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

Using Naturalistic Driving Data to Examine Teen Driver Behaviors Present in Motor Vehicle Crashes, 2007-2015

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Title

Using Naturalistic Driving Data to Examine Teen Driver Behaviors Present in Motor Vehicle Crashes, 2007-2015. *(June 2016)*

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About the Sponsor

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Executive Summary

As the driving environment continues to evolve we want to identify those crashes that teens are most frequently involved in as well as the distractions or competing activities that are most often being engaged in leading up to these crashes. However, determining what activities teens are engaging in before a crash occurs is not an easy task. Previous research has largely relied on survey and crash data to attempt to obtain this type of information.

In this study, we conducted a large-scale comprehensive examination of naturalistic crash data from over 2200 moderate to severe collisions that involved teenage drivers between 2007 and 2015. The data allowed us to examine behaviors and potential contributing factors in the seconds leading up to the collision, and provided information not available in police reports. It also allowed us to look for trends associated with crashes of young drivers from 2007-2015, paying particular attention to the behaviors being engaged in leading up to those crashes. Specifically, we explored the following research questions:

- Has there been a change in the prevalence of a particular crash type between 2007 and 2015?
- Has there been a change in the proportion of crashes with distraction present?
- Has there been any change in the type of potentially distracting behaviors being engaged in?
- Have eyes off forward roadway (EOFR) times changed relative to specific distractions or crash types?

Methods

Crashes examined in this study involved drivers ages 16-19 who were participating in a teen driving program that involved the use of a Lytx DriveCam system. This system records video, audio, and accelerometer data when a crash or other high g-force event (e.g., hard braking, acceleration or impact) is detected. Each video is 12 seconds long, and provides data from the 8 seconds before to 4 seconds after the event. Lytx made 8228 videos of crashes that occurred between August 2007 and April 2015 available for review. In order to reduce this number and to eliminate minor curb strikes from the analysis, those crashes in which the vehicle sustained forces less than 1g were excluded. Crashes in which the DriveCam equipped vehicle was struck from behind were also excluded. Additional videos were excluded for other reasons (e.g., animal strikes, video problems, or the driver not being a teen). A total of 2229 moderate-to-severe crashes met the inclusion criteria and were analyzed for the current study.

Video from the 6 seconds preceding each crash were coded for analysis as it was determined to have the most potential to be contributory and allowed for comparison with previous naturalistic studies (e.g., Neale et al., 2005). A coding methodology which focused on identifying the factors present in crashes was developed specifically for gathering information from the videos. Four broad categories of coded variables included: (1) general background and environmental variables; (2) variables specific to the crash; (3) variables specific to the driver; and (4) variables specific to passengers. Each crash was double coded by two University of Iowa (UI) analysts and mediated by a third when necessary.

A trend analysis was completed for the crash data from 2007 to 2015. Years 2007 and 2015 were incomplete, containing data from only a portion of the year; therefore, the trend analysis estimated the average change over a 12-month period (as opposed to a calendar year). To examine changes over time, we used linear regression models for each outcome of interest and included month and year of the crash as the continuous predictor to estimate the average change in prevalence over a 12-month period. Due to the small sample size when examining cell phone use by crash type, logistic regression was used to model each outcome of interest (cell phone use type) by year (rather than month and year) stratified by the crash type. For continuous variables (e.g., eyes off road time), linear regression was used.

Results

Overall, male drivers were present in 51.3% of the crashes and female drivers in 48.5%. The driver was seen wearing a seatbelt in 93.5% of all crashes. Passengers were present in the vehicle in one-third of crashes (34.3%), with one passenger present in 24.5% and two or more passengers present in 9.8%. Results did show a significant decline in the percentage of crashes in which passengers were present (annual average % change: -1.63 percentage points per year; 95% Confidence Interval [CI]: -2.54 – -0.72 percentage points per year). Overall, of crashes with passengers, 25.0% had at least one passenger that was unbelted. However, there was a significant trend toward increasing belt use for passengers (annual % change: 1.64; CI: 0.25 – 3.04). The majority of the passengers, when present, were estimated to be 16-19 years old (84.8%) and were male in 54.4% of crashes and female in 44.9%.

In general, crashes occurred most often on collectors (52.8%). Road surface conditions were more likely to be either dry (45.5%) or covered with snow/ice (40.3%). Overall, crashes were more frequent during the week (71.5%) than on the weekend. They also occurred more frequently between the hours of 6am to 9am (18.8%) and 3pm to 6pm (26.0%), when drivers are commuting to/from school and work and more traffic is present on the roadways. The proportion of crashes occurring on arterial roads decreased significantly in 2014 and 2015 ($p=0.0003$) and the proportion of crashes on dry roads increased significantly ($p<.0001$).

Trend associated with prevalence of crash types

Results showed that from 2007 to 2015 the proportion of angle crashes remained relatively consistent (annual % change: -0.28; CI: -0.99 – 0.44). However, there was a significant increase in the proportion that were rear-end crashes (annual % change: 3.23; CI: 2.40 – 4.05), thus accounting for a significant overall increase in vehicle-to-vehicle crashes. Significant reductions in both road departure (annual % change: -1.18; CI: -1.72 – -0.65) and loss of control (LOC) crashes (annual % change: -2.11; CI: -3.06 – -1.15) contributed to a corresponding significant decrease in single-vehicle crashes overall.

Trend associated with prevalence of distracting behaviors

Results did not show a significant change over time in the proportion of crashes containing drivers engaged in potentially distracting behavior. Between 2007 and 2015 an average of 58.5% of crashes contained some type of potentially distracting behavior during the six

seconds leading up to a crash. While the proportion of crashes containing a particular distraction did vary over time, the distractions that were the most common in the previous study remained the most common: attending to passengers (14.6%), cell phone use (11.9%), and attending inside the vehicle (10.7%). There were no significant increases or decreases in the proportion of crashes in which drivers were seen engaging in these behaviors.
As stated, there was not a significant change in the percentage of crashes with drivers using their cell phone. However, when we looked at how drivers were using the phone, we found a significant decrease in the proportion (among all crashes) with drivers talking/listening (annual % change: -0.39; CI: -0.68 – -0.09). And, although it appears as though the proportion of crashes that involved a driver operating/looking at the phone increased over time, there was too much variability in the data to show a significant increase as a proportion of all crashes. However, among cell phone related crashes only, the proportion that involved a driver operating or looking at the cell phone, as opposed to talking/listening, increased significantly over the years examined (annual % change: 4.22; CI: 1.15 – 7.29).

When cell phone use was examined by crash type over time, there was a decline in the proportion of both road departure and angle crashes in which the driver was seen talking/listening; however, neither was significant (β=-0.3968, p=0.0813; β=-0.3533, p=0.0546). There was, however, a significant increase in the proportion of rear-end crashes with drivers operating/looking at a cell phone (β=0.1715, p=0.0262).

<u>Trend associated with eyes off forward road (EOFR) time, glance duration and reaction time</u>

Among rear-end crashes, the average eyes off road time for the 6 seconds immediately preceding the crash significantly increased over time from 2.0s to 3.1s (β=0.1527, p=0.0004), as did the duration of the longest glance, from 1.5s to 2.1s (β=0.1020, p=0.0014). Reaction time was analyzed for rear-end crashes only, and then only when the lead vehicle was moving and the brake lights were visible. Therefore, among rear-end crashes, a reaction time (including no reaction) was coded for 58.7% of crashes. Between 2008 and 2014, reaction times increased from 2.0s to 2.7s (p=0.25). Additionally, the percent of rear-end crashes in which the driver had no reaction prior to the crash increased from 12.5% in 2008 to 25.0% in 2014 (p=0.07).

Summary

As the driving environment continues to evolve we want to identify those crashes that teens are most frequently involved in as well as the distractions or competing activities that are most often being engaged in leading up to these crashes. Using naturalistic driving data allows researchers a unique view into the vehicle and provides invaluable information regarding the behavioral and environmental factors present before a crash. The data gathered offers a much more detailed context relative to police reports and other crash databases, and allows more micro-level analyses to be conducted.

This study examined crash data from 2007 to 2015 to determine whether there were any changes in the prevalence of particular crash types. It also explored changes in the proportion of crashes with distraction present. Additionally, trends associated with the

prevalence of particular distracting activities were investigated. Finally, information was provided regarding changes in eyes-off-road time, glance durations and reaction times relative to specific distractions and crash types.

Of particular interest was the increase in rear-end crashes for the teens in this study. Importantly, rear-end crashes were associated with an increase in operating/looking at the cell phone as well as an increase in the time spent engaging in this activity. While causality cannot be inferred in this study, the trend suggests that more research be conducted in the area of cell phone use, with specific regard to how and when teens are choosing to engage in this behavior, whether it is truly causing an increase in rear-end crashes and whether existing technologies can be effective in mitigating these crashes.

Introduction

In the context of driving, a distraction has been defined as the diversion of attention from activities critical for safe driving towards a competing activity (Regan et al., 2011). Distractions vary widely, from eating to looking at a billboard on the side of the road to thinking about a conversation with a friend. They can take a driver's hands, eyes or mind off the road. For teens, distracted driving has been identified as a particularly large problem. The latest government statistics indicate that, in 2014, 10% of teen drivers involved in a fatal crash were reported to have been distracted at the time of the crash (NHTSA, 2016). Proportionally, this is more than any other age group. Additionally, experts believe that the government statistics substantially underestimate the prevalence of driver distraction. Data suggests that the true proportion of crashes that can be attributed to distraction and inattention is likely much higher (Stutts et al., 2001; Braitman et al., 2008; Curry et al., 2011; Beanland et al., 2013; Carney et al., 2015).

Inexperience (McKnight & McKnight, 2003; Greenberg et al., 2003; Patten et al., 2006), overconfidence (Finn & Brag, 1986; Brown & Groeger, 1988), social pressure (Farrow, 1987; Simons-Morton et al., 2005; Allen & Brown, 2008), a tendency to underestimate risk (Evans & Wasielewski, 1983; Horrey et al., 2008; Albert & Steinberg, 2011), and to engage more often in risky behaviors (McEvoy et al., 2006; Sayer et al., 2005) are just some of the factors confronting the teen driver. Any or all may increase the chance of young drivers engaging in distracted driving, and if they do, make it more likely that their distraction will have an unfavorable outcome (Simons-Morton et al., 2014; Klauer et al., 2014).

A 2012 national survey of over 6000 drivers assessed the extent to which drivers engage in certain potentially-distracting activities. Drivers reported they at least sometimes engaged in the following behaviors while driving: talking with passengers (80%), adjusting the radio (68%), eating or drinking (47%), talking on a cell phone (40%), reading a text or e-mail (14%) and sending a text or email (10%) (Shroeder et al., 2013). Some of these distractions have been identified as particularly dangerous for young drivers. These include factors that have been the focus of recent research: peer passengers and technology—particularly cell phones.

Cell Phones

For teens, in particular, the cell phone has become the primary mode of communication. In 2008, according to Pew Research Center, approximately 83% of teens ages 15-17 had a basic cell phone (Lenhart, 2009). By 2015 this had increased to 92% of teens ages 15-17 owning a cell phone, with 76% of those owning a smartphone (Lenhart et al., 2015a).

With the evolution of cell phones to smart phones, users have gone from simply using this technology for talking, to using it for texting and now for engaging in social media. Among teen smart phone owners, 91% of teens use their phones to go online for navigating, surfing, and especially engaging in social media. Ninety-four percent of these teens go on-line daily or more often, with 24% reporting they are on-line "almost constantly" (Lenhart et al., 2015b).

A recent survey of drivers commissioned by AT&T and conducted by Braun Research found that 70% of drivers who own a smartphone engage in some type of cell phone use while driving (AT&T, 2015). Most report texting and e-mailing, however, 40% access social media, 30% surf the internet and 10% even report snapchatting, taking pictures or shooting video while driving. While this data is not specific to teens, one might speculate that these numbers would be highest for drivers in that age group, as they report being online more frequently (Lenhart et al., 2015b).

In a 2015 survey of drivers sponsored by the AAA Foundation for Traffic Safety (AAAFTS, 2016), nearly 70% of drivers ages 16-18 reported they had talked on a cell phone, 42% had read a text or e-mail and 32% had typed/texted while driving in the past 30 days. The most recent data from the 2014 National Occupant Protection Use Survey (NOPUS) indicate that the percent of young drivers estimated to be between the ages of 16 and 24 seen visibly manipulating their phones while driving has increased significantly, from 1.0% in 2007 to 4.8% in 2014 (NHTSA, 2015). At the same time, there has been a significant reduction in the percent of drivers in that same age group engaging in hand-held cell phone use (i.e., holding the phone to their ear), 8.8% in 2007 to 5.8% in 2014 (NHTSA, 2015).

A previous AAA Foundation study of nearly 1700 teen driver crashes examined the behaviors drivers were engaged in leading up to a crash (Carney et al., 2015). In 12% of crashes, teens were participating in some type of cell phone use: 8.6% of those crashes showed a driver manipulating a cell phone while 3.4% were seen talking on or listening to their cell phones (i.e., holding the phone to their ear).

Passengers

The National Motor Vehicle Crash Causation Survey (NMVCCS) dataset shows almost half (48%) of all young driver crashes with a passenger present involved passenger distraction (Thor & Gabler, 2010). According to an online survey of 1000 15-17 year-olds, 47% of teenagers admitted that they were distracted just by having other people in the vehicle with them (The Allstate Foundation, 2005); 44% of teens said that they were safer drivers when they drove *without* their friends. A 2008 survey of over 1700 California high school seniors found that nearly 45% reported passenger(s) talking, yelling, arguing or being loud, and 22% said that passengers distracted them by "being stupid" or "fooling around" (Heck & Carlos, 2008). Distractions due to passengers playing music or dancing were reported by 15.5%, while 7.5% reported deliberate distractions like tickling the driver or trying to manipulate the vehicle controls.

A recent AAA Foundation study of teen driver crashes found that the most frequent behavior that teens were seen engaging in during the six seconds leading up to a crash was attending to a passenger (i.e., looking at them or engaging in conversation). In fact, this behavior was present leading up to approximately 41% of crashes in which passengers were present and nearly 15% of all teen driver crashes (Carney et al., 2015).

Project Objectives

Determining what activities teens are engaging in before a crash occurs is not an easy task. Previous research has largely relied on survey and crash data to attempt to obtain this type of information. Surveys can provide data on drivers' attitudes toward and frequency of engaging in certain distracting activities as well as ask a driver to recall their engagement prior to a crash. There are issues, however, associated with the reliability and validity of these data. Crash data can be found in the large databases such as NHTSA's FARS and the National Automotive Sampling System (NASS) General Estimates System (GES). These databases rely on police reported crash data, in which distraction is notably underreported for a variety of reasons, including (1) reliance on a driver to self-report engaging in distracting behavior, (2) information being unavailable for fatal crashes, and (3) variability across police jurisdictions associated with reporting.

In Phase 1 of this study (Carney et al., 2015), we conducted a large-scale comprehensive examination of naturalistic crash data from nearly 1700 moderate to severe collisions that involved teenage drivers. The data allowed us to examine behaviors and potential contributing factors in the seconds leading up to the collision, and provided information not available in police reports.

During Phase 2 of this study we examined over 500 additional crashes, combined the data with that from Phase 1, and looked for trends associated with crashes of young drivers from 2007-2015, paying particular attention to the behaviors being engaged in leading up to those crashes. Specifically, we explored the following research questions:

- Has there been a change in the prevalence of a particular crash type between 2007 and 2015?
- Has there been a change in the proportion of crashes with distraction present?
- Has there been any change in the type of potentially distracting behaviors being engaged in?
- Have eyes off forward roadway (EOFR) times changed relative to specific distractions or crash types?

Methods

In order to examine teen driver crashes, we used video data that was provided to us by Lytx, Inc.'s DriveCam system. The system is mounted on the inner windshield of a vehicle, and captures events, triggered by set g-force thresholds due to sharp cornering or hard braking, for example. Twelve seconds of video, audio and accelerometer data are captured, 8 seconds before the trigger and 4 seconds after. The system affords a view of the inside cab and driver of the vehicle, as well as the view out the front of the vehicle (see Figure 1). The videos are reviewed and the driver receives weekly feedback on any that require coaching. The data of interest in this particular study were the teen crashes captured by the system. All crashes were released by the parents of the teen drivers involved. Additionally, this secondary data analysis was approved by the University of Iowa Institutional Review Board.

Figure 1. View of DriveCam video

Crash-involved Drivers

Crashes involved young drivers between the ages of 16 and 19 years who were enrolled in a teen driving program that involved the use of the DriveCam system. The program provides both the teen and their family with weekly web-based feedback regarding the young driver's performance and promotes safe driving behaviors. The majority of the participants lived in Arizona, Colorado, Illinois, Iowa, Minnesota, Missouri, Nevada, and Wisconsin.

Crash Selection

Over 8200 crashes were obtained during Phase 1 and Phase 2 of this project. Because crash coding is such an arduous process, it was necessary to perform a preliminary review of each crash to determine its relevance to the project goals before full coding commenced. Crash videos identified and removed from the database included:

- Minor crashes
- DriveCam installed vehicle was hit from behind
- Problem with video (e.g., interior/forward view unavailable or video wouldn't open)

- Someone other than the teen was driving
- Animal strikes
- Empty vehicles
- Other crashes

Figure 2 shows the review process and illustrates how we determined the videos to be used in the final analyses. In total, more than half of crashes were removed due to being identified as minor (e.g., the maximum lateral and longitudinal g-forces were less than 1.0g). The initial goal of this project was to focus on police-reportable crashes, in particular moderate to severe crashes. Furthermore, numerous videos were triggered when the vehicle containing the DriveCam was hit from behind. These videos were removed because information pertaining to what had caused the crash was generally unavailable. Events in which the driver lost control but never left the roadway were identified by Lytx as a crash but were excluded from our analyses. Additional crashes identified as "Other" were ones in which the reviewers were not able to discern the events surrounding the crash sufficiently for coding purposes.

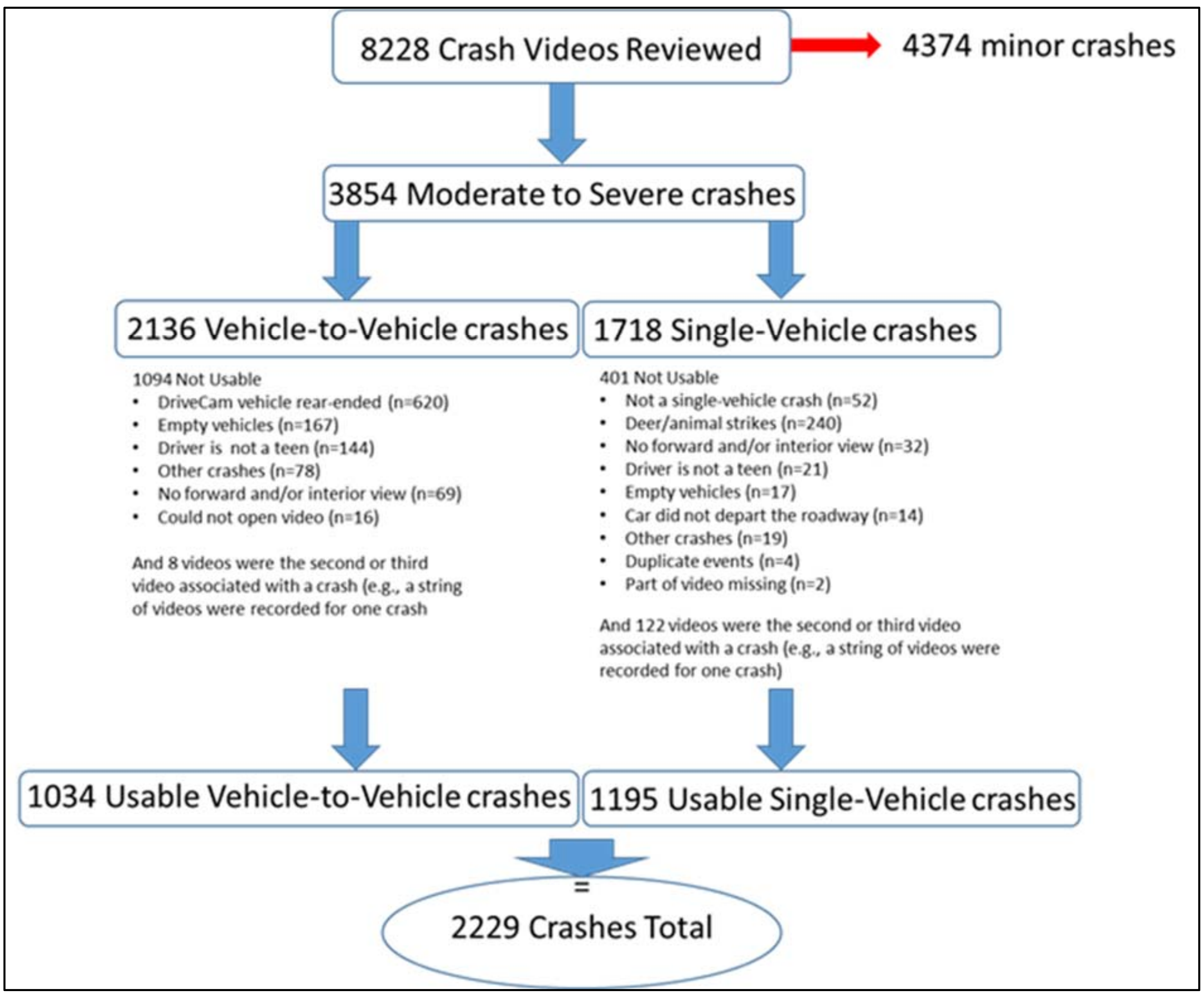

Figure 2. Breakdown of crash videos

Once the unusable crashes were removed, 2229 crashes remained for coding and further analysis; 1034 vehicle-to-vehicle (V2V) crashes and 1195 single-vehicle (SV) crashes. Table 1 (Appendix) shows a breakdown of these crashes by year and project phase as well as crash type.

Crash Coding

Vehicle-to-vehicle crashes were coded first. The majority fell into two categories of crashes: rear-end and angle. A rear-end crash occurs when the driver collides with the rear of another vehicle, while the two vehicles are traveling in the same direction. An angle crash occurs when two motor vehicles impact at an angle, such as when the front of one motor vehicle collides with the side of another. For angle crashes, no determination was made regarding which vehicle was the striking vehicle and which was being struck. However, as noted earlier, for rear-end crashes, this study only included those crashes where the subject vehicle was the striking vehicle.

Single-vehicle crashes were the second category of crashes to be coded. These crashes included loss-of-control (LOC) and road-departure crashes. LOC crashes occur most often when a driver either overcorrects/oversteers or understeers, and as a result, the vehicle departs the roadway. These types of crashes occur most often on curves or poor road surface conditions. A road-departure crash does not involve a driver action before the vehicle departs the roadway, such as when the vehicle drifts out of the travel lane and off of the roadway surface on a straight section of road or when the vehicle continues straight and makes no attempt to negotiate a curve on a curved section of road. These types of crashes occur most often when a driver is inattentive or distracted.

Each crash video was coded by two independent reviewers. The time period of interest was the 6 seconds leading up to the crash, as it was determined to have the most potential to be contributory and allowed for comparison with previous studies (e.g., 100-car study; Neale et al., 2005). A detailed coding scheme was developed specifically for analyzing crash video as part of Phase 1 (see Carney et al., 2015). Four broad categories of coded variables included: (1) general background and environmental variables; (2) variables specific to the crash; (3) variables specific to the driver; and (4) variables specific to passengers. These are described below and defined in Appendix B.

General background and environmental variables, including:

- Month, day, and year
- Time
- Weather
- Light conditions
- Road surface conditions
- Road type

Variables specific to the crash, including:

- Forward and lateral *g*-force at time of impact
- Vehicle speed immediately before impact
- Manner of collision

- Critical precipitating event
- Contributing circumstances, Driver
- Contributing circumstances, Environment
- Contributing circumstances, Roadway
- Airbag deployment

Variables specific to the driver, including:

- Gender
- Potentially Distracting Behavior (e.g., cell phone use, talking with passengers, eating)
- Condition (e.g., emotional, asleep, under the influence)
- Vision obscured by (e.g., glare, weather or an improperly cleared windshield)
- Number of glances off roadway
- Total number of frames the eyes were off roadway
- Total time eyes were off roadway
- Duration of longest glance
- Reaction time (for rear-end crashes only)
- Inadequate surveillance
    - *Coded when traffic signals/signs were missed*
    - *Coded when braking reaction times were poor (>1s)*
    - *Coded when the Total eyes off forward roadway time was >2s*
- Seatbelt non-use

Multiple potentially distracting behaviors could be present in the vehicle leading up to the crash. Each one was coded. Some crashes included as many as four behaviors. Analysts made no judgments as to whether the driver was actually distracted by the behavior—they simply coded the secondary tasks the driver was engaged in leading up to the crash. Table 2 (Appendix A) shows the potentially distracting behaviors coded.

Variables specific to the passenger(s) present in the vehicle were also coded. These included:

- Age (estimated)
- Gender
- Behavior (e.g., conversation with driver, singing, etc.)
- Seatbelt non-use

Once all coding was complete, the data files were merged and any discrepancies were identified. If the discrepancy was due to an error, corrections were made in the data file. However, if the discrepancy was due to a disagreement, the event was turned over to a third reviewer for mediation. Glance durations and reaction times differing by even as little as 1 frame (0.25 s) were mediated in an attempt to achieve the highest possible level of accuracy.

Data Analysis

A trend analysis was completed for the crash data from 2007 to 2015. Years 2007 and 2015 were incomplete, containing data from only a portion of the year; therefore, the trend analysis estimated the average change over a 12-month period (as opposed to a calendar year). To examine changes over time, we used unadjusted linear or logistic regression models for each outcome of interest (e.g., rear-end crash, cell phone use) and included month and year of the crash as the continuous predictor (e.g. 1=July 2007, 2=August 2007 through 94=April 2015) to estimate the average change in prevalence over a 12-month period (the average 12-month change rate). Due to small numbers, all regression models are unadjusted. If the percent change over 12 months is positive it indicates an increasing prevalence, and if it is negative it indicates a decreasing prevalence. If the 95% confidence interval (95% CI) around the percent change includes zero, the increase/decrease in prevalence is not statistically significant at the 95% confidence level. To investigate whether including partial years (2007 and 2015) affected the prevalence change estimates, a sensitivity analysis was completed with each model being run with and without the partial years. There was not a greater than 10% change in the prevalence change estimate when including the partial years, therefore we concluded they were not significantly affecting the estimates, and the partial years were included in all trend analyses. This analysis methodology was used for Tables 3, 5 and 6. Differences in roadway and environmental characteristics over the crash years (Table 4) were examined using the Pearson chi-square test. Due to the small sample size when examining cell phone use by crash type (Table 7), logistic regression was used to model each outcome of interest (e.g., talking/listening on a cell phone vs. operating/looking at a cell phone) by year (rather than month and year) stratified by the crash type. If the beta (β) was statistically significant ($p<0.05$) then the time trend was considered significant. A positive β can be interpreted as the outcome of interest increased over time while a negative β can be interpreted as a decrease over time. For continuous variables (e.g., eyes off road time), linear regression was used and the β was interpreted as stated previously.

Results

The 2229 crashes analyzed involved young drivers between the ages of 16 and 19 years. A summary of the driver and passenger characteristics is presented in Table 3 (Appendix A). Overall, male drivers were present in 51.3% of the crashes and female drivers in 48.5%. The driver was seen wearing a seatbelt in 93.5% of all crashes. Passengers were present in the vehicle in one-third of crashes (34.3%), with one passenger present in 24.5% and two or more passengers present in 9.8%. Results did show a significant decline in the percentage of crashes in which passengers were present between 2007 and 2015 (annual average % change: -1.63 percentage points per year; 95% Confidence Interval [CI]: -2.54 – -0.72 percentage points per year). Overall, of crashes with passengers, 25.0% had at least one passenger that was unbelted. However, there was a significant trend toward increasing belt use for passengers across time (annual % change: 1.64; CI: 0.25 – 3.04). The majority of the passengers, when present, were estimated to be 16-19 years old (84.8%) and were male in 54.4% of crashes and female in 44.9%.

The environmental and roadway conditions present at the time of the crash are shown in Table 4 (Appendix A). In general, crashes occurred most often on collectors (52.8%). Road surface conditions were more likely to be either dry (45.5%) or covered with snow/ice (40.3%). Overall, crashes were more frequent during the week (71.5%) than on the weekend. They also occurred more frequently between the hours of 6am to 9am (18.8%) and 3pm to 6pm (26.0%), when drivers are commuting to/from school and work and more traffic is present on the roadways. The proportion of crashes occurring across the different road types changed significantly over the years ($p=0.0003$) as did surface conditions ($p<.0001$).

Crash type

Results showed that from 2007 to 2015 the proportion of angle crashes remained relatively consistent (annual % change: -0.28; CI: -0.99 – 0.44). However, there was a significant increase in the proportion of all crashes that were rear-end crashes (annual % change: 3.23; CI: 2.40 – 4.05), thus accounting for the significant overall increase in vehicle-to-vehicle crashes. There was a significant reduction in both road departure (annual % change: -1.18; CI: -1.72 – -0.65) and LOC crashes (annual % change: -2.11; CI: -3.06 – -1.15) and therefore a significant decrease in single-vehicle crashes overall (Table 5 – Appendix A). Figure 3 is a visual representation of these trends over time.

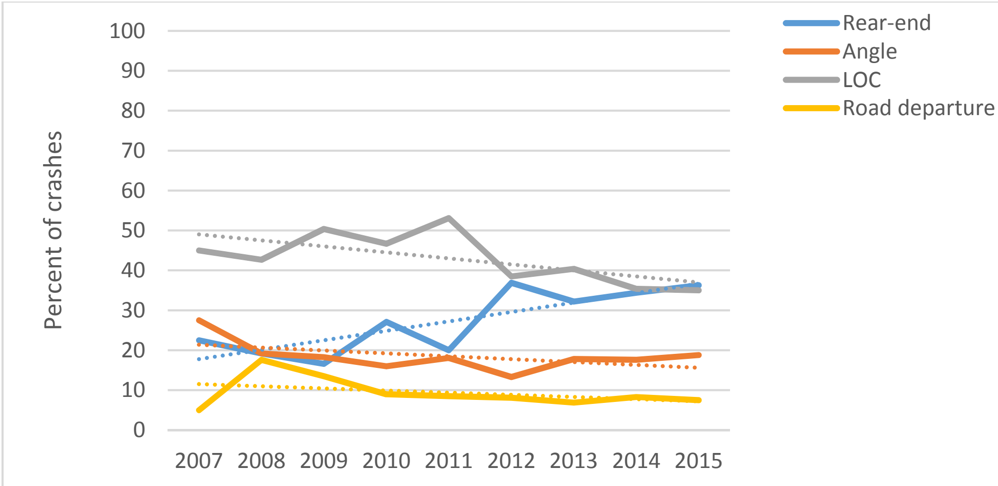

Figure 3. Trends associated with crash types

Potentially distracting behaviors

Results do not show a significant change over time in the proportion of crashes in which drivers were engaged in potentially distracting behavior (Table 6 – Appendix A). Between 2007 and 2015 an average of 58.5% of crashes contained some type of potentially distracting behavior during the six seconds leading up to a crash.

While the proportion of crashes involving a particular distraction did fluctuate over time, the distractions that were the most common remained the same throughout the study period: attending to passengers (14.6%), cell phone use (11.9%), and attending inside the vehicle (10.7%). There were no significant increases or decreases in the proportion of crashes in which drivers were seen engaging in these behaviors (Figure 4).

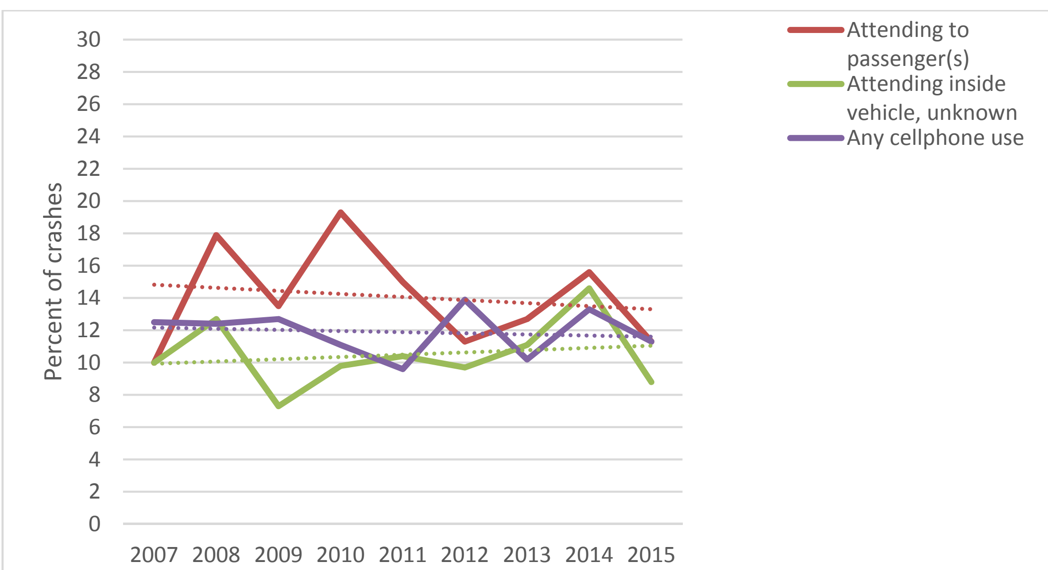

Figure 4. Trends associated with the most frequent driver behaviors

Cell phone use

As stated previously, there was not a significant change in the percentage of crashes with drivers using their cell phone (Figure 5). However, when we looked at how drivers were using the phone, we found a significant decrease in the proportion (among all crashes) with drivers talking/listening (annual % change: -0.39; CI: -0.68 – -0.09). And, although it appears as though the proportion of crashes that involved a driver operating/looking at the phone increased over time, there was too much variability in the data to show a significant increase as a proportion of all crashes. However, when crashes involving cell phones were analyzed in isolation, the proportion that involved a driver operating or looking at the cell phone, as opposed to talking/listening, increased significantly over the years examined (annual % change: 4.22; CI: 1.15 – 7.29).

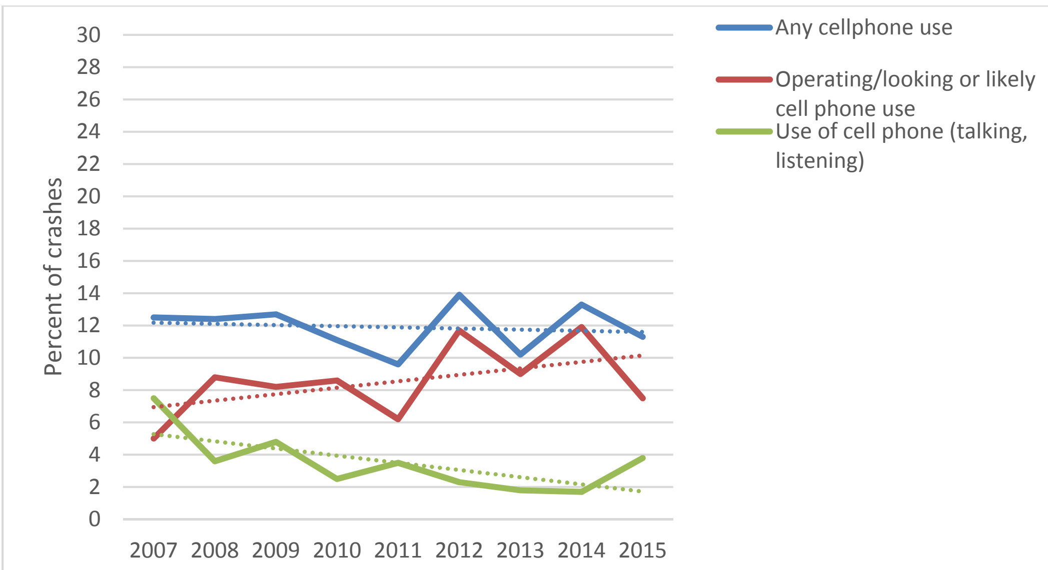

Figure 5. Trends associated with cell phone use

When cell phone use was examined by crash type (Table 7 – Appendix A), drivers were operating/looking at the cell phone in 27.8% of road departure crashes and 18.9% of rear-end crashes, significantly more frequently than in LOC or angle crashes (1.2% and 3.3%, respectively). Over time, there was a decline in the proportion of both road departure and angle crashes in which the driver was seen talking/listening; however, neither was significant (ß=-0.3968, p=0.0813; ß=-0.3533, p=0.0546). There was, however, a significant increase in the proportion of rear-end crashes with drivers operating/looking at a cell phone (ß=0.1715, p=0.0262).

Eyes off forward road time

Eyes off forward road (EOFR) time was calculated only for those crashes in which it could be accurately determined. The average eyes off forward road time for all crashes was 1.5 seconds during the 6 seconds immediately prior to the crash. Table 8 (Appendix A) presents the percent of crashes in which EOFR time was available, in addition to eyes off forward road time and duration of longest glance by year and crash type. Among rear-end crashes, the average eyes off road time significantly increased over time, from 2.0s in 2008 to 3.1s in

2014 (ß=0.1527, p=0.0004, see Figure 6) as did the duration of the longest glance, from 1.5s to 2.1s (ß=0.1020, p=0.0014, see Figure 7).

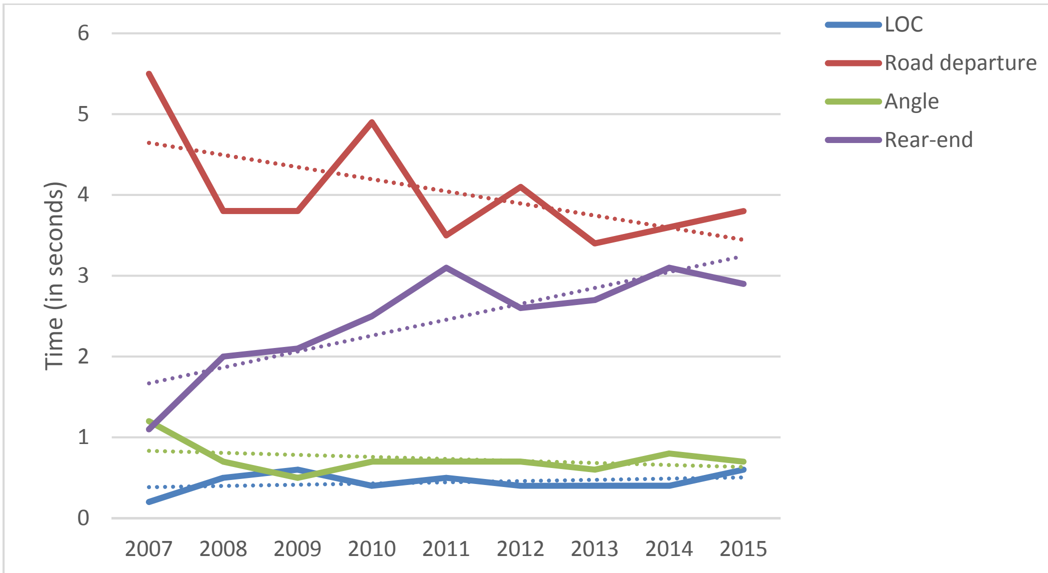

Figure 6. Trends associated with mean eyes off forward road time by crash type

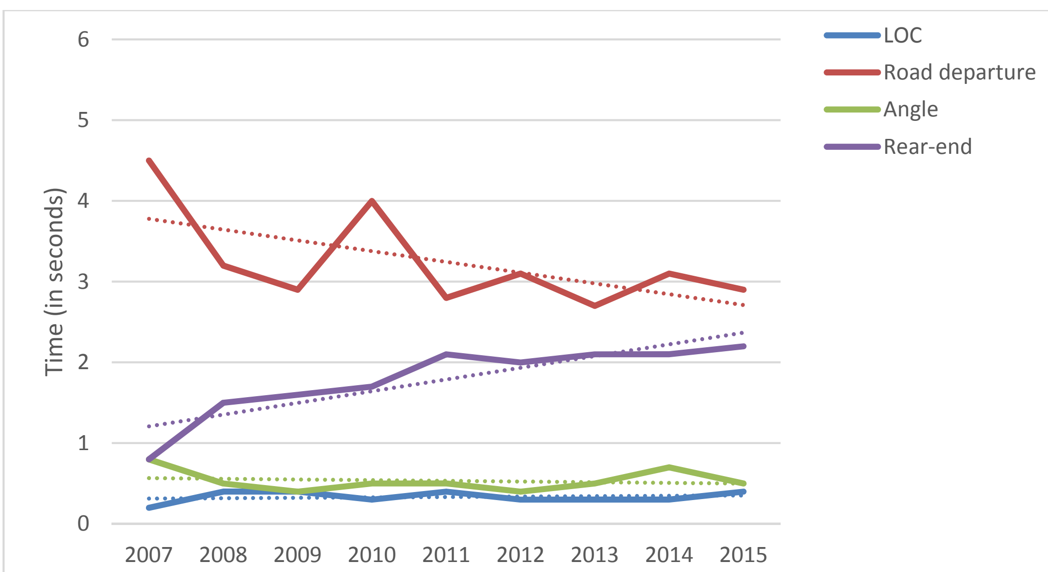

Figure 7. Trends associated with mean duration of longest glance by crash type

Reaction Time

Reaction time was analyzed for rear-end crashes only, and then only when the lead vehicle was moving and the brake lights were visible. Therefore, among rear-end crashes (n=599), a reaction time (including no reaction) was coded for 352 (58.7%) crashes. Between 2007 and 2015, reaction times increased (slowed), although not significantly, among drivers who reacted at all, from 2.0s to 2.7s (Table 9 – Appendix A, $p=0.25$). Additionally, the percent of rear-end crashes in which the driver had no reaction prior to the crash increased from 12.5% in 2008 to 25.0% in 2014 ($p=0.07$).

Discussion

From 2007 to 2015, there was a significant increase in the proportion of teen driver crashes in this study that were rear-end collisions. This generally agrees with available data on police-reported crashes involving teen drivers nationwide. Data from the NHTSA's National Automotive Sampling System/General Estimates System (NASS/GES) indicates that there has been a steady increase in the proportion of crashes of drivers aged 16-19 that are rear-end crashes. Excluding crashes in which the teen driver's vehicle was struck from behind (which were also excluded from the present study), the proportion of all police-reported crashes of drivers ages 16-19 that were rear-end crashes was 24.7% in 2000, 27.2% in 2007, and 32.2% in 2014. Rear-end crashes most often involve a driver who is following too closely and/or responding too slowly due to inattention or distraction. While it is possible that teens have started following more closely, it seems more likely that distraction has led to an increase in eyes off road time, slower reaction times and therefore, an increase in the proportion of crashes that are rear-end crashes.

In general, our results did not show an increase over time in the proportion of crashes in which the driver was distracted prior to a crash. However, a more in depth examination of rear-end crashes showed there was a significant increase in the proportion of crashes in which the driver was operating/looking at a cell phone, from 15.3% in 2008 to 27.9% in 2014. Additionally, for rear-end crashes, there was an increase in mean eyes off road time (from 2.0s to 3.1s), the mean duration of the longest glance (from 1.5s to 2.1s) and an increase in the mean reaction time (from 2.0s to 2.7s). This study is not able to say that the increase in rear-end crashes was caused by any of these factors. However, a recent meta-analysis of over 28 experimental studies examined the effects of cell phone use on driving (Caird et al., 2014). Findings suggest that the cognitive effects of cell phone use would both slow reaction times and increase the amount of time drivers look away from the road, thus leading to an increase in all crashes, particularly rear-end crashes as we have seen in this study.

In contrast, there was a significant reduction in the proportion of teen crashes that were road departure crashes. This reduction coincided with a significant decline in the proportion of road departure crashes in which a driver was seen operating/looking at a cell phone. It is possible that more drivers are choosing to check messages or text at times they perceive to be safer, such as while slowing for, stopped at, or departing from an intersection (Huth et al., 2015). This may also help to explain the rise in rear-end crashes, as many of these types of crashes occur at intersections. The National Occupant Protection Use Survey (NOPUS) provides nationwide probability-based data regarding the electronic device use of drivers. Observational data is collected while drivers are stopped at controlled intersections, such as traffic lights and stop signs. From 2007 to 2014 the percentage of young drivers seen visibly manipulating a hand-held device has more than quadrupled (1.0% vs 4.8%) (NHTSA, 2015). Whether this is an indication of an overall increase in use is not certain; however, it does indicate a significant increase in use at controlled intersections.

It is not clear why we saw a significant decline in the proportion of loss of control crashes. We did not see a significant decrease in the proportion of crashes that occurred on poor road surface conditions. It is possible that the fleet of vehicles teens are driving are evolving and the prevalence of safety features such as electronic stability control have increased over time. However, the data available for this study did not include information regarding whether a given teen's vehicle had electronic stability control, and importantly, the study did not include data from program participants that were not involved in crashes.

As mentioned, we did not find a significant change in the proportion of crashes in which the driver was engaged in potentially distracting behaviors collectively. Drivers were consistently seen engaging in some type of secondary activity in the seconds leading up to the crash in 59% of crashes. Several other studies have found similar results, starting with Treat et al. (1979), which found some form of driver distraction/inattention in 56% of crashes. More recently, Beanland et al (2013) found that 58% of crashes had distraction present. Other naturalistic studies, although not specific to teens, have found that drivers are engaged in some type of secondary task over half the time that they are driving (Klauer et al., 2006; Fitch et al., 2013). Victor et al. (2015) found that 54% of drivers were distracted in the time leading up to a crash. More recently, an analysis of injury and property damage crashes from SHRP2 found drivers were distracted during the 6-seconds leading up to 68% of crashes (Dingus et al., 2016). The fact that distraction is so prevalent has led some to say that distractions may simply be a part of everyday driving (Stutts et al., 2005). In fact, Lee (2014) suggests that perhaps distracted driving should be considered the "baseline." It may be the combination of an unexpected event and an inopportune glance away from the forward roadway that truly determines whether or not a collision will occur.

The most frequent distractions were: attending to passengers (14.6%), cell phone use (11.9%), and attending to something inside the vehicle (10.7%). The proportion of crashes containing these potentially distracting behaviors did not significantly increase or decrease over time; however, these remained the leading potentially distracting behaviors throughout the entire study period. This is consistent with other research in which teens reported their most common distraction as conversation with passengers (Royal, 2003; Tison et al., 2011). It is also consistent with the data from NHTSA's NMVCCS study, which found that passenger distraction represented the most significant distraction for teen drivers, and was present in 20% of young-driver crashes (Thor & Gabler, 2010). A naturalistic study of young drivers conducted by Foss & Goodwin (2014) found use of electronic devices to be the most common distracted driving behavior. Although not specific to teens, the 100-car naturalistic study (Neale et al., 2005) and a recent analysis of crashes from SHRP2 (Dingus et al., 2016) also found using a wireless device and attending to a passenger to be the most frequent distractions engaged in by drivers.

While there was not a significant increase in cell phone use between 2007 and 2015, we did see a significant change in the way the phone was being used. There was a significant decline in the proportion of crashes in which the driver had been talking/listening on the cell phone. While the increase in the proportion of all crashes in which the driver was operating/looking at the phone was not statistically significant, the increase in operating/looking at the phone was statistically significant when examined as a proportion of crashes that involved cell phone use. Similarly, the most recent NOPUS observational survey of drivers on the roadway found that visible manipulation of hand-held devices by drivers ages 16-24 has increased from 1.0% in 2007 to 4.8% in 2014, whereas talking on a hand-held cell phone has decreased from 8.8% in 2007 to 5.8% in 2014 (NHTSA, 2015).

For rear-end crashes, the mean eyes off road time and duration of longest glance both increased significantly between 2008 and 2014. This is at the same time that we saw a significant increase in the proportion of rear-end crashes with drivers operating/looking at their cell phone. This does not seem likely to be a coincidence. As mentioned previously, more and more people are texting while driving, and usually without consequence; thus the glances slowly become longer and longer without the driver realizing that they have looked away for longer than they should. It has also been suggested that people are engaged in 'task preservation' where they become fixated on completing a task such as reading an e-mail or finishing a text and neglect the goal of safely operating the vehicle (Lee et al., 2012). Thus, glances may become more frequent and longer glances may lead to even longer glances.

Strengths and Limitations

Using naturalistic driving data allows researchers to examine many aspects of driving, and provides invaluable data that would not be available otherwise. The vast majority of crash studies have been based on data derived from police reports. While this information is helpful, it has many limitations. One very important limitation of police reports is the lack of information regarding driver distraction, which is limited to what an officer was able to view or what a driver, passenger, or witness reported. Naturalistic data provides researchers an unbiased view inside the vehicle during those important seconds leading up to the crash.

A major advantage of this study is that it provides data from over 2200 moderate-to-severe crashes. This is far larger than any other naturalistic study of teen driver crashes to date. For example, the 100-car Naturalistic Driving Study had 69 crashes, with 75% of those being non-police-reported low-*g* contact or curb strikes (Dingus et al., 2006). The SHRP2 naturalistic driving study is projected to have approximately 900 property damage crashes (Owens et al., 2015); however, only a percentage of those will involve teenage drivers. Having such a large sample makes our findings more generalizable to the young-driver population. Even with the large number of crashes available to us, we were unable to examine time trends by crash type and driver behaviors. When crashes were broken down by crash type *and* driver behavior *and* glances the sample size became too small to provide reliable statistical estimates. This only emphasizes the need to continue to gather data from these crashes for additional future research.

Another major advantage of this particular study, compared to naturalistic studies such as the 100-Car Naturalistic Driving Study or SHRP2, is that the current study had continuous view of the entire vehicle cabin as well as audio. This information provided us with a more comprehensive context of what was occurring during the six seconds before each crash. It was particularly important when examining crashes that involved passengers. Given the high frequency of young drivers attending to passengers highlighted both in our data and in previous research, it is important to be able to investigate the nature of the interaction that occurs between a driver and passengers prior to crashes.

As with all naturalistic driving research there are concerns regarding the representativeness of the drivers involved in the study. Since the drivers in the crashes examined in the present study were simply driving and were not participating in a study at the time of their crashes, they may be slightly more representative of the population of young drivers than those who might voluntarily enroll in driving studies. However, these drivers were participating in a program intended to improve teen driver safety, and most were likely encouraged or required by their parents to participate. Drivers were aware that they were participating in the program and that their driving was being monitored, and one might argue that this would make them less likely to exhibit risky or aggressive driving behaviors, or to engage in potentially distracting behaviors. If this were the case, the frequency of driver behaviors reported may not be generalizable to all young drivers, and we hypothesize that the proportions reported may underestimate certain behaviors among the general driver population of young drivers. Nonetheless, even when participating in a teen driving program that involved video monitoring, potentially distracting driver behaviors were observed in nearly 60 percent of all crashes.

The type of data analyzed here cannot be used to draw inferences regarding crash risk. Specifically, the video data examined in the present study was only available when a crash triggered the recording of video; no video was available for ordinary uneventful non-crash driving, which precludes comparing the prevalence of various driver behaviors and other factors present in crashes versus in ordinary driving, which would be necessary in order to draw any inferences about the actual crash risk associated with any particular factor. Additionally, it is important to note that the crash data provided by Lytx was only made available as de-identified videos. It was not possible to determine whether the same driver was involved in more than one of the crashes examined. Therefore, we did not control for the possible correlation within crashes occurring by the same driver.

Conclusions

This study is one of the first naturalistic studies to examine changes in teen crashes over a number of years. As the driving environment continues to evolve, there is a need to identify the types of crashes in which young drivers are most frequently involved in as well as the distractions or competing activities that are most often being engaged in leading up to these crashes. The increase in rear-end crashes for the teens in this study is of particular interest. Importantly, rear-end crashes were associated with an increase in operating/looking at the cell phone as well as an increase in the time spent engaging in this activity. While causality cannot be inferred in this study, the trend suggests that more research be conducted in the area of cell phone use, with specific regard to how and when teens are choosing to engage in this behavior, whether it is truly causing an increase in the incidence of rear-end crashes, and whether existing technologies can be effective in mitigating these crashes.

As the driving environment evolves, it is important to continue to examine teen driving behavior. Examining naturalistic teen driving data to identify those distractions or competing activities most often engaged in is the first step toward better educating drivers, informing policy makers, and aiding in the design of both in-vehicle technologies and vehicle safety systems.

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Appendix A – Tables

Table 1. Number of crashes by year and project phase

Time Period	Project Phase	V2V Crashes	SV Crashes	Total Crashes
2007 (August thru Dec)	Phase 1	20	20	40
2008	Phase 1	122	185	307
2009	Phase 1	128	227	355
2010	Phase 1	108	136	244
2011	Phase 1	100	160	260
2012	Phase 1	165	144	309
2013 (Jan thru July)	Phase 1	84	92	176
2013 (Aug thru Dec)	Phase 2	91	65	156
2014	Phase 2	170	132	302
2015 (Jan thru April)	Phase 2	46	34	80
		1034	1195	2229

Table 2. Driver behaviors coded for all crashes

Behavior	Definition or Description
Talking to self	Driver is talking out loud without a passenger or audience in the vehicle
Reading	Driver is reading or looking at map/book/papers
Attending to passenger(s)	Driver is looking at, in conversation with, or otherwise interacting with passenger(s)
Attending to a moving object	Driver is looking at an object/animal moving around inside the vehicle
Use of cell phone (talking/listening)	Driver is having a conversation using a cell phone
Use of cell phone (operating/looking)	Driver is looking at/manipulating a cell phone (i.e., texting, surfing)
Use of cell phone is likely but not visible	Driver is likely operating/looking at cell phone but device is out of view of the camera
Adjusting controls	Driver is operating some in-vehicle control
Using electronic device	Driver is looking at and/or manipulating an electronic device other than a cell phone
Handling an object	Driver is picking something up, putting something down, or passing object to another person
Eating or drinking	Driver is putting food or drink to mouth
Smoking related	Driver is lighting, smoking or extinguishing cigarette
Personal grooming	Driver is engaged in some form of personal hygiene, with or without mirror glance (i.e., fixing hair, picking teeth)
Singing or dancing to music	Driver is singing (regardless of volume) or moving any part of their body to the music
Attending to person outside the vehicle	Driver is looking at or communicating with someone outside of the vehicle (i.e., pedestrians)
Attending to another vehicle or passengers of another vehicle	Driver is looking at another vehicle or communicating with its passengers
Attending inside the vehicle, unknown	Driver is looking at something of unknown location inside the vehicle
Attending outside the vehicle, unknown	Driver is looking at something of unknown location outside the vehicle (not at the forward roadway)
Attending elsewhere, unknown	Driver is looking somewhere other than forward roadway, unknown

Table 3. Driver and passenger characteristics, by year of crash, August 2007 – April 2015

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
	N (col %)									
Driver sex										
Male	20 (50.0)	151 (49.2)	182 (51.3)	117 (48.0)	139 (53.5)	178 (57.6)	165 (49.7)	155 (51.3)	37 (46.3)	1144 (51.3)
Female	20 (50.0)	155 (50.5)	171 (48.2)	127 (52.1)	121 (46.5)	131 (42.4)	166 (50.0)	147 (48.7)	43 (53.8)	1081 (48.5)
Unknown	0	1 (0.3)	2 (0.6)	0	0	0	1 (0.3)	0	0	4 (0.2)
Driver belted										
Yes	38 (95.0)	282 (91.9)	320 (90.1)	231 (94.7)	247 (95.0)	297 (96.1)	308 (92.8)	284 (94.0)	78 (97.5)	2085 (93.5)
No	2 (5.0)	25 (8.1)	35 (9.9)	13 (5.3)	13 (5.0)	12 (3.9)	24 (7.2)	18 (6.0)	2 (2.5)	144 (6.5)
Passenger present										
None	21 (52.5)	185 (60.3)	234 (65.9)	150 (61.5)	172 (66.2)	199 (64.4)	236 (71.1)	210 (69.5)	58 (72.5)	1465 (65.7)
One	17 (42.5)	85 (27.7)	84 (23.7)	67 (27.5)	65 (25.0)	74 (24.0)	74 (22.3)	66 (21.9)	13 (16.3)	545 (24.5)
Two or more	2 (5.0)	37 (12.0)	37 (10.4)	27 (11.0)	23 (8.8)	36 (11.6)	22 (6.6)	26 (8.6)	9 (11.3)	219 (9.8)
All passengers belted										
Yes	15 (78.9)	85 (69.7)	85 (70.3)	68 (72.3)	70 (79.6)	83 (75.5)	73 (76.0)	78 (84.8)	15 (68.2)	542 (75.0)
No	4 (21.1)	37 (30.3)	36 (29.8)	26 (27.7)	18 (20.5)	27 (24.6)	23 (24.0)	14 (15.2)	7 (31.8)	181 (25.0)
Passenger age (approximate)										n= 1060 passengers in 764 events
1 to 4	0	2 (1.1)	0	0	0	2 (1.2)	0	0	0	4 (0.4)
5 to 10	3 (13.6)	2 (1.1)	4 (2.4)	5 (3.9)	2 (1.6)	4 (2.4)	1 (0.8)	3 (2.4)	0	24 (2.3)
11 to 15	5 (22.7)	22 (12.2)	8 (4.7)	22 (8.7)	15 (12.3)	8 (4.9)	18 (14.6)	8 (6.4)	3 (9.4)	98 (9.2)
16 to 19	13 (59.1)	146 (80.7)	149 (88.2)	106 (83.5)	102 (83.6)	145 (87.9)	101 (82.1)	110 (87.3)	28 (87.5)	900 (84.4)
20 to 29	0	1 (0.6)	0	2 (1.6)	1 (0.8)	1 (0.6)	0	0	0	5 (0.5)
30 to 64	1 (4.6)	8 (4.4)	5 (3.0)	3 (2.4)	2 (1.6)	5 (3.0)	3 (2.4)	4 (3.2)	0	31 (2.9)
65 +	0	0	3 (1.8)	0	0	0	0	1 (0.8)	1 (3.1)	5 (0.5)
Passenger sex										
Male	16 (72.7)	88 (48.6)	93 (55.0)	65 (51.2)	67 (54.9)	100 (60.6)	74 (60.2)	64 (50.8)	19 (59.4)	586 (55.3)
Female	6 (27.3)	90 (49.7)	76 (45.0)	61 (48.0)	55 (45.1)	63 (38.2)	49 (39.8)	61 (48.4)	13 (40.6)	474 (44.7)
Unknown	0	3 (1.7)	0	1 (0.8)	0	2 (1.2)	0	1 (0.8)	0	7 (0.7)

Table 4. Characteristics of roadway and environment, by year of crash, August 2007 – April 2015

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
	N (col %)									
Road type										
Interstate	1	15	22	16	16	21	15	29	5	140
	(2.5)	(4.9)	(6.2)	(6.6)	(6.2)	(6.8)	(4.5)	(9.6)	(6.3)	(6.3)
Arterial	6	78	76	63	60	74	81	45	12	495
	(15.0)	(25.4)	(21.4)	(25.8)	(23.1)	(24.0)	(24.4)	(14.9)	(15.0)	(22.2)
Collector	22	151	196	135	140	154	168	167	44	1177
	(55.0)	(49.2)	(55.2)	(55.3)	(53.9)	(49.8)	(50.6)	(55.3)	(55.0)	(52.8)
Local	11	47	38	23	28	37	39	40	5	268
	(27.5)	(15.3)	(10.7)	(9.4)	(10.8)	(12.0)	(11.8)	(13.3)	(6.3)	(12.0)
All other	0	16	23	7	16	23	29	21	14	149
		(5.2)	(6.5)	(2.9)	(6.2)	(7.4)	(8.7)	(7.0)	(17.5)	(6.7)
Surface Condition										
Dry	14	151	158	109	89	157	148	147	40	1013
	(35.0)	(49.2)	(44.5)	(44.7)	(34.2)	(50.8)	(44.6)	(48.7)	(50.0)	(45.5)
Gravel	0	19	26	14	13	15	10	9	0	106
		(6.2)	(7.3)	(5.7)	(5.0)	(4.9)	(3.0)	(3.0)		(4.8)
Snow/ice	21	93	148	97	126	116	144	117	37	899
	(52.5)	(30.3)	(41.7)	(39.8)	(48.5)	(37.5)	(43.4)	(38.7)	(46.3)	(40.3)
Wet	5	39	23	20	31	21	28	28	3	198
	(12.5)	(12.7)	(6.5)	(8.2)	(11.9)	(6.8)	(8.4)	(9.3)	(3.8)	(8.9)
Other/unknown	0	5	0	4	1	0	2	1	0	13
		(1.6)		(1.6)	(0.4)		(0.6)	(0.3)		(0.6)
Time of Day										
Midnight to 2:59am	1	7	2	2	3	3	1	2	1	22
	(2.5)	(2.3)	(0.6)	(0.8)	(1.2)	(1.0)	(0.3)	(0.7)	(1.3)	(1.0)
3am to 5:59am	1	2	4	5	4	4	4	2	0	26
	(2.5)	(0.7)	(1.1)	(2.1)	(1.5)	(1.3)	(1.2)	(0.7)		(1.2)
6am to 8:59am	7	55	58	39	53	66	69	55	18	420
	(17.5)	(17.9)	(16.3)	(16.0)	(20.4)	(21.4)	(20.8)	(18.2)	(22.5)	(18.8)
9am to 11:59am	9	28	44	23	31	32	44	30	8	249
	(22.5)	(9.1)	(12.4)	(9.4)	(11.9)	(10.4)	(13.3)	(9.9)	(10.0)	(11.2)
12pm to 2:59pm	4	44	61	38	48	57	59	52	18	381
	(10.0)	(14.3)	(17.2)	(15.6)	(18.5)	(18.5)	(17.8)	(17.2)	(22.5)	(17.1)
3pm to 5:59pm	10	81	91	67	62	82	83	85	19	580
	(25.0)	(26.4)	(25.6)	(27.5)	(23.9)	(26.5)	(25.0)	(28.2)	(23.8)	(26.0)
6pm to 8:59pm	4	52	52	46	35	44	44	49	9	335
	(10.0)	(16.9)	(14.7)	(18.9)	(13.5)	(14.2)	(13.3)	(16.2)	(11.3)	(15.0)
9pm to 11:59pm	4	38	43	24	24	21	28	27	7	216
	(10.0)	(12.4)	(12.1)	(9.8)	(9.2)	(6.8)	(8.4)	(8.9)	(8.8)	(9.7)
Day of the week										
Sunday	5	29	41	27	19	27	32	26	8	214
	(12.5)	(9.5)	(11.6)	(11.1)	(7.3)	(8.7)	(9.6)	(8.6)	(10.0)	(9.6)
Monday	4	39	54	34	45	45	48	54	7	330
	(10.0)	(12.7)	(15.2)	(13.9)	(17.3)	(15.5)	(14.5)	(17.9)	(8.8)	(14.8)
Tuesday	7	53	55	38	41	43	47	49	10	343
	(17.5)	(17.3)	(15.5)	(15.6)	(15.8)	(13.9)	(14.2)	(16.2)	(12.5)	(15.4)
Wednesday	5	35	50	28	34	58	42	42	19	313
	(12.5)	(11.4)	(14.1)	(11.5)	(13.1)	(18.8)	(12.7)	(13.9)	(23.8)	(14.0)
Thursday	5	50	51	39	42	48	64	48	8	355
	(12.5)	(16.3)	(14.4)	(16.0)	(16.2)	(15.5)	(19.3)	(15.9)	(10.0)	(15.9)
Friday	7	58	55	51	38	59	61	47	12	388

	(17.5)	(18.9)	(15.5)	(20.9)	(14.6)	(19.1)	(18.4)	(15.6)	(15.0)	(17.4)
Saturday	7	43	49	27	41	29	38	36	16	286
	(17.5)	(14.0)	(13.8)	(11.1)	(15.8)	(9.4)	(11.5)	(11.9)	(20.0)	(12.8)
On a weekend **(Fri 5pm to Sun 11:59pm)**										
Yes	14	93	116	72	74	73	88	78	27	635
	(35.0)	30.3	(32.7)	(29.5)	(28.5)	(23.6)	(26.5)	(25.8)	(33.8)	(28.5)
No	26	214	239	172	186	236	244	224	53	1594
	(65.0)	(69.7)	67.3)	(70.5)	(71.5)	(76.4)	(73.5)	(74.2)	(66.3)	(71.5)
Light Condition										
Daylight	12	140	173	115	121	164	161	145	39	1070
	(30.0)	(45.6)	(48.7)	(47.1)	(46.5)	(53.1)	(48.5)	(48.0)	(48.8)	(48.0)
Degraded daylight	12	58	72	33	64	53	60	60	17	429
	(30.0)	(18.9)	(20.3)	(13.5)	(24.6)	(17.2)	(18.1)	(19.9)	(21.3)	(19.3)
Dusk/dawn	2	20	19	22	13	26	25	30	5	162
	(5.0)	(6.5)	(5.4)	(9.0)	(5.0)	(8.4)	(7.5)	(9.9)	(6.3)	(7.3)
Dark, but lighted	7	41	45	26	40	48	54	39	13	313
	(17.5)	(13.4)	(12.7)	(10.7)	(15.4)	(15.5)	(16.3)	(12.9)	(16.3)	(14.0)
Dark, not lighted	7	48	46	48	22	18	32	28	6	255
	(17.5)	(15.6)	(13.0)	(19.7)	(8.5)	(5.8)	(9.6)	(9.3)	(7.5)	(11.4)

Table 5. Percentage of crash type, by year of crash, August 2007 – April 2015

Crash type	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	Time Trend % change/ 12 months (95% CI)
	N (col %)										
Vehicle-to-vehicle	**20 (50.0)**	**122 (39.7)**	**128 (36.1)**	**108 (44.3)**	**100 (38.5)**	**165 (53.4)**	**175 (52.7)**	**170 (56.3)**	**46 (57.5)**	**1034 (46.4)**	**3.05 (1.63-4.46)**
Angle	11 (27.5)	59 (19.2)	65 (18.3)	39 (16.0)	47 (18.1)	41 (13.3)	59 (17.8)	53 (17.5)	15 (18.8)	389 (17.5)	-0.28 (-0.99-0.44)
Rear-end	9 (22.5)	59 (19.2)	59 (16.6)	66 (27.0)	52 (20.0)	114 (36.9)	107 (32.2)	104 (34.4)	29 (36.3)	599 (26.9)	3.23 (2.40-4.05)
Other vehicle-to-vehicle	0	4 (1.3)	4 (1.1)	3 (1.2)	1 (0.4)	10 (3.2)	9 (2.7)	13 (4.3)	2 (2.5)	44 (2.0)	Not calculated
Single vehicle	**20 (50.0)**	**185 (60.3)**	**227 (63.9)**	**136 (55.7)**	**160 (61.5)**	**144 (46.6)**	**157 (47.3)**	**132 (43.7)**	**34 (42.5)**	**1195 (53.6)**	**-3.05 (-4.46- -1.63)**
Loss of control	18 (45.0)	131 (42.7)	179 (50.4)	114 (46.7)	138 (53.1)	119 (38.5)	134 (40.4)	107 (35.4)	28 (35.0)	968 (43.4)	-2.11 (-3.06- -1.15)
Road departure	2 (5.0)	54 (17.6)	48 (13.5)	22 (9.0)	22 (8.5)	25 (8.1)	23 (6.9)	25 (8.3)	6 (7.5)	227 (10.2)	-1.18 (-1.72- -0.65)
All crashes	**40**	**307**	**355**	**244**	**260**	**309**	**332**	**302**	**80**	**2229**	

Table 6. Percent of all crashes containing a potentially distracting behavior by year, August 2007 – April 2015.

Potentially distracting behavior	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	Time Trend % change/ 12 months (95% CI)
	N (% of all crashes in a year)[a]										
Any distraction	21 (52.5)	185 (60.3)	201 (56.6)	147 (60.3)	150 (57.7)	183 (59.2)	182 (54.8)	189 (62.6)	46 (57.5)	1304 (58.5)	0.11 (-0.84-1.06)
Attending to passenger(s)	4 (10.0)	55 (17.9)	48 (13.5)	47 (19.3)	39 (15.0)	35 (11.3)	42 (12.7)	47 (15.6)	9 (11.3)	326 (14.6)	0.62 (-1.0-2.3)
Attending inside vehicle, unknown	4 (10.0)	39 (12.7)	26 (7.3)	24 (9.8)	27 (10.4)	30 (9.7)	37 (11.1)	44 (14.6)	7 (8.8)	238 (10.7)	0.32 (-0.25-0.89)
Any cellphone use	5 (12.5)	38 (12.4)	45 (12.7)	27 (11.1)	25 (9.6)	43 (13.9)	34 (10.2)	40 (13.3)	9 (11.3)	266 (11.9)	-0.05 (-0.66-0.56)
Use of cell phone (operating/looking)	*2 (5.0)*	*27 (8.8)*	*29 (8.2)*	*21 (8.6)*	*16 (6.2)*	*36 (11.7)*	*30 (9.0)*	*36 (11.9)*	*6 (7.5)*	*203 (9.1)*	*0.42 (-0.13-0.96)*
Use of cell phone (talking, listening)	*3 (7.5)*	*11 (3.6)*	*17 (4.8)*	*6 (2.5)*	*9 (3.5)*	*7 (2.3)*	*6 (1.8)*	*5 (1.7)*	*3 (3.8)*	*67 (3.0)*	*-0.39 (-0.68- -0.09)*
Attending outside vehicle, unknown	1 (2.5)	21 (6.8)	28 (7.9)	18 (7.4)	24 (9.2)	35 (11.3)	40 (12.1)	40 (13.3)	12 (15.0)	219 (9.8)	1.24 (0.68-1.80)
Singing/Dancing to music	1 (2.5)	18 (5.9)	29 (8.2)	17 (7.0)	20 (7.7)	32 (10.4)	23 (6.9)	28 (9.3)	7 (8.8)	175 (7.9)	0.41 (-0.13-0.94)
Reaching for object	1 (2.5)	17 (5.5)	22 (6.2)	14 (5.7)	16 (6.2)	16 (5.2)	14 (4.2)	19 (6.3)	4 (5.0)	123 (5.5)	-0.03 (-0.47-0.42)
Operating in-vehicle controls/devices	2 (5.0)	9 (2.9)	11 (3.1)	8 (3.3)	9 (3.5)	8 (2.6)	14 (4.2)	14 (4.6)	2 (2.5)	77 (3.5)	0.14 (-0.21-0.49)
Personal grooming	1 (2.5)	19 (6.2)	18 (5.1)	13 (5.3)	11 (4.2)	20 (6.5)	16 (4.8)	12 (4.0)	5 (6.3)	115 (5.2)	-0.13 (-0.55-0.29)
Eating or drinking	0	5 (1.6)	5 (1.4)	5 (2.1)	3 (1.2)	6 (1.9)	6 (1.8)	9 (3.0)	1 (1.3)	40 (1.8)	0.14 (-0.13-0.42)
Attending to another vehicle or its passenger(s)	0	11 (3.6)	17 (4.8)	9 (3.7)	14 (5.4)	20 (6.5)	8 (2.4)	8 (2.7)	2 (2.5)	89 (4.0)	-0.15 (-0.58-0.27)
Talking to self	2 (5.0)	8 (2.6)	4 (1.1)	1 (0.4)	10 (3.9)	10 (3.2)	4 (1.2)	7 (2.3)	3 (3.8)	49 (2.2)	0.05 (-0.21-0.32)
Attending elsewhere, unknown	0	1 (0.3)	1 (0.3)	2 (0.8)	1 (0.4)	2 (0.7)	1 (0.3)	2 (0.7)	0	10 (0.5)	0.02 (-0.12-0.16)
Use of electronic device (not cell phone)	1 (2.5)	0	1 (0.3)	0	2 (0.8)	5 (1.6)	6 (1.8)	1 (0.3)	1 (1.3)	17 (0.8)	0.14 (0.02-0.27)
Attending to a person outside the vehicle	1 (2.5)	1 (0.3)	0	2 (0.8)	1 (0.4)	3 (1.0)	4 (1.2)	1 (0.3)	3 (3.8)	16 (0.7)	0.11 (-.01-0.24)
Attending to a moving object inside vehicle	0	1 (0.3)	2 (0.6)	1 (0.4)	1 (0.4)	0	1 (0.3)	0	0	6 (0.3)	-0.07 (-0.19-0.05)
Smoking related	0	6 (2.0)	5 (1.4)	4 (1.6)	1 (0.4)	1 (0.3)	3 (0.9)	0	0	20 (0.9)	-0.49 (-0.91- -0.07)

[a] More than one behavior of a driver could be coded. Therefore, the percentages shown are of each column total and will not equal 100%.

Table 7. Cell phone use, by year of crash and crash type, August 2007 – April 2015 [a]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL
	N (% of all crashes in a year)									
Loss of control										
Talking/listening	1 (5.6)	5 (3.8)	9 (5.0)	4 (3.5)	7 (5.1)	3 (2.5)	4 (3.0)	3 (2.8)	0	36 (3.7)
Operating/looking	0	1 (0.8)	2 (1.1)	2 (1.8)	1 (0.7)	3 (2.5)	2 (1.5)	0	1 (3.6)	12 (1.2)
Road departure										
Talking/listening	0	4 (7.4)	2 (4.2)	1 (4.6)	2 (9.1)	0	0	0	1 16.7)	10 (4.4)
Operating/looking	1 (50.0)	12 (22.2)	16 (33.3)	10 (45.5)	4 (18.2)	10 (40.0)	3 (13.0)	6 (24.0)	1 (16.7)	63 (27.8)
Angle										
Talking/listening	2 (18.2)	2 (3.4)	5 (7.7)	1 (2.6)	0	1 (2.4)	1 (1.7)	0	2(13.3)	14 (3.6)
Operating/looking	0	4 (6.8)	2 (3.1)	0	3 (6.4)	1 (2.4)	1 (1.7)	1 (1.9)	1 (6.7)	13 (3.3)
Rear-end										
Talking/listening	0	0	1 (1.7)	0	0	3 (2.6)	0	2 (1.9)	0	6 (1.0)
Operating/looking[3]	1 (11.1)	9 (15.3)	8 (13.6)	9 (13.6)	8 (15.4)	22 (19.3)	24 (22.4)	29 (27.9)	3 (10.3)	113 (18.9)

Trend over time [1]$p<0.0001$ [2]$p<0.01$ [3]$p<0.05$. [a] Crashes categorized as "other" are not included in these numbers.

Table 8. Eyes off forward road (EOFR) time and duration of longest glance by year of crash and crash type, August 2007 – April 2015.

Year	Crash type	Crashes N	EOFR time N (%)	EOFR time Mean (SD)	Longest glance Mean (SD)
2007	LOC	18	17 (94.4)	0.2 (0.4)	0.2 (0.4)
	Road Departure	2	2 (100)	5.5 (0.0)	4.5 (1.4)
	Angle	11	10 (90.9)	1.2 (1.4)	0.8 (1.1)
	Rear-end	9	8 (88.9)	1.1 (1.5)	0.8 (1.0)
2008	LOC	131	111 (84.7)	0.5 (0.9)	0.4 (0.6)
	Road Departure	54	47 (87.0)	3.8 (1.7)	3.2 (1.6)
	Angle	59	47 (79.7)	0.7 (1.3)	0.5 (0.9)
	Rear-end	59	53 (89.8)	2.0 (2.0)	1.5 (1.4)
2009	LOC	179	152 (84.9)	0.6 (1.1)	0.4 (0.7)
	Road Departure	48	44 (91.7)	3.8 (1.7)	2.9 (1.6)
	Angle	65	54 (83.1)	0.5 (1.0)	0.4 (0.8)
	Rear-end	59	53 (89.8)	2.1 (1.7)	1.6 (1.3)
2010	LOC	114	81 (71.1)	0.4 (0.8)	0.3 (0.6)
	Road Departure	22	17 (77.3)	4.9 (1.0)	4 (1.4)
	Angle	39	36 (92.3)	0.7 (1.0)	0.5 (0.6)
	Rear-end	66	61 (92.4)	2.5 (1.7)	1.7 (1.3)
2011	LOC	138	109 (79.0)	0.5 (0.8)	0.4 (0.6)
	Road Departure	22	18 (81.8)	3.5 (1.4)	2.8 (1.3)
	Angle	47	40 (85.1)	0.7 (1.1)	0.5 (0.7)
	Rear-end	52	50 (96.2)	3.1 (1.8)	2.1 (1.6)
2012	LOC	119	90 (75.6)	0.4 (1.0)	0.3 (0.7)
	Road Departure	25	19 (76.0)	4.1 (1.7)	3.1 (1.6)
	Angle	41	38 (92.7)	0.7 (1.3)	0.4 (0.7)
	Rear-end	114	108 (94.7)	2.6 (1.9)	2 (1.6)
2013	LOC	134	112 (83.6)	0.4 (0.8)	0.3 (0.6)
	Road Departure	23	16 (69.6)	3.4 (1.7)	2.7 (1.5)
	Angle	59	53 (89.8)	0.6 (1.1)	0.5 (1.0)
	Rear-end	107	95 (88.8)	2.7 (2.0)	2.1 (1.7)
2014	LOC	107	94 (87.9)	0.4 (0.7)	0.3 (0.5)
	Road Departure	25	20 (80.0)	3.6 (2.3)	3.1 (2.1)
	Angle	53	49 (92.5)	0.8 (1.5)	0.7 (1.3)
	Rear-end	104	98 (94.2)	3.1 (2.0)	2.1 (1.6)
2015	LOC	28	27 (96.4)	0.6 (1.2)	0.4 (0.9)
	Road Departure	6	4 (66.7)	3.8 (2.7)	2.9 (2.4)
	Angle	15	15 (100)	0.7 (1.5)	0.5 (1.2)
	Rear-end	29	29 (100)	2.9 (2.0)	2.2 (1.7)
TOTAL	LOC	968	793 (81.9)	0.5 (0.9)	0.4 (0.6)
	Road Departure	227	187 (82.4)	3.9 (1.7)	3.1 (1.6)

	Angle	389	341 (87.7)	0.7 (1.2)	0.5 (0.9)
	Rear-end	599	554 (92.5)	2.6 (1.9)	1.9 (1.5)

Table 9. Reaction time for rear-end crashes by year, August 2007 – April 2015.

Year	Reaction Time (N=248)		No Reaction (N=104)
	N (col %)	Mean (SD)	N (col %)
2007	5 (2.0)	2.8 (1.1)	0
2008	34 (13.7)	2.0 (1.1)	8 (7.7)
2009	29 (11.7)	2.2 (1.0)	6 (5.8)
2010	29 (11.7)	2.6 (1.1)	7 (6.7)
2011	19 (7.7)	2.4 (0.9)	11 (10.6)
2012	47 (19.0)	2.4 (1.0)	20 (19.2)
2013	36 (14.5)	2.6 (1.3)	21 (20.2)
2014	38 (15.3)	2.7 (1.1)	26 (25.0)
2015	11(4.4)	2.4 (0.6)	5 (4.8)

Appendix B – Vehicle-to-vehicle crash coding sheet

Variables	Codes
Event Number from DC	Alphanumerical
Month	Numerical
Day	Numerical
Year	Numerical
Day of the Week	Sunday Monday Tuesday Wednesday Thursday Friday Saturday
Time	Numerical
Time 2	AM PM
Manner of Collision *for pictures and clarification go to* http://www.mmucctraining.us/ ***sideswipe is coded when there is no significant involvement of the front or rear surface, the impact swipes along the surface of the vehicle parallel to the direction of travel***	Front to rear Front to front Angle Sideswipe, same direction Sideswipe, opposite direction Rear to front Rear to side Rear to rear Unknown
Forward g-force at impact	Numerical
Lateral g-force at impact	Numerical
Magnitude ***(calculated based on the g-forces entered)***	Numerical
Angle ***(calculated based on the g-forces entered)***	Numerical
Angle_360_0E ***(calculated based on the angle)***	Numerical
Angle_360_0N ***(calculated based on the angle)***	Numerical
Collision Vector Direction ***(determined by the angle_360_0N)***	Front Front Left Left Front Left Left Rear Rear Left Rear Rear Right Right Rear Right Right Front Front Right

Impact Zone ***(determined by the angle_360_0N)***	Front Front Left Left Front Left Left Rear Rear Left Rear Rear Right Right Rear Right Right Front Front Right
Weather ***If it is dark, weather should be coded as unknown unless visible in street lights or headlights (i.e., fog, rain, snow, sleet, hail, freezing rain)***	No adverse weather (i.e., clear/partly cloudy/cloudy) Fog Rain Sleet, hail, freezing rain Snow Unknown
Light ***Dawn- the transition period going from "dark of night" to daylight. Typically the 30 minute period before sun rises.*** ***Dusk- the transition period going from daylight to "dark of night". Typically the 30 minute period after sun sets.*** ***If necessary, google time, time zone, and date to aid in coding.***	Daylight Degraded daylight (cloudy or **visible** weather- some/all vehicles w **headlights on**) Dawn/dusk (sun is not visible but there is daylight on horizon – some vehicles with **headlights on**) Dark, roadway lighted at location of critical event Dark, roadway not lighted at location of critical event
Road Type ***(Assign crash to trafficway on which the first harmful event occurred. At intersection, assign the crash to the highest function class of trafficway.)*** *Interstates- high speeds over long distances- 55-75mp* *Arterials- freeways and multi-lane highways, connect urbanized areas, cities, and industrial centers- 50-70mph* *Collectors-major and minor roads that connect local roads and streets with arterials, balance mobility with land access- 35-55mph* *Local- limited mobility, primary access to residential areas, businesses, farms- speeds up to 25mph* *http://ntl.bts.gov/lib/23000/23100/23121/09RoadFunction.pdf* *http://www.fhwa.dot.gov/environment/publications/flexibility/ch03.cfm*	Interstate Arterial Collector Local Parking lot/ramp Entrance/exit ramp Driveway/alley Off road Unknown

Surface condition ***(Determined at location of critical event)***	Dry Wet Ice Snow Mud, dirt Gravel Water (standing or moving) Other/Unknown
Vehicle speed at time of impact ***Note: Only available for approximately 10% of the teen crashes***	This can be found in the Event Details only if GPS was provided for this crash. If it is not available, then leave blank to indicate “missing”.

Critical/Precipitating Event ***(i.e., what action by this vehicle, another vehicle, person, animal, or non-fixed object was critical to this vehicle's crash?)*** ***First determine the pre-crash category (main heading). Then decide on the pre-crash event under that heading that category. Only 1 critical event can be coded per crash.*** ***Note: Driveway is defined as a private way which provides access to the public from a trafficway to private property. Is considered to be not open to the public for transportation purposes as a trafficway. Includes a private drive to a residence or private business.*** ***Excludes parking lots, which includes parking stalls, lots or ways***	**<u>This Vehicle Loss of Control Due to:</u>** 1. Blow out/flat tire 2. Stalled engine 3. Vehicle failure 4. Poor road conditions 5. Excessive speed 6. Other **<u>This Vehicle Traveling:</u>** 7. Stopped on roadway (includes parked on roadway) 8. Decelerating on roadway 9. With slower constant speed 10. Over the line on the left side of travel 11. Over the line on the right side of travel 12. Over the left edge of roadway 13. Over the right edge of roadway 14. Turning left at intersection 15. Turing right at intersection 16. Passing through intersection **<u>Other Vehicle in Lane:</u>** 17. Stopped on roadway 18. Traveling in same direction with lower speed 19. Traveling in same direction decelerating 20. Traveling in same direction with higher speed 21. Traveling in opposite direction 22. In crossover 23. Backing **<u>Another Vehicle Encroaching:</u>** 24. From adjacent lane (same direction)- over lt lane line (i.e., other vehicle crosses its right lane line 25. From adjacent lane (same direction)- over rt lane line (i.e., other vehicle crosses its left lane line 26. From opposite direction over left lane line 27. From opposite direction over right lane line 28. From parking lane, median, shoulder, roadside 29. From crossing street- turning in same direction 30. From crossing street- across path 31. From crossing street- turning into opposite direction 32. From driveway- turning in same direction 33. From driveway- straight across path 34. From driveway- turning into opposite direction **<u>Pedestrian, Cyclist, Non-motorist:</u>** 35. Pedestrian in roadway 36. Pedestrian approaching roadway 37. Cyclist/non-motorist in roadway 38. Cyclist/non-motorist approaching roadway **<u>Object or Animal:</u>** 39. Animal in roadway 40. Animal approaching roadway 41. Object in roadway 42. Object approaching roadway

Contributing circumstances, Driver ***Code all that are applicable*** ****Inadequate surveillance should be coded whenever traffic signals, road signs are missed OR BRT is poor >1 sec OR EOFR is >2 seconds*** *****Rolling stop should be coded if there are not any frames without forward motion*** ******Inattentive/distracted should be coded whenever there is a distraction coded as present***	Driving too fast for conditions Misjudged gap Inadequate surveillance ***See Note** Followed too close (**<2 seconds**) Ran traffic signal (**includes running yellow lights**) Ran stop sign (**includes rolling stops, see note****) Exceeded speed limit Made improper turn (turn from wrong lane or illegal u-turn) Travelling wrong way or on wrong side of road Crossed centerline Lost control (driver unable to maintain/regain control to avoid crash) Swerved to avoid an object/vehicle or animal in roadway Overcorrected/Over steering Operating in a reckless, aggressive or negligent manner Failed to yield ROW- from stop sign Failed to yield ROW- from yield sign Failed to yield ROW- making left turn Failed to yield ROW- making right on red Failed to yield ROW- from driveway Failed to yield ROW- from parked position Failed to yield ROW- to pedestrian Failed to yield ROW- at uncontrolled intersection Failed to yield ROW- entering roadway (from parking lots) Unsafe lane change Other illegal maneuver Inattentive/distracted *****See Note** Fatigued/tired (yawning) No improper action
Contributing circumstances, Environment ***Code all that are applicable***	None apparent Weather Physical obstruction Pedestrian action Glare Animal in roadway Other
Contributing circumstances, Roadway ***Code all that are applicable*** **** Traffic back up is coded whenever there is an accumulation of traffic caused by vehicles slowing or stopping the traffic flow due to prior crashes, non-recurring events or regular congestion (see MMUCC)*** ***** Road surface condition should be coded when the BRT is good (<1sec) and max braking stays at a consistent level, indicating sliding or hydroplaning***	None apparent Traffic back up ***See Note** Road surface condition****See Note** Debris Ruts, holes, bumps Work zone Obstruction in roadway Traffic control device inoperative, missing Problem with road shoulder Pavement edge drop off
Reaction time to hazard- ***ONLY code for rear end crashes in which leading vehicle brake lights are visible and both vehicles are travelling in the same lane. If the lv brake lights become visible but it is apparent that they had slowed or stopped much before that, do not code RT and make a note.***	Number of seconds between the time hazard appears and the driver reacts ***(calculated for Front to Rear crashes- from onset of brake lights to active braking of > 0.15g)*** *(In cases that are unclear, such as multiple instances of braking, do not code and make note)* ***If the lead vehicle brake lights appear and the driver does not have a response before impact, RT should be coded as NRT (no reaction time)***

Driver Age *(approximate)*	1. 16-19 2. 20-29 3. 30-64 4. 65+
Driver Gender	1. Male 2. Female 3. Unknown
Driver Condition	1. Normal 2. Drowsy (**obviously** falling asleep) 3. Driver visibly angry 4. Driver visibly upset/crying 5. Unknown
Driver Behavior ***(code all that is seen from -6.0 seconds to impact)***	1. No observable behaviors 2. Talking to self 3. Reading map/directions/book 4. Attending to passenger(s) (looking at/in conversation with) 5. Attending to a moving object/animal inside vehicle 6. Use of cell phone (talking, listening) 7. Use of cell phone (operating, looking) 8. Use of cell phone likely but not visible 9. Adjusting in-vehicle controls 10. Using electronic device (mp3, iPod, nav system) 11. Reaching for object (picking object up/setting down, passing object to others) 12. Eating or drinking 13. Smoking related 14. Personal grooming 15. Attending to a person outside the vehicle 16. Attending to another vehicle or passengers of another vehicle 17. Looking for a street address 18. Attending elsewhere, inside the vehicle 19. Attending elsewhere, outside the vehicle 20. Attending elsewhere, unknown 21. Singing/dancing to the music
Vision possibly obscured by ***(at time of critical event)***	1. No obstruction 2. Rain, snow, fog, smoke, dust 3. Glare (sun, headlights) 4. Curve or hill 5. Building, billboard 6. Trees or other vegetation 7. Moving vehicle 8. Parked/stopped vehicle 9. Inadequate clearing of windshield 10. Obstruction in the interior of vehicle 11. Other
Hands on wheel ***(at time of critical event)*** ***Unless hands are visible or arm movement is very apparent, code as Unknown. Do not try to guess or spend a lot of time on this***	1. No hands 2. One hand 3. Both hands 4. Unknown
Number of Passengers in the vehicle	Numerical

Passenger Characteristics (repeat for ALL passengers) **Code passengers clockwise starting with the front seated passenger**	
Age *(approximate)*	1. <1 (rear-facing car seat) 2. 1-4 (front- facing car seat) 3. 5-10 (booster seat) 4. 11-16 5. 16-19 6. 20-29 7. 30-64 8. 65+
Gender	1. Male 2. Female 3. Unknown
Passenger Behavior ***(code all that is seen from -6.0 to impact)*** (modified from Heck and Carlos, 2008)	**Passenger is:** 1. Not engaging in potentially distracting behavior 2. Talking to driver 3. Talking to other passenger(s) 4. Emotional (visibly angry or upset; includes infant/child crying, screaming) 5. Singing 6. Yelling 7. Making loud noises (i.e., whistling) 8. Moving around in the vehicle (turning around in seat, switching seats, wrestling, dancing, fighting with another px) 9. Adjusting vehicle controls 10. Giving directions 11. Pointing something out/showing driver something 12. Talking on the phone 13. Texting/using cell phone 14. Reaching for or dropped/spilled something 15. Purposely distracting driver (poking, tickling, grabbing, hitting) 16. Smoking related (lighting cigarette, handing cigarette to driver)
Social Influence ***When a passenger is pressuring the driver to behave in a more or less risky manner.*** **** Alerting the driver is coded when the passenger makes a movement or sound that redirects the driver's attention to the impending hazard***	1. Encouraging bad driving/or errors 2. Discouraging bad driving/or errors 3. Not an influence 4. Alerts driver *** see note**
Eye Glance Data	***NOTE: Transitions to and from the forward roadway should be appended to the glance*** ***Speed checks and rv mirror checks are NOT coded as glances off forward roadway*** ***If we can't see at least one eye, do NOT code. If we can see one eye, head position may be used to assist in coding*** ***If driver has glances in the direction of travel during a turn, rather than forward (toward oncoming traffic), code as inadequate surveillance and do not code glances as EOFR.*** ***If driver is approaching a stop sign/red light and begins scanning for their turn before coming to a stop, these glances are coded as EOFR*** ***If a driver is scanning before a lane change, these glances are coded as EOFR*** ***Glances are calculated from eyes off forward to their return to forward, multiple glance locations can occur within one glance***
Number of glances off roadway	Number of glances away from forward roadway during the 6 seconds prior to the impact

Total number of frames- eyes off road	Number of event frames eyes off roadway during the 6 seconds prior to the impact
Total time- eyes off road	Number of seconds the drivers eyes are off the forward roadway during the 6 seconds prior to the impact *(divide Total Number of frames by 4)*
Duration of longest glance	The duration of the longest glance that was initiated during the 6 seconds prior to the impact *(count frames and divide by 4)*

Notes	**Please make a note if:** • Airbag deployed • Driver wearing sunglasses (when coding of eye glances not possible) • Object in way of camera (when coding of eye glances not possible) • Anytime "other" is coded make sure to identify here • Describe any special circumstances • When crash is front to rear but reaction time cannot be coded, indicate why • Any coding questions should begin with "??" so that we can search for this and address later if necessary
Unbelted ***Note: It is possible that two or more front (or rear) seated passengers could be unbelted; this would still be coded simply as a Front Px (Rear Px) was unbelted.***	Driver Driver and Front Px (passenger) Driver and Front Px and Rear Px Driver and Rear Px Front Px Front Px and Rear Px Rear Px
Airbag deployed	Yes If blank, there was not an airbag deployment visible during the video
Possibly drowsy/asleep ***indicated by yawning, shaking of head, eye closures that seem long, mention in notes that drowsiness might be a factor***	Yes If blank, there was no indication that the driver might be drowsy/asleep
Traffic Control Present ***Only coded for those events with the critical event coded under the category of "This vehicle traveling" or "Another vehicle encroaching"***	This vehicle traveling: No controls present Stop sign Stop sign at t-intersection 2-way stop sign 4-way stop sign Traffic light- flashing signal Traffic light- left on solid green (unprotected left turn) Traffic light- left on yellow/red Traffic light- right on red Traffic light- straight on red Traffic light- straight on yellow/red Unknown, exiting parking lot Another vehicle encroaching: No controls present Stop sign Traffic light 2-way stop sign 4-way stop sign Cross traffic entering from parking lot Cross traffic had flashing red Cross traffic had red light Cross traffic had stop sign Cross traffic had yield in roundabout Cross traffic turned right on red Cross traffic turned left on solid green (unprotected left turn) Cross traffic turned left on yellow