes occur at intersections and junctions (NHTSA, FARS 2007). High-speed turning/corning has also been linked to rollover crashes—one of the most injurious and fatal types of crash.[18]

There was also a reduction in the frequency of abrupt braking events, 43% overall. However, it took several weeks longer to achieve this benefit. The aim of the system was to get teens to slow down, look further ahead, and put more distance between their vehicle and the vehicle in front of them—in other words, to become more aware of hazards. They were also reminded that distractions (i.e., passengers and cell phones) undermine their driving and their ability to respond to a hazardous situation.

Results also showed that the frequency of coachable events remained significantly lower than the initial baseline, even after the intervention phase was complete, suggesting that the effect of the intervention may be a lasting one. However, abrupt accelerations did increase once the intervention had been removed.

Technology like that evaluated in this study can influence teen drivers in a number of ways. One is that it extends parental monitoring and inhibits teens' tendency to engage in intentionally risky behavior. Another is that it extends parental mentoring and helps teens learn to recognize roadway hazards. The data suggest that the intervention in this study had both effects, but that its predominant effect was due to mentoring.

Consistent with a mentoring effect, certain benefits of the feedback emerged over time and persisted beyond the intervention. If participants in this study had simply reduced their events because they did not want their parents to see their behavior, we would have seen a significant rebound in the number of events once the intervention was stopped. A lack of a significant rebound suggests that the intervention was successful in training young drivers to be better able to assess and react to hazardous situations.

The data also show a pattern consistent with a monitoring effect: other benefits were immediate, particularly for events associated with intentionally unsafe behavior (e.g., abrupt acceleration). For those behaviors the benefit diminished after the feedback was removed.

Interestingly, it was the high-risk drivers that engaged more often in improper turns and abrupt accelerations, those events that we saw rebound after the intervention was complete, suggesting that it was simply the parental monitoring reducing their frequency. Low-risk drivers had the majority of their events coded as abrupt braking. These events did not rebound after the feedback was removed, suggesting that for this group the intervention may have trained them to be more hazard-aware.

Whether drivers see the system as one that enables mentoring or monitoring could have substantial implications for acceptance and long-term safety benefit. Monitoring systems are less likely to be well accepted by teens and the effect may be limited to the period during which the device is in the car. However, even this could have a substantial impact on the number of teen motor vehicle deaths. Understanding the factors that lead teens and other drivers to perceive feedback-based systems as monitoring or mentoring remains an important research issue (Lee, 2007)

Limitations

The one-group pretest-posttest quasi-experimental design has several important limitations. The most obvious is that there was no control group for comparison. As a consequence, it is difficult to conclude that history, maturation, and regression could not have accounted for the observed effects, thus affecting the internal validity (Cook et al.

1990). Another limit concerns the recruitment of newly licensed teen drivers to be in a video-feedback intervention study in which their parents will be informed of their safety-relevant behaviors. The willing population is small and the sample may have suffered from a self-selection bias. The self-selected bias reflects two motivations. Some participants may have been motivated by an interest in improving their driving, others by a desire to be compensated financially. Questionnaire data supports the notion that both motivations were at work in this sample, with 69% responding that they wanted to be a better driver and 44% saying they were motivated by the money. Interestingly, four of the six drivers in the high-risk group reported participating for the money and 1 of the six to be a better driver, while all six drivers in the low-risk group claimed interest in becoming a better driver and only 1 reported participating for the money.

Another limit of this study concerns the imperfect estimates of exposure. Event frequency was linked to mileage. This proved to be a challenge in that teen participants would frequently neglect to report their weekly odometer reading. Therefore, for some of the subjects, mileage had to be estimated by extrapolating from the readings that were available. In addition, the nature of the system only afforded a glimpse into the vehicle when it was triggered. There may therefore have been times when a driver other than the participant drove the vehicle. We have assumed that the participant drove the miles they reported, which may not necessarily be true in all cases. The influences of specific behaviors, such as cell phone use or passenger distractions, are difficult to quantify because the data capture only events, not exposure to the behaviors when no events are triggered. In addition, information regarding the number or trips per day, length of trips, or specific route information is also not available.

One of the biggest limitations is that we were unable to control the amount or type of interaction the teen had with their parent during the intervention period. It seems, especially for the riskiest drivers, that direct involvement is necessary for the success of the intervention. Without a parent to monitor and mentor, we may not have seen a significant reduction in any of the safety-relevant events.

Conclusions

Motor vehicle crashes are the most common cause of injury and mortality in teens, and the first six to 12 months of independent driving is the most crash-prone period.[13] This study showed that immediate and cumulative video feedback shared with parents during this period can have a dramatic influence on the rate of safety-relevant driving events. To the extent that such events are a proxy for crash risk, this study suggests that feedback might enhance teen driving safety.

Whether this benefit will generalize to a broader population of teens and what mechanisms underlie the benefits is still unknown. Data from this study suggests that a device that enables parental monitoring can reduce exposure to risky behavior during the critical first months of driving. This could have substantial safety benefits because of the high crash rate during this period. Data also suggest that a device the enables parental mentoring can make teens more hazard-aware, which could help forge good driving habits for the long term. By informing both teen drivers and their parents when driving errors are made, it allows for review and discussion and for many ‘teachable moments.’ Even if a driver has no events in a given week, the simple acknowledgement of a good report card keeps driving issues part of the family discussion. Such communication is critical in helping parents to regulate the most dangerous activity they allow their children to do.

Acknowledgements

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