DEPARTMENT OF TRANSPORTATION

Effectiveness of Teenage Support System (TDSS) on Reducing Traffic Violation Behaviors for Teenage Drivers at the Early Time of Licensure

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16. Abstract (Limit: 250 words)

Teenage drivers are at a disproportionate risk of fatal and serious injuries due to motor vehicle crashes. A Field Operational Test (FOT) funded by MnDOT used the Teen Driver Support System (TDSS) smartphone application to collect real-time driving performance data from a cohort of approximately 300 teen drivers, recruited in early 2013, who were monitored over a 12-month period after licensure. Study results showed the TDSS application's success in reducing instances of speeding for the two groups that received feedback, compared to teens who received no coaching or parental involvement, was influential in reducing kinematic driving events, e.g., hard braking. This five-year follow-up investigation of the long-term outcomes of the TDSS FOT cohort aimed to determine the frequency of state-recorded traffic citations and crashes along with these drivers' self-reported driving behaviors and attitudes. Of the original cohort, 251 agreed to be contacted for future studies and 150 were successfully recruited into the follow-up study. A re-examination of the FOT risky driving distributions divided into tertiles (low, moderate, high) found overdispersion of control group teens in the high risky tertiles compared to the two TDSS intervention groups, particularly for speeding-related behaviors and texting. The tertile risk level of early risky driving (e.g., speeding, hard braking) was found to significantly predict long-term safety outcomes for traffic violations/tickets. However, the sample size for crashes among the over sample was too small to determine if the mediating effect of the TDSS on early risky driving resulted in long-term reductions in crashes.

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Effectiveness of Teenage Support System (TDSS) on Reducing Traffic Violation Behaviors for Teenage Drivers at the Early Time of Licensure

FINAL REPORT

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LIST OF ABBREVIATIONS

App: Application

DPS: Department of Public Safety

DVS: Driver and Vehicle Services

FOT: Field Operational Test

GDL: Graduated Driver's License

GPS: Global Positioning System

ISA: Intelligent Speed Adaptation

PDO: Property Damage Only

RFID: Radio Frequency Identification

TDSS: Teen Driver Support System

TDSS Group: Experimental group with in-vehicle coaching only

TDSS+ Group: Experimental group with in-vehicle coaching and parental feedback

EXECUTIVE SUMMARY

Teenage drivers are at a disproportionate risk of fatal and serious injuries due to motor vehicle crashes. Because of inexperience and a risk-seeking propensity, novice teenage drivers are often more prone to demonstrate risky driving behaviors such as speeding and harsh maneuvers, especially during the first few months of licensure. A project funded by MnDOT used the Teen Driver Support System (TDSS) smartphone application to collect real-time driving performance data from a cohort of approximately 300 teen drivers (age *M* = 16), recruited between the months of February and June 2013, who were monitored over a 12-month period after licensure. The TDSS collected data about risky driving behaviors (e.g., speeding, hard braking, sharp turning, and aggressive accelerating). Participants were placed in one of three groups: TDSS, TDSS+, or a control group. The TDSS group received real-time coaching, primarily through a custom-designed intelligent speed adaptation system, the TDSS+ group received nearly identical in-vehicle coaching but this group's application notified parents of detected risky driving behaviors, via text message, email, and website logging, while the control group received no coaching. Results indicated that those who used the TDSS or TDSS+ had reduced instances of speeding compared to teens in the control group. Further, parental involvement was influential in reducing kinematic driving events, e.g., hard braking. Preliminary analysis of the TDSS project also indicated that approximately 10% of teens across all three experimental groups reported involvement in a crash, traffic citation, and/or ticket during the study period. However, it is unclear as to whether the TDSS affected these traffic violation and risky driving outcomes.

A follow-up investigation of the TDSS Field Operational Test (FOT) cohort was conducted approximately five years later to examine the frequency of state recorded traffic citations and crashes as well as several driver self-report measures (e.g., driving behaviors, attitudes, sensation seeking, and perceived risks). This follow-up study was conducted to understand the long-term effectiveness of an in-vehicle support system, as well as to promote future implementations to a broader range of driver populations.

An initial study was conducted with an aged-matched cohort focus group to develop and validate survey instruments related to driving safety. A packet of measures was assembled to assess driving history, behaviors, and attitudes toward driving safety. Interviews with the focus groups provided insight as to when young drivers (20-22 years old) either engaged in risky driving or observed others engaging in risky driving (i.e., as a passenger). Participants perceived their risky driving to be lower than as a teen driver in high school (e.g., less likely to drive drowsy, be influenced by passengers, or speed).

Two-hundred and fifty-one of the original 300 teens in the TDSS FOT cohort agreed to be contacted regarding potential follow-up study opportunities (i.e., 83 in the control group, 86 in the TDSS group, and 82 in the TDSS+ group). Of the available 251 participants, 150 were located and successfully recruited into the follow-up study (i.e., 47 in the control group, 58 in the TDSS group, and 45 in the TDSS+ group). Study participants engaged in a series of surveys to provide information about their driving history, behaviors, attitudes, and self-reported crashes and citations. They also gave the research team authorization to formally request their crash and citation records from the Minnesota Department of Public Safety Driver and Vehicle Services. The Minnesota agency provided the research team detailed information about authorized participants' citation records and provided limited information about their

crash history (i.e., frequency, date, and crash severity). Participants were paid $100 via Visa debit card for their participation.

A new analysis of the 150 participants' original driving performances and risky behaviors was conducted to re-establish the influence of experimental condition on driving performance during the 12-month study. The analysis indicated that teen drivers in both the in-vehicle coaching conditions (i.e., TDSS and TDSS+) were significantly less likely to trigger a "red speeding warning" (i.e., exceeding 7 mph above the speed limit) while driving, relevant to the control group. Similarly, the TDSS and TDSS+ groups were also found to have a significantly reduced rate of "red speeding parent notifications" (i.e., exceeding 7 mph above the speed limit long enough to send a text notification to parents or log the event if not in the TDSS+ group), as well as significantly reduced rates of texting behaviors. However, while the TDSS+ system demonstrated a significant positive effect on reducing all three harsh driving maneuvers (i.e., braking, turning, and accelerating), none of the results were statistically significant for the TDSS group (i.e., no parental feedback).

Risky driving rates measured during the FOT were highly skewed to the right (i.e., over-dispersion to the small values), so these data were categorized into three levels (i.e., low, moderate, and high) to further quantify the risks by the tertile (i.e., distribution divided into thirds) cut-off points for each of the variables. Differences in the distributions across the tertiles for the three experimental groups were found to be particularly remarkable for the speeding-related behaviors and texting. Namely, the control group was associated with the highest proportion of a "high" level of event rates, followed by the TDSS group and the TDSS+ group (e.g., 71.1% compared to 24.1% and 6.7%, respectively, for the red speeding parent initiatives). Similar trends were also observed for the harsh driving maneuvers. The results of the Chi-square tests for each category of risky driving behavior also provided evidence of significant associations between the TDSS treatment levels and the risky driving behavior levels.

The state-recorded traffic violation/citation records for the participants indicated that 65 traffic citations/tickets were documented from this cohort of young drivers. Approximately 70% of the young drivers were free of traffic citations/tickets. Excessive speeding-related citations/tickets were observed to be the most prevalent type of traffic citation/ticket, accounting for 89.5% (control), 70.1% (TDSS) and 86.4% (TDSS+) of all recorded citations/tickets. The state-recorded traffic crash records for the participants indicated that 26 crashes occurred in the six years after they obtained their full driver's licenses. Approximately 80% of the participants within all of the three groups were crash-free in the state records. Of the documented crashes, there were four injury or possible injury crashes and 22 property damage only crashes.

The tertile risk groups for each of the risky behaviors were used in a series of multivariate analyses using Poisson regressions to examine the relationship between early risky driving and long-term safety outcomes, i.e., traffic violations and crashes. The young drivers in the moderate and high tertile groups for all risky measurements, with the exception of red speeding parent initiative and texting, were significantly more likely to have a citation/ticket than those in the low risk-taking group. Only young drivers who had high red speeding parent initiative had a significantly higher likelihood of having a ticket/citation compared to the low group. Finally, only young drivers who had moderate texting

behavior while driving had a significantly higher likelihood of a ticket/citation compared to the low group. The multivariate analyses conducted to predict the likelihood of crash outcomes by early risky behaviors appeared to be too small to determine if any significant differences existed. The analyses demonstrated that there were no significant differences in the likelihood of crash by engagement in risky behaviors in the first year of licensure.

Risky driving behaviors in early licensure (e.g., excessive speeding and elevated g-force events) have been well recognized as strong precedent predictors for later crash involvement. In these current investigations, the TDSS system demonstrated significant direct treatment effects on reducing the rates of various risky driving outcomes over the first year of independent driving. Simultaneously, the rates of later citation/ticket involvement were found to increase with an increase in the levels of all risky driving behaviors exhibited by young drivers, except for texting. However, due to small sample sizes, significant associations between the risky driving behaviors and crashes were not observed in the current assessment. The findings from the current study suggest that the use of real-time, in-vehicle coaching systems may be effective for improving the safety of younger drivers, in both short- and long-term metrics for risky driving engagement.

CHAPTER 1: INTRODUCTION

1.1 PROJECT OBJECTIVES

Teenage drivers are at a disproportionate risk of fatal and serious injuries due to motor vehicle crashes. Because of inexperience and a risk-seeking propensity, novice teenage drivers are often more prone to demonstrate risky driving behaviors such as speeding and harsh maneuvers, especially during the first few months of licensure. In an effort to reduce risky driving among novice teenage drivers, a cohort of approximately 300 drivers (*M* = 16 years) was recruited and monitored over a 12-month period after licensure. This was done to collect their real-time driving performance data using the Teen Driver Support System (TDSS) in a project funded by Minnesota Department of Transportation (MnDOT). Preliminary analysis of the TDSS project suggested that approximately 10% of these drivers reported involvement in a crash, traffic citation, and/or ticket during the study period within each of the three experimental groups (i.e., control, interface-only, and interface plus parents). However, to what extent the TDSS affected these traffic violations and risky driving outcomes over a longer term was yet to be known. Therefore, this investigation will focus on 1) collecting information on these drivers' self-reported driving behaviors, driving attitudes, sensation seeking, and perceived risks in a cross-sectional approach; and 2) collecting the traffic violation and crash outcomes from the Minnesota Department of Public Safety (DPS) since they were recruited into the TDSS project. The outcome of the study is expected to clarify the long-term effectiveness of an in-vehicle support system as well as promote future implementations with a broader range of driver populations.

1.2 TEEN DRIVER CRASH RISK OVERVIEW

Young drivers account for only a small proportion of the total driver population; however, they are generally overrepresented in crashes and traffic offenses, especially during the early period of unsupervised driving. A survival analysis of self-reported crash involvement and citations revealed that teenage drivers exhibit the greatest risk of incurring a first crash or citation during the first month or first 500 miles driven within 12 months after licensure (McCartt, Shabanova, & Leaf, 2003).

Previous literature on teenage driving has thoroughly documented several important factors that may be attributable to increased crash and injury risks. In particular, male teenage drivers are at greater risks of fatal crashes and are more prone to engage in risky driving compared to females (Williams, 2003). Similarly, young male drivers are also found to exhibit more serious traffic violation behaviors and experience crashes sooner than young female drivers (Waller et al., 2001; McCartt et al., 2003). Yagil's (1998) identifying that young, male drivers considered traffic laws to be significantly less important than other laws also supported this pronounced gender difference. However, some studies argued that the driving risks among female teenage drivers should not be overlooked, in part because they may drive substantially fewer miles than male drivers (Jones, 2017).

Furthermore, driving at an earlier age due to immature physical and psychological development (Steinberg, 2008) significantly increases the crash risk for teenagers, particularly in the nighttime and in the presence of other teenage passengers (Williams, 2003; McCartt, Hellinga, & Haire, 2007). Specifically, peer passengers may also influence teenage drivers by encouraging distraction and a higher propensity for thrill-seeking behaviors (Neyens & Boyle, 2008). Many studies have found that teens with sensation-seeking personalities and other personal traits, such as having more friends with risk seeking personalities, are more likely to be engaged in risky driving behaviors, and these drivers are overrepresented in the frequency of excessive speeding over time (Simons-Morton et al, 2012; Hatfield, Fernandes, & Job, 2014). In a national survey, only 10%of teenage drivers perceived peer passengers as dangerous, yet over 60% reported witnessing this behavior quite frequently in the vehicles (Ginsburg et al., 2008). The potential negative influence of peer passengers appears to be significantly underestimated among adolescent drivers.

Teenage drivers who have unsupervised access to vehicles or own vehicles have a greater chance of being involved in risky driving events and traffic violations (Williams, 2003). Despite the combined prevention efforts by the Graduated Driver's License (GDL) laws and many parent provisions and education programs, teenager drivers are still found to have a greater proportion of deficient seatbelt use and inattentive driving compared to other age groups. Several societal factors might have also affected the occurrences of crashes and traffic offenses among young drivers. For instance, teenage drivers were found to have an increased risk of being involved in a traffic offense or crash incident if their parents had repeatedly violated traffic laws or incurred crashes three and more times (Ferguson, Williams, Chapline, Reinfurt, & De Leonardis, 2001). Combinations of these risk factors have been recognized to cause a substantially higher crash risk and incidence of traffic offenses among teenage drivers. Stricter parental control or involvement over teenage driving and improving the family safety environment or culture have been incorporated as important elements of many driver education interventions and programs (Taubman-Ben-Ari & Katz-Ben-Ami, 2012).

While traffic violation behaviors in general are correlated with crashes, their prevalence and trend appeared to be quite different among young drivers. Chapman, Masten, and Browning (2014) examined crash and traffic violation records for different ages of novice drivers during three phases including learner permit (12 months), provisional licensure (12 months with restrictions), and full licensure (24 months). For novice drivers aged 16 and 17 years old, the total crash rate stayed relatively low in the learner permit phase. It took the highest jump during the first few months of independent driving, declined rapidly for a period of months, and then continued a slow decline over the early years of full licensure. It was also found that over 70% of 16- and 17-year-old drivers were crash-free during the first three years of licensure (Chapman et al., 2014).

While the traffic violation rate among novice teenage drivers also started low during the learner permit phase, the violation rate rapidly increased over the period of provisional licensure, and then peaked at the time when drivers turned almost 18 years of age before slightly dropping off (Chapman et al., 2014). Moreover, regarding the severity of crashes and traffic violations, the likelihood of involvement in an "at-fault" crash or a serious type of traffic violation (e.g., DUI, speeding at greater than 15 mph, etc.)

was found to decline as the year of licensure increased (Waller, Elliott, Shope, Raghunathan, & Little, 2001) . As a result, these findings further justify the need for evaluations of traffic violation behaviors for the TDSS cohort, since an increased risk of traffic violations was observed longer term following licensure and may persist until early adulthood.

Drivers' risk perceptions, driving attitudes and the prevalence of certain driving behaviors may undergo significant changes from early teenage driving to early adulthood. Specifically, Buckley et al. (2017) conducted a survey among young drivers recruited from an emergency room department and revealed that over 20% of them reported driving after drinking alcohol. Even worse, the frequency of riding with a driver who had been drinking was estimated to be up to 40% among both females and males. Similarly, young adult drivers, particularly males, were also found to be overrepresented in sleep-related crashes and other drowsy driving incidents (Filtness, Armstrong, Watson, & Smith, 2017). To better explore driver behaviors, the importance of focus group research has been highlighted in many recent studies for developing tailored survey questions through asking semi-structured open-ended questions of young drivers (e.g., Behavior of Young Novice Drivers Scale (BYNDS) by Scott-Parker et al., 2010; 2012). While some of the BYNDS items might provide good references for the research team in developing the initial survey, it is also important to note that the age range for the BYNDS interviewees was much younger than the anticipated participants in the current project. Similarly, researchers developed a quick 11-item measurement to inquire about young drivers' texting behaviors while driving. Based on the responses from the focus group, more detailed questions were designed on how frequently and under what driving conditions each risky event occurred for the young drivers (Bergmark, Gliklich, Guo, & Gliklich, 2016).

1.3 TEEN DRIVER SUPPORT SYSTEM OVERVIEW

A previous study sought to leverage smartphone technology to address risky maneuvers by teen drivers to improve safety. A smartphone application known as the Teen Driver Support System (TDSS), was created to measure relevant driving maneuvers related to crash risk and provide feedback to drivers in real time (see Creaser et al., 2015, for full details). The study recruited 300 teens (aged 16-18, M = 16.03, SD = 0.22) and their parents to join the field operational test (FOT) from February 2013 through June 2013 to participate in a 12-month study. Teens joined the study within one month of receiving their provisional driver's license, which allows for unsupervised driving. Participant regions (i.e., selected communities surrounding the Minneapolis-Saint Paul metro area in a two-hour radius) were assigned to one of three experimental groups, with approximately 100 teens recruited for each group. The resident communities contained a balance of three population sizes and two levels of commuting patterns across the three experimental groups. Upon completion of the 12-month study, 274 participants remained with completed data (16 participants dropped out and 10 resulted in inadequate data) (see Table 1.1). Teen participants were allowed to keep the provided smartphone and were paid $300 for their participation.

Table 1.1 TDSS Cohort Sample for Final Analysis (adapted from Creaser et al., 2015)

Final TDSS Sample	Control	TDSS	TDSS+	Total
Males	43	42	45	**130**
Females	49	50	45	**144**
Total	**92**	**92**	**90**	**274**

The smartphone application features were tiered to provide different experimental treatments among a cohort of teen drivers in Minnesota. The three tiers for each of the experimental groups included in-vehicle monitoring only (i.e., control group), in-vehicle monitoring and in-vehicle coaching (i.e., TDSS group), and in-vehicle monitoring, in-vehicle coaching, and parental feedback (i.e., TDSS+ group). The application automatically launched when the vehicle ignition was turned on through Bluetooth synchronization with other specially installed experimental hardware within the vehicle (see Creaser et al., 2015, for detailed description). Vehicle ownership was variable with some of the teens sharing a car with a parent or sibling and some owning their own car; however, teens were instructed to primarily drive their designated vehicle with the installed study equipment. No driving behavior data were collected from vehicles or shared in the absence of the teen's phone/TDSS application being present in the vehicle. Parents were provided a radio frequency identification (RFID) tag to disable the application when they were driving a designated study vehicle and the teen was present, with his or her phone, as a passenger.

The control group's application measured drivers' current posted speed as available through the application's stored digital map, along with their travel speeds (as measured by the phone's GPS), turning speeds, deceleration rates, and acceleration rates (as measured through the phone's accelerometer), among other metrics such as stop sign compliance, driver seat belt use, presence of passengers, and Graduated Driver Licensing (GDL) curfew compliance. The application did not alert teens or their parents about any observed driving performance at any time during the study, and although the teens were instructed to comply with laws regarding phone use while driving, there were no restrictions on the phone's use as implemented by the application. However, any phone use (e.g., calling or texting) was documented within the application's software.

Teens assigned to the TDSS group received in-vehicle coaching through intelligent speed adaptation (ISA) that displayed the posted speed limit of the roadway. If the teen exceeded the posted limit by 2.5 mph, the speed limit sign displayed a yellow color (see Figure 1, a-c). If the teens exceeded the speed limit by 7 mph, the speed limit sign displayed a red color and presented a verbal message (i.e., "*Exceeding speed limit, reduce speed now*") instructing them to reduce their speeds. This message was repeated after five seconds for a total of three times, with the third message reminding the teen that speeding is dangerous. The cycle restarted if speeding was not discontinued after five minutes had passed. In-vehicle coaching was also provided when excessive braking, acceleration, or turning was detected. Similar alerts were provided when the seat belt sensor indicated a failure to buckle or the teen did not come to a complete stop at a stop sign. Additionally, the application took control of the phone's

screen and suppressed incoming calls and texts so that teens were prohibited from otherwise using the phone while driving. (Complete feedback and coaching descriptions can be found in Creaser et al., 2015).

Teens assigned to the TDSS+ group received largely the same in-vehicle coaching and phone restrictions as teens in the TDSS group. However, the third verbal warning related to speeding stated, "*Reduce speed now or parents will be notified.*" Teens were then provided between one and five seconds (at random) to reduce their speed. If they did not reduce their speed, their phone would automatically send a text message to their parents detailing the speeding event (see Figure 1.1(d)). Similar text messages were instantly sent when excessive braking, turning, and acceleration maneuvers, among others were detected. Summary reports were emailed to parents once a week. Risky maneuvers were posted on a private website that parents could log in to and review recent and trending performances for their teen (see Creaser et al, 2015, for more complete details about parental feedback).

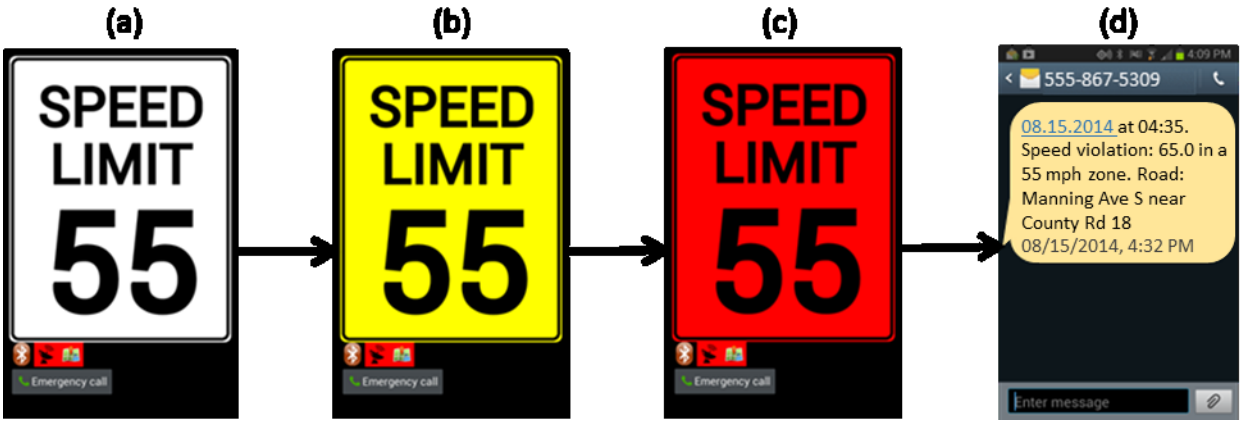

Figure 1.1 ***Screenshots of graded speed warnings for each stage of the advisory ISA feature in the TDSS. (a) speed compliance up to 2.5 mph over the speed limit, (b) "yellow zone" speeding within 2.5 to 6.9 mph over the speed limit, (c) "red zone" speeding at 7 mph or greater above the speed limit, and (d) example TDSS Parent group text message sent to parent detailing the speeding event.***

It was hypothesized that teens would perform the fewest risky driving maneuvers (e.g., speeding, excessive braking, excessive turning, etc.) in the TDSS+ group due to the combination of the real-time, in-vehicle coaching and parental intervention of keeping parents "in the loop" regarding their teens' measured driving performance. It was also hypothesized that the TDSS group intervention would also have some level of efficacy, although less than the TDSS+, to reduce risk taking by teens compared to the control group.

The results of the original FOT yielded multiple significant findings. First, it was found that there was a significant difference in the number of miles driven in each group. The miles driven for teens in the control group dropped more than for the other two groups (Creaser, Swanson, & Morris, 2015). Teens in the TDSS group initially appeared to drive more miles than the TDSS+ group; however, when controlling for vehicle ownership (i.e., examining those that did not share a vehicle), there was no significant difference in the total miles driven for teens in the TDSS or TDSS+ experimental groups. These findings

demonstrated how the in-vehicle monitoring system may enhance parental supervision and oversight and may be a mediating factor in reducing total miles driven and overall exposure. Additionally, the blocking feature of the application to suppress teens' engagement with the phone in both the TDSS and TDSS+ groups was effective to diminish teens' ability to call or text while driving (Creaser, Edwards, Morris, & Donath, 2015).

The key findings of the original FOT were that the TDSS and TDSS+ groups' exposure to the graded speed warning feedback resulted in fewer instances of speeding. These two groups drove a significantly smaller percent of their total miles at 7+ mph over the speed limit, known as the "red zone," compared to the control group (Creaser et al., 2015). The parental feedback provided by the TDSS+ group was found to be a critical component to significantly lowering rates of excessive driving maneuvers (e.g., hard braking, hard acceleration, and hard turning). Despite the large sample size, there was insufficient duration of data collection to observe any significant difference among the groups relating to self-reported crashes or citations. Overall, the system was reported to be a useful tool that parents and teens would recommend to others.

1.4 TEEN DRIVER SUPPORT SYSTEM FOLLOW UP

In the current project, the primary objective was to evaluate the long-term efficacy of the TDSS intervention on reducing traffic violations (i.e., crashes and citations). The teens in the original TDSS FOT completed the study between February 2014 and July 2014. As such, approximately five years had passed when this new investigation was initiated. The aim of this study was to contact the original TDSS cohort to collect information regarding their driving history (i.e., state recorded and self-reported crash and citation records and self-reported risk-taking behaviors), current self-reported driving behaviors, perceptions on driver education, and acceptance of advanced technologies. It was hypothesized that teens in one or both of the TDSS intervention groups would have fewer violations based on their level of treatment (i.e., TDSS and TDSS+) compared to the control group and that traffic violation outcomes would be potentially mediated by factors such as attitudes and perceptions toward driving safety and technology.

The study was done in three major phases. First, a focus group of an age-matched cohort to the TDSS cohort was conducted to revise and refine survey materials to determine that the language was understandable and captured relevant behaviors and attitudes relating to road safety. Second, a major effort was taken to contact the original TDSS cohort to invite them to join the follow-up study. Finally, data collection and analysis of state-recorded and self-reported measures was carried out to determine the extent to which the TDSS intervention and other mediating factors had on long-term driving safety outcomes.

CHAPTER 2: FOCUS GROUP AND SURVEY VALIDATION

In preparation for data collection with the TDSS cohort, the research team created a battery of surveys to assess driving history, behaviors, and attitudes on driving safety. The surveys were tested in a focus group format with an age-matched cohort and were then revised (see Appendix A) based on the recommendations of the group.

Several aspects of the surveys were investigated among these young adult drivers, including any confusion of messages conveyed, accessibility of delivery methods, overall effort taken to complete these questions, and so on. The survey development underwent an iterative process of design modifications on the content, layout, and presentation of specific survey questions to help improve its quality and validity. Moreover, the revised survey also incorporated input from the study's Technical Advisory Panel (TAP) members regarding their feedback of the draft survey questions.

2.1 PART I: FOCUS GROUP STUDY

Eleven participants (5 males, 6 females) completed the focus group study either through individual interviews or via a small group discussion. To best match the TDSS cohort, the eligibility of the focus group was pre-determined as young adult drivers between the ages of 20 to 22 years old and obtained their provisional driver's license at either 16 or 17 years old.

Participants of the focus group were provided a mock-up of the survey (see Appendix A) that was delivered using the University of Minnesota Qualtrics online software survey tool. Several additional participants were recruited for an interview to help researchers review the online survey design as well as identify any technical issues they may have encountered while using it. To evaluate behavioral changes among the TDSS cohort, the same survey questions regarding driver behaviors, risk perceptions and general feedback on the TDSS system were adopted from the previous project. Researchers also developed tailored survey questions that were intended to represent the unique driving attitudes and behaviors among the young adult driver population.

2.1.1 Self-reported Citations and Crash Outcomes

A majority of the young drivers reported having been cited, ticketed or warned by a police officer for traffic offenses during the first or second years of independent driving, mainly due to speeding. However, drivers indicated that they had rarely been convicted of traffic violations in the past two years of early adulthood. The research team also surveyed previous crash history among this focus group since young drivers obtained their driver's license. Only two crashes were reported from participants. One driver was rear-ended by another vehicle, and the other driver ran off the road while driving on a snowy day. While the two drivers who reported having ever been involved in a crash were both females, this may not necessarily reflect the gender difference in crash involvements among the young driver population, due to the small sample size in the focus group. In general, young male drivers have been

identified to have higher crash involvement rates than young female drivers (Waller et al., 2001; McCartt et al., 2003).

2.1.1.1 Survey Design

- All of the young drivers in this focus group favored the online survey over any other delivery method (e.g., by mail, by phone interview, or on-site, in-person survey). Most of the participants indicated that they preferred receiving a single web link that contained all survey questions compared to receiving multiple web links that connected to different segments of the survey. However, one female who reported having had previous experience with participation in a survey study commented that she provided false answers and selected "neutral" for all of the remaining questions when she got bored by a lengthy survey that seemed "never to end."
- Almost all participants liked the idea of being able to view, save and retrieve their progress while doing the study. A clear presentation of the survey contents and time duration was the most favorable option to disseminate the survey.
- Participants also suggested several methods for which they would like to receive their compensation. Among all of the options, a smartphone payment application (for example, Venmo) is the most frequent method used to transfer money among college students.
- Several changes were made that focused on the clarity and conciseness of specific survey questions based on participants' feedback. Please refer to the updated version of the survey for more details (i.e., Version#05 as shown in Appendix A).

2.1.1.2 Behavior Changes from Teenage Drivers to Young Adult Drivers

- Many of the young adult drivers reported driving less frequently in college compared to high school when they were teenage drivers. They also stated that they were more likely to drive under fatigue or drowsiness in high school, in part due to more condensed schedules or lack of control on time commitments.
- In general, young adult drivers considered themselves a less risky driver than they were as teenagers, such as demonstrating less frequent speeding. Presently, they felt more casual and comfortable with their ability to glance around the driving environment compared to the early time independent driving.
- The presence of peer passengers appeared to be a less influential factor for incurring risky driving behaviors for young adult drivers compared to when they were teenage drivers. However, some drivers suggested that it would be overwhelming for them to engage in conversations with passengers under certain circumstances, for instance, navigating directions, etc.

2.1.1.3 Effects of Season and Work Status

- Significant differences were apparent regarding the driving exposures for young adult drivers, between summer and school semester(s). This is because many of the college students do not have a car with them during the school year.
- The most common reason for young adults to drive over summer is a summer job. The work status appeared to be a significant factor that may require further examination. In the updated survey design, the same questions were presented side-by-side to inquire about young driver's driving frequencies during the summertime and the school semester(s), separately.

2.1.1.4 Engagement with Cellular Devices

- Young drivers typically engaged with cellular devices while driving at low speeds, waiting at a stop light or in stop-and-go traffic.
- Besides reading and writing text messages, taking pictures or videos (e.g., Snapchat, Instagram, etc.) while driving appeared to be gaining popularity, particularly among some of the young females.
- Bluetooth is the most commonly used technology among this age group for making phone calls.
- Almost all of the drivers used their phone for navigation. Google Maps was considered the most usable application compared to other in-vehicle navigation systems. Most of the drivers report that they rely on both visual and audio information provided by the system while navigating. The smartphone is generally placed in the driver's lap or the cup holder. Young drivers rarely have a phone mount in their car.

2.1.1.5 Drinking While Driving

- Uber service may have changed the prevalence of drinking while driving among young drivers. Almost all of the young drivers mentioned that they would either designate a driver or use Uber after heavy drinking. However, drivers' perceptions of the amount of alcohol consumption for safe driving and driving with a hangover may vary between individuals.
- DUIs were perceived to be the most harmful traffic violation events, whereas driving with passengers in the vehicle seemed to be the least dangerous overall risky driving scenarios discussed.

2.1.1.6 Compliance with the Traffic Rules

- In addition to safety considerations, avoiding fines appeared to be the biggest motivation for young drivers to not violate traffic rules. Some also mentioned that promoting safety culture on highways, i.e., in the community or neighborhood, was an effective way to help people better comply with traffic rules.

- Insurance was paid by the parents of all of the young adult drivers in this focus group, no matter whether they owned the car or not. Therefore, reducing the insurance rate did not seem to be a determining factor for avoiding traffic convictions.

2.1.1.7 Confidence in Driving

- Male drivers tended to feel overly confident, in comparison to their female peers, in their driving performance. Some perceived themselves to be a better driver than their parents and perceived their parents to execute unnecessary caution when coaching them during most of their driving supervision.
- Most of the drivers considered themselves a safer driver than the average driver; however, the answers might vary depending on the interpretations of "safe," whether it was regarding safe driving habits or safe driving skills. Drivers, particularly females, were more likely to be less confident when this referred explicitly to their driving skills.

2.1.1.8 Advanced In-vehicle Technologies

- Many of the young drivers, particularly males, said that they liked the fuel-efficient monitoring functions built in some of the new cars (i.e., an indicator that provides immediate feedback on the mpg of the car as well as a summary of the mpg on the previous trip). However, they also reported that "playing with it" could sometimes be distracting.
- About half of the participants mentioned that they would like to have cameras in their vehicle to provide assistance for going in reverse or parallel parking.
- In general, participants in this focus group held a conservative attitude towards autonomous vehicles. Most commented that the idea was exciting, but they would not drive it unless the technology is fully developed and widely adopted.

2.2 SUMMARY

The main purpose of the focus group was to validate and iterate the survey materials for the TDSS cohort to ensure accurate and comprehensive measurement of the factors that may contribute to driving safety. This activity served this goal well and allowed for thoughtful iteration of the survey content, structure, and length.

Additionally, the results of the focus group provided useful insight into the use cases in which young drivers in the age range of 20-22 years old may drive, engage in driving risk, or observe others engaging in risk while riding as a passenger. Generally, participants perceived their risk to be lower at present than it was as a teen driver in high school, in particular less likely to drive drowsy, less likely to be influenced by passengers, and less likely to speed. Those enrolled in college tended to have a great deal of fluctuation in their driving frequency throughout the year, where they drive little during the semesters and significantly more during session breaks. Overall, the results indicated a high level of confidence in driving skill and performance, particularly among the males, within this small cohort.

CHAPTER 3: TDSS COHORT RECRUITMENT

The primary challenge for this study was successfully recruiting as many of the original TDSS cohort participants into the study through the contact information obtained by the research team approximately five to six years prior. A variety of methods were utilized and described below to maximize this effort and obtain sufficient statistical power to determine the extent to which the TDSS intervention resulted in long-term driving safety outcomes.

3.1 RECRUITING METHODS

The recruiting methods for the current study consisted of two major approaches: 1) by reconnecting to those teens and parents directly using records of their contact information maintained by the HumanFIRST lab from the previous study; and 2) by announcing open calls or posting advertisements to seek for prospective participants from the original TDSS cohort.

A careful approach was required in reconnecting with past participants in compliance with current University of Minnesota Institutional Review Board (IRB) standards. Current practices require that participants agree to future research opportunities within their informed consent process; however, such consent practices did not exist during the original FOT consenting and assenting (i.e., for the teen participants who cannot consent) processes. Instead, past study records held a comparable question posed to study parents in the final question item in their "Month 12" online questionnaire. The survey item stated, "We might want to follow up with additional questions in the future to further explore your experiences in this study. Are you willing to remain on our contact list for this study in the case that we might wish to reach you or your teen in the future?" In total, 251 participants had indicated "yes" to this question, and their contact information (including the contact information of their teen in the dyad) have been maintained in the event of a follow-up study such as this one or for other similar research opportunities. The "Month 12" online survey did not include this same question for the teens as they had assented to participate and it was assumed improper to request the permission or consent of minors to be contacted for future studies.

Another careful approach was required regarding the way in which the research team re-identified participants joining follow-up study with their de-identified data. In coordination with the University of Minnesota IRB, the research team developed a protocol during the pre-screening phone call with prospective participants to interview them regarding their self-reported experience in the past FOT to confirm their enrollment status in the study without priming them to information they may not know or remember.

Some cues that were examined and categorized after the consent process was complete to help determine which experimental group the participant belonged to:

- My phone recorded how I drove (but no mention of coaching or feedback) *May indicate control/baseline group

- My phone "talked" to me or gave me messages while I drove (but no mention of parent involvement) *May indicate TDSS group
- My phone sent text messages to my parents or my parents knew when I had been speeding (etc.) *May indicate TDSS+ group
- My phone wouldn't let me talk or text while driving *May to exclude baseline group

The combined self-reported information along with their gender and date of birth was expected to provide sufficient information for the research team to match the participant to their participant ID in the original study.

Finally, because the follow-up research study proposed to collect sensitive data on drivers' violation records and self-reported crashes from Minnesota Department of Driver Vehicle Services, the study protocol incorporated a strict data monitoring and data security procedures. The final protocol for recruitment and data collection was granted approval by the university IRB (IRB Study Number: STUDY00005385).

The recruitment activities began with researchers initiating contact with all consented teen-parent dyads (*N* = 251) of the original TDSS study to present them with the opportunity to participate in the follow-up study. The HumanFIRST laboratory maintained records of the original participants with contact information to both the teens and their parents/guardians. However, much of the contact information (e.g., email addresses, phone numbers, and home addresses) was no longer valid, and required additional time and resources to connect with the former teens or their parents. An effort was established to recruit equal numbers of participants from each of the three original experimental groups (e.g., control, TDSS, and TDSS+).

At the same time, the research team announced open calls on social media platforms such as the HumanFIRST lab Facebook webpage, HumanFIRST Twitter, researcher LinkedIn (professional account), researcher Twitter (professional account), Craigslist, etc. Some teen participants or their parents had "followed" the research lab or research team members' professional networking profiles on social media sites (i.e., Facebook, Twitter, or LinkedIn) during or shortly after the original FOT, so it was likely that some may view open call messages posted to those platforms. Advertisements regarding the study were posted on local or community papers where these teens were initially recruited. Additionally, the study flyer was distributed to locations that the original study flyer was distributed (excluding high school locations), as well. Nevertheless, this indirect recruitment approach was considered to be less efficient because the study sample was composed of a closed cohort with a fixed membership. Factors such as relocation can significantly affect the recruitment rate, particularly given that most of the teens have entered into college and experienced life transitions during the five years since the TDSS project was initiated. Few participants contacted the researchers and were able to be enrolled in the study through this approach.

3.2 RECRUITING MATERIALS AND PROCEDURE

The recruitment and data collection were performed in the following methods. First, participants reached out to the researcher and expressed interest in the research after they reviewed the recruiting emails/texts, received parent-forwarded study information, or study advertisements. The response rate to teens' emails and texts was comparatively low since most of these contacts were either invalid or no longer used by the teens. The researcher team also sent emails and made phone calls to each consenting parent in the previous study to seek their help with forwarding the study information to their child.

After a former teen reconnected with the research team and agreed to participate, they scheduled a brief pre-screening phone call to assess their past participation status with the original project, as well as their eligibility for the current follow-up study. The interview involved two parts: 1) a few simple questions that designed to assess whether the person had cognitive, physical or health constraints that may potentially prohibit them from normal driving, and 2) several open-ended questions that would help verify if the person had been enrolled in the TDSS project based on the pre-identified criteria as aforementioned. If the eligibility of the participant was satisfied, he/she was also provided with a brief introduction to the current research goals, the study procedure, the confidentiality and voluntary nature of the research, as well as additional information to help them better recall how the TDSS system functioned.

Following pre-screening, the researcher passed along an IRB approved consent form via email to the participant for obtaining their written consent for taking part in the study. Together with the consent form, the participant also received two authorization forms for them to grant IRB approved researchers on authorized access to their traffic violation and crash records through the State of Minnesota's Department of Public Safety (DPS), Driver and Vehicle Services (DVS). Upon receiving these signed documents, an email containing the survey link would be emailed to the participant through the University of Minnesota Qualtrics survey system. It was expected that the participant should complete and submit the survey within one week after the survey was delivered. Participants were also asked to provide their driver's license numbers to allow researchers to access their crash records, citation and ticket registries upon the authorization from the consented participants. After the individual driver license number was obtained, researchers submitted a data request to the Minnesota DPS DVS. Outcomes of traffic violation records were de-identified and assigned with a unique participant ID number for the study that would also be matched with those in the previous TDSS project. Detailed records of crashes could not be provided to the research team under data privacy laws, but the signed participant authorization did allow the research team to request the information about crash frequency, date, and severity for each participant, with no other details. Participants were assured of the strict confidentiality of the data they shared with the research team and that self-reported crashes, even those not previously reported to DPS or insurance companies, should not be shared with any party outside of the research team.

After participants filled out the survey and its completeness has been confirmed by the research team, a $100 Visa card was mailed to them for compensation. Each participant received a follow-up thank you note along with a delivery notification of the Visa card (so that the participant was aware that the compensation had arrived) for completing the study.

3.3 RECRUITMENT OUTCOMES

At the conclusion of all recruitment efforts, the research team reached out directly to all parent-teen dyads who indicated the willingness to be contacted for further research studies (*N* = 251). There was a nearly even distribution, i.e., 83, 86, and 82, of available participants that could be contacted from the control group, TDSS group, and TDSS+ group, respectively. An overall of *N* = 150 participants were enrolled into the study, accounting for 59.8% of those who consented to be contacted for future research from the previous TDSS cohort (*N* = 251). There were some remaining participants who had inquired with interest in the study and/or completed the initial screening process, but did not fully consent to join the study by the close of study enrollment. The final study sample consisted of 47 in the control group, 58 in the partial TDSS group, and 45 in the full TDSS group. There was a disproportionate number of females (*n* = 95) compared to males (*n* = 55) in the follow up study compared to the relatively balanced distribution of females and males in the original sample (144 and 130, respectively).

Table 3.1 TDSS Cohort Participant Recruitment and Enrollment Overview

Original TDSS Experimental Group / Follow Up Study Group	Control (*n* = 83)		TDSS (*n* = 86)		TDSS+ (*n* = 82)	
	Mean	*SD*	**Mean**	*SD*	**Mean**	*SD*
Age (Mean, SD)	**22.3**	*0.30*	**22.2**	*0.29*	**22.2**	*0.26*
Gender (Number, Percent)	***N***	*%*	***n***	*%*	***n***	*%*
Male	**17**	*36.2*	**21**	*36.3*	**17**	*37.8*
Female	**30**	*63.8*	**37**	*63.8*	**28**	*62.2*
Total Recruited Follow-up Sample	***n = 47***		***n = 58***		***n = 45***	

The recruitment goals, i.e., 50% of the original TDSS cohort, were largely met. The TDSS group was oversampled (67.4% of the available sample) in comparison to the control and TDSS+ groups (56.6% and 54%, respectively). Overall, the recruitment was deemed successful in relocating a substantial number of the original TDSS cohort and was expected to provide sufficient statistical power to draw meaningful conclusions regarding the long-term effectiveness of the TDSS intervention for driving safety.

CHAPTER 4: DATA ANALYSIS

This chapter provides an overall summary of the analysis results based on a combined dataset that incorporated a subset of the data from the original TDSS FOT matched with the same respondents in the current follow up survey. Specifically, the present investigation of this follow-up project focused on addressing two major research components, including:

1. An exploration into the role of the TDSS system in reducing the long-term traffic violation behaviors among young drivers, to identify its potentials as a practical, easily applicable and low-cost driving intervention method during the early period of licensure.
2. Comparison of subjective ratings between data collected in the current study, and those retrieved from the previous TDSS study; the purpose was to understand the influence of TDSS on modifying young drivers' subjective perceptions towards developing safe driving attitudes, as well as to what extent these perceptions would be maintained in the end.

In addition, Appendix B provided more detailed distributions of the survey responses among young drivers within each of the three experimental groups (i.e., control, TDSS, and TDSS+ groups). The appendix also includes a summary of the descriptive statistics and relevant interpretations.

4.1 THE EFFECT OF TDSS SYSTEM ON TRAFFIC VIOLATION BEHAVIORS

A variety of risky driving behaviors were extracted from the previous study to help better reveal the underlying relationship between the TDSS system and its long-term effect on the traffic violation outcomes. It was hypothesized that the adoptions of the TDSS system could positively modify risky behaviors among teenagers, allowing them to foster much safer habits towards becoming more experienced adult drivers. This treatment effect may, in turn, transit into a subsequent reduced risk of them getting involved in a traffic violation event in the later independent driving from late adolescence until early adulthood.

As a result, two separate series of multivariate analyses were established that aimed to examine:

1) The relationships between the TDSS system and early risky driving behaviors (i.e., treated as the dependent variables) from the previous study; and
2) The relationships between teenage drivers' tendency of demonstrating early risky driving (i.e., treated as the independent variables) and their involvements in either a crash or a traffic citation/ticket event.

4.1.1 TDSS and Early Risky Driving Behaviors

This session started with an introduction to the early risky driving behaviors extracted from the naturalistic driving data in the previous TDSS project. Following that, the relationships between the TDSS system and these risky driving behaviors were further investigated through a series of multivariate

analyses that were adjusted for various demographic exposures at the enrollment time of the previous project between 2013 and 2014.

4.1.1.1 Early Risky Driving Behaviors

Seven risky driving-related variables were obtained for the current analyses, including the speeding-related risky driving, texting behaviors, and harsh driving maneuvers. For each of the risky driving variables, an event rate was calculated over the total vehicle miles driven by an individual driver throughout the first year period after full licensure (See Table 4.1 for more descriptions). In Table 4.1, the exposed vehicle miles (i.e., denominators) were carefully selected in order to provide accurate and reliable measures for the rate calculations.

Table 4.1 Descriptions of early risky driving behaviors

Variables Names	Descriptions
Speeding-related Risky Driving	
Red Speeding Initiative	● Event rate per 100 miles, measured as the total counts of red speeding initiatives (i.e., triggered when teenagers exceeded the threshold of 7 miles above the posted speed limit), over the total miles driven on the roads with known posted speed limits.
Red Speeding Parent Initiative	● Event rate per 100 miles, measured as the total counts of red speeding parent initiatives (i.e., triggered when the teen persisted in driving above the 7 mile per hour threshold above the speed limit long enough to send a text notifications to their parent or log the prolonged speeding event if not in the TDSS+ group), over the total miles driven on the roads with known posted speed limits.
Texting Behaviors	
Texting	● Event rate per 100 miles, measured as the total number of texting behaviors demonstrated by the teenager while driving, over the total miles driven by the teenagers, regardless of the position of the phone.
Harsh Driving Maneuvers	
Hard Acceleration	● Event rate per 100 miles, measured as the total counts of abrupt acceleration events over the total recorded miles where the phone was correctly mounted.
Hard Baking	● Event rate per 100 miles, measured as the total counts of the hard braking events over total recorded miles where the phone was correctly mounted.
Hard Turning	● Event rate per 100 miles, measured as the total counts of the hard turning events total recorded miles where the phone was correctly mounted.

4.1.1 The Relationship between the TDSS System and Early Risky Driving Behaviors

Table 4.2 summarized the baseline demographics of the same cohort of young drivers (i.e., *N*=150) who also completed an enrollment survey upon starting with the original TDSS study in 2014. Data were also obtained on those factors that have been identified to be attributable to increased risk of early risky driving behaviors among teenagers. In the current analyses, teenage drivers' academic performance, risk-seeking propensity (i.e., represented by the total sensation-seeking score in this study), vehicle information, and parental supervision were included (

Table 4.2).

Table 4.2 Baseline demographics of the young driver cohort at enrollment in 2014

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
	Mean	*SD*	**Mean**	*SD*	**Mean**	*SD*
Age (Mean, SD)	**15.8**	*2.51*	**16.2**	*0.28*	**16.2**	*0.30*
Academic Performance (i.e., GPA)	**3.6**	*0.43*	**3.7**	*0.32*	**3.7**	*0.31*
Total Sensation-seeking Score	**50.2**	*7.12*	**51.2**	*7.10*	**48.9**	*7.53*
	N	*%*	**N**	*%*	**n**	*%*
Gender (Number, Percent)						
Male	**17**	*36.2*	**19**	*32.8*	**15**	*33.3*
Female	**27**	*57.5*	**32**	*55.2*	**25**	*55.6*
Primary Supervisor						
Mother	**22**	*46.8*	**21**	*36.2*	**14**	*31.1*
Father	**19**	*40.4*	**24**	*41.4*	**20**	*44.4*
Other Adult Drivers	**1**	*2.1*	**3**	*5.2*	**0**	*0.0*
Vehicle Type						
Passenger Vehicle	**27**	*57.5*	**36**	*62.1*	**24**	*53.3*
Pick-up Truck	**4**	*8.5*	**2**	*3.5*	**1**	*2.2*
Sport Utility Vehicle (i.e., SUV)	**8**	*17.0*	**7**	*12.1*	**7**	*15.6*
Minivan or Van	**3**	*6.4*	**4**	*6.9*	**4**	*8.9*
Shared Vehicle						
Yes	**30**	*63.8*	**30**	*51.7*	**24**	*53.3*
No	**13**	*27.7*	**19**	*32.8*	**11**	*24.4*

Note a). All listed percentages did not add up to 100%, due to rounding and missing responses from the enrollment survey; b). Frequencies and percentages of the missing responses were not shown.

For each of the experimental groups, the event rates of all early risky driving behaviors were estimated (See below Table 4.3). As was shown in the table, teenage drivers, in general, triggered much more red-speeding events than any other driving behaviors. The estimated rates were 46.5 per 100 miles for the control group, 20.3 per 100 miles for the partial TDSS group, and 19.4 per 100 miles for the full TDSS group, respectively. In contrast, a minimal event rate was observed for the texting behavior among the two intervention groups, as a result of the system's built-in functionalities in blocking the in-coming text messages during every vehicle trip.

Table 4.3 Estimated risky driving event rates per 100 miles driven during the first year of licensure

	Red Speeding Initiative				Red Speeding Parent Initiative			Texting			
	Miles[a]	**N**	**Rate**	***95% CI***	**N**	**Rate**	***95% CI***	**Miles[b]**	**N**	**Rate**	***95% CI***
TDSS Group											
Control	1064.4	51,614	46.5	*36.1-60.0*	7365	6.2	*4.2-9.2*	1745.2	15284	7.5	*5.2-11.0*
TDSS	1120.4	26,548	20.4	*16.3-25.5*	2787	2.1	*1.5-2.9*	1802.5	890	0.5	*0.4-0.7*
TDSS+	870.9	17,902	19.4	*15.1-25.1*	403	0.5	*0.3-0.8*	1297.2	774	0.7	*0.5-1.0*

		Hard Acceleration			Hard Braking			Hard Turning		
	Miles[c]	N	Rate	*95% CI*	N	Rate	*95% CI*	N	Rate	*95% CI*
TDSS Group										
Control	869.7	1279	1.9	*1.4-2.7*	3264	3.8	*2.9-5.0*	2671	3.9	*2.8-5.4*
TDSS	1312.8	1884	1.7	*1.2-2.2*	3342	3.3	*2.6-4.1*	2897	2.6	*2.0-3.5*
TDSS+	1063	716	0.9	*0.7-1.3*	1522	1.8	*1.4-2.4*	1051	1.3	*1.0-1.8*

Several multivariate analyses were conducted to inspect the relationships between the TDSS system and a variety of risky driving behaviors during early independent driving. To control for data inflation, the negative binomial regression models were utilized to calculate the Rate Ratios (i.e., RRs) along with corresponding 95% Confident Intervals (i.e., CIs). All of the models were adjusted for the baseline demographic covariates at enrollment in 2014, including for teenage driver's age, gender, GPA, total sensation-seeking score, primary supervisor, vehicle type and vehicle shared status.

As shown in Table 4.4, teenage drivers who adopted the TDSS treatment, either the partial or the full system, were found to be significantly less likely to trigger a red speeding warning while driving, relevant to the control group (i.e., RR = 0.43, 95% CI = 0.29-0.63, and RR = 0.43, 95% CI = 0.48-0.65, respectively). Similarly, the TDSS treatments were also significantly associated with a reduced rate of red speeding parent notifications, as well as texting behaviors among these teenage drivers. However, while the full TDSS system demonstrated a significant positive effect on reducing all three harsh driving maneuvers, none of the results were significant for the partial group.

Table 4.4 Estimated rate ratios (RR) for risky driving events per 100 miles driven during the first year of licensure

	Red Speeding Initiative		Red Speeding Parent Initiative		Texting	
	Estimated RR	*95% CI*	Estimated RR	*95% CI*	Estimated RR	*95% CI*
TDSS Group						
TDSS vs Control	**0.43**	***0.29-0.63***	**0.26**	***0.14-0.49***	**0.07**	***0.03-0.11***
TDSS+ vs Control	**0.43**	***0.48-0.65***	**0.08**	***0.04-0.17***	**0.08**	***0.04-0.15***

	Hard Acceleration		Hard Braking		Hard Turning	
	Estimated RR	*95% CI*	Estimated RR	*95% CI*	Estimated RR	*95% CI*
TDSS Group						
TDSS vs Control	1.01	*0.64-1.61*	0.80	*0.55-1.15*	0.82	*0.52-1.30*
TDSS+ vs Control	**0.53**	***0.32-0.88***	**0.43**	***0.29-0.64***	**0.43**	***0.26-0.73***

Because the risky driving rates were highly skewed to the right (i.e., over-dispersion to the small values), these data were categorized into three levels (i.e., Low, Moderate, and High) to further quantify the risks by the tertile (i.e., distribution divided into thirds) cut-off points for each of the variables. Table 4.5 to Table 4.10 indicated how the risk levels of risky driving behavior rates were distributed across the three experimental groups. Data on the risky driving outcomes were incomplete for two drivers from the previous records and thereby they were excluded from this portion of the study.

As shown in the below tables, the levels of risky driving behaviors were not equally distributed across the three experimental groups. Such differences were found to be particularly remarkable for the speeding-related behaviors and texting, where the control group was associated with the highest proportion of a "High" level of event rate, followed by the partial intervention group and the full intervention group (e.g., 71.1% compared to 24.1% and 6.7% for red speeding parent initiative as shown in Table 4.6). Similar trends were also observed for the harsh driving maneuvers. The results of the Chi-square tests also provided evidence of significant associations between the TDSS system and the risky driving behaviors.

Table 4.5 Distributions of the red speeding initiative tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Red Speeding Initiative	**n**	%	**n**	%	**n**	%
Low	7	**15.6**	23	**39.7**	19	**42.2**
Moderate	11	**24.4**	22	**37.9**	17	**37.8**
High	27	**60.0**	13	**22.4**	9	**20.0**

A Chi-square test was conducted and demonstrated the distributions for red speeding initiative risk was significantly different by TDSS treatment group, ($\chi^2 = 21.905$, $p < 0.001$).

Table 4.6 Distributions of the red speeding parent initiative tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Red Speeding Parent Initiative	**N**	%	**n**	%	**n**	%
Low	1	**2.2**	18	**31.0**	30	**66.7**
Moderate	12	**26.7**	26	**44.8**	12	**26.7**
High	32	**71.1**	14	**24.1**	3	**6.7**

A Chi-square test was conducted and demonstrated the distributions for red speeding parent initiative risk was significantly different by TDSS treatment group, ($\chi^2 = 62.333$, $p < 0.001$).

Table 4.7 Distributions of the texting tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Texting	**N**	%	**n**	%	**n**	%
Low	4	**8.9**	25	**43.1**	20	**44.4**
Moderate	7	**15.6**	26	**44.8**	17	**37.8**
High	34	**75.6**	7	**12.1**	8	**17.8**

A Chi-square test was conducted and demonstrated the distributions for texting risk was significantly different by TDSS treatment group, ($\chi^2 = 53.640$, $p < 0.001$).

Table 4.8 Distributions of the hard acceleration tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Hard Acceleration	**N**	%	**n**	%	**n**	%
Low	14	**31.1**	15	**25.9**	21	**46.7**
Moderate	13	**28.9**	20	**34.5**	15	**33.3**
High	18	**40.0**	23	**39.7**	9	**20.0**

A Chi-square test was conducted and demonstrated the distributions for hard acceleration risk was significantly different by TDSS treatment group, Chi-square test (χ^2 = 7.281, p = 0.122).

Table 4.9 Distributions of the hard braking tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Hard Braking	**N**	%	**n**	%	**n**	%
Low	15	**33.3**	14	**24.1**	20	**44.4**
Moderate	9	**20.0**	22	**37.9**	18	**40.0**
High	21	**46.7**	22	**37.9**	7	**15.6**

A Chi-square test was conducted and demonstrated the distributions for hard braking risk was significantly different by TDSS treatment group, (χ^2 = 13.477, p < 0.01).

Table 4.10 Distributions of the hard turning tertiles across TDSS groups

	Control (*n*=45)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Hard Turning	**n**	%	**n**	%	**n**	%
Low	11	**24.4**	22	**37.9**	17	**37.8**
Moderate	14	**31.1**	16	**27.6**	18	**40.0**
High	20	**44.4**	20	**34.5**	10	**22.2**

A Chi-square test was conducted and demonstrated the distributions for hard turning risk was significantly different by TDSS treatment group, (χ^2 = 6.211, p = 0.184).

4.1.2 Early Risky Driving and Traffic Violation Behaviors

The following session consisted of an overall description of the state-recorded traffic violation behaviors, as well as summary results of several multivariate analyses examining the relationships between risky early driving and the traffic violation outcomes.

4.1.2.1 State-recorded traffic violation behaviors

Stated-recorded traffic violation behaviors, including crashes and traffic citations/tickets, were obtained from the Minnesota Department of Public Safety upon the participant's written authorization. Overall, more than 80% of the participants within all of the three groups were crash-free over approximately six years after they obtained the full driver's license (See Table 4.11). There were four injury or possible injury crashes resulting from a total of N = 26 crashes (See Table 4.12).

Table 4.11 Frequencies of participants' crash involvements recorded since full licensure

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
	N	*%*	**n**	*%*	**n**	*%*
Crash-free	**39**	*83.0*	**48**	*82.8*	**40**	*88.9*
One crash	**7**	*14.9*	**8**	*13.8*	**5**	*11.1*
Two crashes	**1**	*2.1*	**2**	*3.4*	**0**	*0.0*

Table 4.12 Distributions of the severity level of crashes

	Control (n =9)		TDSS (*n*=12)		TDSS+ (*n*=5)	
	N	*%*	**n**	*%*	**N**	*%*
No injury	**8**	*88.9*	**11**	*91.7*	**3**	*60.0*
Possible injury	**1**	*11.1*	**1**	*8.3*	**1**	*20.0*
Non-incapacitating injury	**0**	*0.0*	**0**	*0.0*	**1**	*20.0*

A total of *N* = 65 traffic citations/tickets were documented from this cohort of young drivers (see Table 4.13). Approximately 70% of the young drivers have maintained a crash-free record from traffic citations or tickets. Excessive speeding-related citations/tickets were observed to be the most prevalent type of traffic citation/ticket, accounting for 89.5%, 70.1% and 86.4% of all recorded citations/tickets within the Control, TDSS, and TDSS+ groups, respectively (see Table 4.14).

Table 4.13 Frequencies of participants' citation/ticket involvement recorded since full licensure

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
	n	*%*	**n**	*%*	**N**	*%*
Citation/ticket-free	**35**	*74.5*	**40**	*69.0*	**32**	*71.1*
One citation/ticket	**8**	*17.0*	**15**	*25.9*	**9**	*20.0*
Two citations/tickets	**2**	*4.3*	**1**	*1.7*	**0**	*0.0*
Three citations/tickets	**1**	*2.1*	**1**	*1.7*	**3**	*6.7*
Four citations/tickets	**1**	*2.1*	**1**	*1.7*	**1**	*2.2*

Table 4.14 Distributions of citation/ticket type

	Control (*n*=19)		TDSS (*n*=24)		TDSS+ (*n*=22)	
	n	*%*	**n**	*%*	**n**	*%*
Excessive speeding	**17**	*89.5*	**17**	*70.1*	**19**	*86.4*
Driving under the influence	**0**	*0.0*	**3**	*12.5*	**0**	*0.0*
Careless driving	**1**	*5.3*	**1**	*4.2*	**1**	*4.5*
Fail to obey traffic control device	**0**	*0.0*	**3**	*12.5*	**1**	*4.5*
Texting or using unsafe equipment	**1**	*5.3*	**0**	*0.0*	**1**	*4.5*

4.1.2.2 The Relationship between Early Risky Driving and Traffic Violation Behaviors

The analyses in the previous sections demonstrated the efficacy of the TDSS intervention to reduce risk-taking behaviors, such as speeding and texting, among the sample cohort from the original TDSS FOT. The over dispersion of teens in the control group within the high tertile for risky behaviors compared to the TDSS and TDSS+ groups allow us to use these tertile distributions to examine the relationship of this risk engagement in the first year of driving (as mediated by the TDSS treatment) to long-term safety outcomes as measured through state-recorded citations/violations and crashes. These risk distributions have been modeled in a multivariate analysis, see Table 4.15 and Error! **Not a valid bookmark self-reference.** provides the same analysis but focuses on the likelihood of crash outcomes by the tertile group status for risky behaviors measured in the first year of licensure. The total crash count appears to be too small to demonstrate if any signification differences exist. The analyses demonstrated that, based

on this sample, there were no significant differences on the likelihood of crash by engagement in risky behaviors in the first year of licensure.

Table 4.16, using Poisson regressions to examine the relationship between early risky driving and long-term safety outcomes, i.e., traffic violations and crashes.

Table 4.15 indicates the rate of citations/tickets outcomes measured for young drivers who demonstrated either low, moderate, or high engagement in risky behaviors during the first year of driving. The analyses provide a rate ratio across the three tertiles and their likelihood to have received a crash or citation since licensure. Moderate and high tertile groups are compared to the low tertile group for each of the risky behaviors, significant differences denoted in bold. The young drivers in the moderate and high tertile groups for all risky measurements, with the exception of Red Speeding Parent Initiative and Texting, were significantly more likely to have a citation/ticket than those in the low risk-taking group. Only young drivers who had high Red Speed Parent Initiative had significantly higher likelihood of ticket/citation compared to the low group. Finally, only young drivers who had moderate texting while driving had significantly higher likelihood of ticket/citation compared to the low group.

Table 4.15 Multivariate analyses on the relationship between early risky driving and traffic violations through Poisson regressions

	Traffic Citations/Tickets (Total *N*=65)			
	Rate	**95% CI**	**Estimated RR**	**95% CI**
Speeding-related Risky Driving				
Red Speeding Initiative				
Low	0.02	0.01-0.05	1.00	----------
Moderate	0.07	0.05-0.11	**3.14**	**1.33-7.42**
High	0.12	0.08-0.16	**5.13**	**2.24-11.77**
Red Speeding Parent Initiative				
Low	0.06	0.04-0.09	1.00	----------
Moderate	0.05	0.03-0.08	0.99	0.49-2.02
High	0.11	0.08-0.15	**1.86**	**1.03-3.36**
Texting Behaviors				
Texting				
Low	0.05	0.03-0.08	1.00	----------
Moderate	0.10	0.07-0.14	**2.11**	**1.07-4.16**
High	0.07	0.04-0.10	1.49	0.74-2.98
Harsh Driving Maneuvers				
Hard Acceleration				
Low	0.03	0.02-0.06	1.00	----------
Moderate	0.10	0.06-0.14	**3.02**	**1.39-6.59**
High	0.10	0.06-0.13	**3.04**	**1.43-6.49**
Hard Baking				
Low	0.03	0.01-0.05	1.00	----------
Moderate	0.08	0.06-0.13	**3.17**	**1.40-7.15**
High	0.10	0.07-0.14	**4.05**	**1.83-8.95**
Hard Turning				

Low	0.02	0.01-0.05	1.00	----------
Moderate	0.10	0.06-0.14	**3.91**	**1.69-9.04**
High	0.10	0.07-0.14	**4.10**	**1.78-9.49**

Error! Not a valid bookmark self-reference. provides the same analysis but focuses on the likelihood of crash outcomes by the tertile group status for risky behaviors measured in the first year of licensure. The total crash count appears to be too small to demonstrate if any signification differences exist. The analyses demonstrated that, based on this sample, there were no significant differences on the likelihood of crash by engagement in risky behaviors in the first year of licensure.

Table 4.16 Multivariate analyses on the relationship between early risky driving and crashes through Poisson regressions

	Traffic Crash (Total *N*=26)			
	Rate	**95% CI**	**Estimated RR**	**95% CI**
Speeding-related Risky Driving				
Red Speeding Initiative				
Low	0.02	0.01-0.04	1.00	----------
Moderate	0.03	0.02-0.06	2.32	0.77-4.59
High	0.04	0.02-0.06	1.53	0.52-4.59
Red Speeding Parent Initiative				
Low	0.03	0.01-0.05	1.00	----------
Moderate	0.01	0.01-0.04	0.47	0.14-1.59
High	0.05	0.03-0.08	1.56	0.64-3.80
Texting Behaviors				
Texting				
Low	0.02	0.01-0.05	1.00	----------
Moderate	0.03	0.02-0.06	1.33	0.43-4.05
High	0.04	0.02-0.06	1.54	0.53-4.48
Harsh Driving Maneuvers				
Abrupt Acceleration				
Low	0.03	0.02-0.06	1.00	----------
Moderate	0.02	0.01-0.04	0.63	0.21-1.91
High	0.04	0.02-0.06	0.98	0.41-2.34
Hard Baking				
Low	0.04	0.02-0.07	1.00	----------
Moderate	0.02	0.01-0.05	0.55	0.20-1.52
High	0.03	0.02-0.06	0.80	0.31-2.04
Hard Turning				
Low	0.02	0.01-0.04	1.00	----------
Moderate	0.03	0.02-0.06	1.97	0.65-5.92
High	0.04	0.02-006	1.67	0.55-5.04

4.1.3 Summary of Results

Risky driving behaviors in early licensures, such as excessive speeding and elevated g-force events, have been well-recognized as strong precedent predictors for later crash involvement. In these current

investigations, the TDSS system demonstrated significant direct treatment effects on reducing the rates of various risky driving outcomes over the first year of independent driving. Simultaneously, the rates of later citation/ticket involvement were found to increase with the increase in the levels of all risky driving behaviors exhibited by young drivers, except for texting. However, due to small sample sizes, significant associations between the risky driving behaviors and crashes were not observed in the current assessment.

The implementation of the smartphone based TDSS application enabled real-time acquisition of complex naturalistic driving data, as well as reliable detections of risky behaviors under different driving conditions. Such risky behaviors may serve as sensitive indicators for the risks of later involvement in a traffic violation event. As a result, it is recommended that a smartphone-based system, such as the TDSS, could be adopted as a practical, easily applicable, and low-cost driving intervention method to modify driver behaviors among younger drivers.

CHAPTER 5: CONCLUSIONS

5.1 STUDY OVERVIEW

The original TDSS FOT was a remarkable endeavor of deploying a novel technology to 300 Minnesota novice teen drivers in their first year of independent licensure (Creaser et al., 2015). The project was the largest study of its kind and demonstrated the power of a low-cost technology to supplement parental guidance and supervision of teens in their most vulnerable year of driving. Importantly, the results of the study demonstrated the success of the smartphone application to restrict and nearly eliminate texting while driving, engagement in speeding, and excessive driving maneuvers, i.e., hard braking, steering, and acceleration.

This approach is unique because it features longitudinal efforts to systematically and thoroughly evaluate a uniquely designed in-vehicle coaching system, by taking advantage of the richness of qualitative and quantitative data collected for young drivers from late adolescence to early adulthood. Although ample previous literature exists that examines crashes in general, knowledge on risk factors associated with traffic citations and tickets among young drivers appears to be limited, especially in terms of how these associations are moderated by a sophisticated real-time intervention. This study establishes a fundamental analysis infrastructure to inform an in-depth understanding of the efficacy of the TDSS for mitigating traffic violations among drivers of the highest risk and advocating long-term safety.

5.2 EXPERIMENT DATA CONCLUSIONS

The research team can draw several broad conclusions from the presented data of relevance to safety experts and practitioners responsible for novice and teen driver education, policymaking, and technology engagement. An updated analysis of the TDSS FOT with the longitudinal sample of 150 participants reaffirmed that the TDSS intervention, i.e., both in-vehicle coaching only and in-vehicle coaching with parental feedback, successfully reduced risky driving behaviors such as speeding, hard braking, and texting. Examining the unequal distribution of these risky driving behaviors across the three experimental groups (i.e., with significantly more control group teens in the high-risk tertile) further cemented the efficacy of the system to reduce risk taking by teen drivers in their first year of independent driving.

While the sample size gathered in this study may have been too small to directly link the TDSS experimental group type to long-term crash and citation outcomes for this cohort of young drivers, the influence of early risk taking was predictive of these outcomes. Multivariate analyses indicated that young drivers who demonstrated high engagement in risky behaviors such as speeding, hard braking, and texting were more likely to have a traffic citation/ticket in the five to six years following licensure than their peers who demonstrated less frequent risky driving engagement. Similar patterns of rate differences were observed with crashes; however, these differences were not significant as the overall number of crashes likely resulted in insufficient power to observe any effect, should it exist.

The study not only examined the pathways from TDSS intervention to the reductions in traffic violation outcomes via various mediating factors, but it also provided insights into several important influencing factors on young driver behaviors among the current cohort. These factors, including season, work status, and vehicle motion status, were typically not well recognized by previous literature. This analysis framework for developing semi-structured survey questions through focus group interviews facilitates the identification of novel aspects of driving-related issues specifically targeted for this driver age group. Further research investigations could be recommended to explore whether and how these factors will modify driving behaviors, driving risks, and relevant crashes and/or injuries in the future.

5.3 BENEFITS EVALUATION

Together the TDSS application development and field operational test was an important and significant endeavor that utilized taxpayer dollars to pursue what was at that time an innovative cutting-edge technology. Today, there are many systems on the marketplace that families can seek out to provide added support for their novice teen drivers. The long-term efficacy of these commercially available systems has been largely unknown. This study provides some insight into the effect that the TDSS may have served as a mediator to reduce the long-term risk of citations among those who received the in-vehicle coaching and may have been even larger among those whose parents received feedback about their teen's performance. It not only provides a follow up to the TDSS study to further explore the localized benefit it may have had on its participants, but it also aims to determine to what extent families, schools, and other organizations should continue to invest in using in-vehicle coaching systems, similar to the TDSS, in the future. Ultimately, the TDSS is a low-cost system that may help to guide cost-effective implementations to reduce crashes among teens or other driver groups in the future.

The research team had initially identified two areas that were expected to have measurable outcomes regarding the project's key benefits: improved safety and reduced risk.

5.3.1 Improved Safety

This study addresses a significant public health concern that is directly associated with the goal of Toward Zero Deaths (TZD) in Minnesota. In 2018 alone, Minnesota teenage drivers aged 15-19 years old were involved in 12,664 crashes of all types (including 42 fatal crashes), which accounted for an estimated $199,459,400 in aggregated total costs (Minnesota Department of Public Safety [DPS], 2019), see Table 5.1. Notably, 15-year-olds represented the least impacted age group, with those drivers involved in only 229 crashes, two of which were fatal. Overall, Minnesota teenage drivers aged 15-19 accounted for only 6.0% of all licensed drivers; however, they accounted for 16% of all traffic crashes in the state (Minnesota DPS, 2019).

Table 5.1 Cost of teen-involved motor vehicle crashes in 2018

Crash Frequency	Severity of Injury	Estimated Cost per Crash	Estimated Aggregated Costs
42	Deaths	$1,615,000	$67,830,000
174	Severe Injuries	$93,800	$16,321,200
1,177	Minor Injuries	$27,100	$31,896,700
1,993	Possible Injuries	$22,300	$44,443,900
9,278	PDO Crashes	$4,200	$38,967,600
		Total Costs: 12,664 Crashes of All Types ($199,459,400)	

This study aimed to determine if in-vehicle coaching technology, when implemented at early licensure, can result in fewer crashes and citations among young adults. This outcome would improve public health and financial burden through fewer crashes.

5.3.2 Reduced Risk

This study was anticipated to establish a substantial analysis framework that thoroughly evaluates the effectiveness of an in-vehicle support system on modifying traffic violation behaviors and driver perceptions among teen to young adult drivers aged 16 to 20. Importantly, the study was expected to determine reduced risk of traffic violation or citation/ticket through the introduction of the TDSS intervention. Further, the study was expected to measure any possible attitudinal or risk perception changes toward driving safety because of the TDSS intervention. For example, it has been shown that teenage drivers are more likely to develop inaccurate risk perceptions of many driving conditions, such as underestimating the influence of peers on their driving performance (Ginsburg et al., 2008), but this may have been altered through the monitoring of passengers in the TDSS study. Overall, this study has been particularly relevant from a societal risk standpoint given the value of longitudinal measurement studies to demonstrate long-term benefits of changing attitudes/behaviors among teens and parents.

5.3.3 Quantification Approach

The study was successfully able to quantify risk reduction outcomes through the examination of state-documented citations. The study analyses demonstrated that the likelihood of receiving a ticket in early adulthood was predicted by risk-taking behaviors in the first year of independent driving. Those who have high engagement in speeding initiation have a rate of 0.12 citations per driver per year and a risk ratio of 5.13 for receiving a citation compared to those who have low engagement in speeding in the first year. This was one of several early risk-taking measures found to be predictive of long-term citation outcomes. Our study results suggested that investing in early prevention and intervention methods to prevent risky behaviors, such as speeding and hard braking, can reduce the long-term risk of citations among young adult drivers.

The estimated cost of a speeding ticket in Minnesota is $145 for 15 mph over the limit and the total cost is $520 when accounting for three years of insurance premium increases (Kuo, 2014). While the extent of speeding for study participants varies over the past five to six years, it is estimated that the 53

excessive speeding citations, the most frequent type of citation, initially cost study drivers $7,685, and the eventual total costs accounting for insurance premium increases amounted to $27,560.

The Minnesota Department of Public Safety reported that there were 101,757 licensed drivers aged 16 and 17 in Minnesota in 2013. By 2018, this cohort of 20- to 21-year-olds would be estimated to represent 125,184 licensed drivers. Evenly segmenting this population into tertiles for low, moderate, and high risk of speeding, we could conservatively estimate that 41,728 people in the cohort may have demonstrated similar speeding behaviors as the TDSS control group in their first year of independent driving. Applying the rate estimates from our study, we would estimate that 5,007 of these young drivers might receive a traffic citation or ticket each year totaling 25,037 tickets over the five-year span of their early licensure. The total cost of these tickets over a five-year period would be $13,019,136 when accounting for fees and insurance premiums. We predict that an intervention, such as the TDSS with parental feedback, applied to these drivers in their first year of independent driving would have reduced the likelihood of early speeding engagement by greater than half based on our study results. Estimating that half of the high-risk tertile population of young drivers aged 20 to 21 in 2018 in Minnesota, i.e., 20,864, or half of the estimated 41,728 high-risk cohort, could have been influenced to match the behavior and ultimate citation rate of their low-risk peers (i.e., a rate of 0.02 citations per driver), the number of estimated citations would be 417 per year or 2,085 over a five-year period. This outcome would reduce citations over a five-year period by 7,755, amounting to reduced costs of $4,032,600, approximately three times the amount of the financial investment that supported the original development and research of the TDSS application and field operational test and this follow-up research.

The study resulted in less clear outcomes regarding improved safety. The sample size was too small for crashes to determine if the TDSS intervention had any ultimate impact on these crash rates and final costs. Additionally, the risk engagement in the first year of driving did not yield significant predictions for crash outcomes. Nonetheless, the estimated cost of the 22 crashes with property damage only for the teens in the study is $92,400 and the documented injury crashes (i.e., 3 possible and 1 minor) are estimated to cost $90,200. However, if the same estimates of high-risk young drivers in Minnesota are applied to the rate of crashes observed in our study, a similar pattern emerges. The rate of crashes per driver per year for the high-risk tertile group in our study is 0.04 compared to 0.02 for the low-risk group. Using the same estimate of 41,728 high-risk young drivers aged 20 to 21 in 2018 in Minnesota, we conservatively estimate that 1,669 of them may have a documentable property damage only (PDO) crash each year and the group as a whole would have 8,346 crashes over their first five years of licensure. Applying estimates from Table 1, the total costs of these PDO crashes would amount to $35,053,200 over a five-year period. We similarly estimate that the TDSS with parental feedback may have influenced half of these young drivers, i.e., 20,864, to match the behavior and ultimate crash rate of their low-risk peers (i.e., 0.02 crashes per driver). Applying this lower rate to half of the high-risk cohort would reduce their number of PDO crashes over a five-year period from 4,173 to 2,086. This would reduce the estimated costs of the PDO crashes by $8,765,400.

Overall, these estimates suggest that the investment in this research may lay the groundwork to support the deployment of more in-vehicle coaching systems to novice teen drivers. The TDSS, or systems with similar functionality and feedback, has been demonstrated to be effective solutions to reducing risk-taking in the first year of driving and this application could result in greater long-term safety and financial gains by reducing the rate of citations and crashes among young drivers.

5.4 EXPERIMENT LIMITATIONS AND FUTURE DIRECTIONS

There were several possible limitations of this follow-up survey study on selection bias and recall bias. First, it is unknown whether the driving perceptions for those who failed to be reconnected with the researchers would be the same as the respondents enrolled in the current study. Second, a fair amount of missing data was also observed, particularly concerning participants' involvement in a specific type of crash or citation/ticket. These missing data were further imputed based on the additional narrative descriptions provided by the participants for individual types of traffic violations in order to remove the disparities from the self-reported total crashes or citation/ticket involvement. Moreover, since some of the survey questions directly examined participants' driving experiences over the past five to six years, it might be difficult for participants to provide accurate and reliable information through memory recall.

There is immense opportunity to further this research to enhance our understanding of the long-term risks to young drivers and which early or late prevention or intervention strategies might result in greater safety outcomes. The present study may be strengthened through another sampling of the TDSS cohort in another five years. This may increase the duration and ultimate study power to capture any differences that may exist in crash outcomes across the experimental groups. Namely, it is suspected that a substantial proportion of the 150 participants had seasonally limited driving exposure while they were in college. Now that many of these participants have now graduated, their driving exposure, along with ultimate crash-risk exposure, may increase. Future studies may better capture how early driving and risk exposure results in long-term driving risk as these young drivers relocate to new areas or take new positions that result in greater driving. Additionally, future studies may refine recruitment methods to capture a larger percentage of the original 300 TDSS cohort, although as time goes by, successfully re-contacting participants will become more difficult than experienced in the present study.

This work has been extended to older drivers, aged 65 and older, in a series of design investigations, controlled field tests, and a pilot field operational test with promising results (see, Morris, Craig, Libby, & Cooper, 2018; Libby, Morris, Craig, 2019). The study findings demonstrated strong user acceptance of the modified TDSS in-vehicle support system, renamed RoadCoach, among the older drivers and indicated promise in reducing hard braking and stop sign running behaviors during and after feedback periods. This work should be continued to investigate the efficacy of reducing other risky behaviors, such as speeding, over a longer exposure period and longer follow-up periods to determine long-term behavior changes. This work may also be expanded to determine the technology's ability to detect driving performance changes as a result of cognitive declines, such as dementia or Alzheimer's disease, or to prolong safe, independent driving among those with mild cognitive impairment. Overall, this technology offers great promise to support other high-risk drivers, such as teens with attention deficit disorder, military service members returning from deployments, and adult novice drivers, or simply drivers in general who are seeking technological support for safe driving and real-time coaching.

Future research deployments of in-vehicle coaching technology should include a longitudinal data collection plan so that this type of long-term contact is more easily established. Engaging in more

frequent data collection (e.g., yearly) would also be beneficial to reduce the risk of inaccurate or unreliable recall of crashes, citations, and overall risk engagement of drivers compared to recalling risky events over a five-year period. Overall, this work is expected to guide other studies to similarly engage in valuable longitudinal study of young drivers to provide critical solutions to reduce traffic deaths on our roadways.

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APPENDIX A
UPDATED SURVEY QUESTIONNAIRE

Final Survey Materials

Greetings! We are pleased to have you once again as a participant in the research project conducted by the HumanFIRST Laboratory at the University of Minnesota. This current project serves as a follow-up study of the Teenage Driver Support System (TDSS) project, in which you were involved at the time when you were a novice teenage driver.

**********BELOW IS INFORMATION ON THE PREVIOUS STUDY**********

In the previous TDSS project, we had a smartphone coaching system installed into your vehicle. Using this system, we managed to obtain your real-time driving data throughout a one-year period after you were licensed. If you may recall, the system was able to provide some level of driving feedback to you, and it may or may not send warning messages to your parents regarding your driving performance. However, depending on which experimental group you were initially assigned to, it is also very possible that the smartphone did not seem to have any of these functions and it just appeared no different from a regular smartphone.

If you may have trouble with recalling your participation in this previous project or if you may have any questions regarding how the system works, please feel free to contact the researcher for further explanation.

**********BELOW IS INFORMATION ON THE CURRENT SURVEY STUDY**********

Now that you have become a more experienced driver, we are interested in learning whether and to what extent the TDSS system might have assisted you with learning to drive safely during your journey of early licensure. Specifically, the current survey study aims to help us gain knowledge of the effectiveness of this specific system in reducing traffic violations behaviors over time (e.g., some examples may include speeding tickets, violation of traffic sign/signal, driving under influences, failure to wear a seatbelt, etc.). Moreover, we would also like to gather your valuable input on how your driving risks, attitudes, and behaviors might have changed over the years from late adolescence to early adulthood. This longitudinal study will help us better understand the potential of using any smartphone coaching system in teenage driver education, as well as provide useful information to help state safety agencies with relevant policy making.

You will need to complete a survey questionnaire, which contains seven parts and includes a total of 110 (for the control group) or 114 (for the intervention groups) short-answer or multiple-choice questions within sixteen pages. The overall survey takes about 1.5 hours to complete. To start, you will be asked to provide your previous and current driver license number(s). The purpose of requesting this information is to help us obtain accurate and reliable data on traffic violation records from the Minnesota Department of Public Safety upon receiving your consent. PLEASE KEEP IN MIND: ALL OF YOUR PERSONAL INFORMATION OR RECORDS WILL BE CONFIDENTIAL.

We highly appreciate your time! A **$100 VISA/CHECK CARD** will be mailed to you immediately upon your completion of all survey sessions. Now let us get started!

Table of Contents

[Note: After the participant complete a specific section, the corresponding red "X" will change to a green checkmark for that section.]

PART I: DRIVER'S LICENSE

The below questions inquire about information on your driver's license. All of the data is CONFIDENTIAL. The research team cannot release your personal information to anybody or a third party without your authorization.

Q1: Please provide a scanned image or take a picture of the front of your Minnesota driver's license (regular Class D). Make sure it is legible.

[Upload the file in here]

OR type in your full name and Minnesota driver's license number:

Your Full Name: _____

Your Minnesota driver's license number: □□□□□□□□□□□□□

Q2: Have you ever been issued a regular driver's license in another state? [Skip if not applicable]

- □ Yes
- □ No

If yes, please provide a scanned image or take a picture of your driver's license in another state.

[Upload the file in here]

OR type in your driver's license number in another state:

You driver's license number in another state _____

Q1 and Q2 will be used for requesting your driving records during the past five years from the state safety agencies. Your name, picture and other personal information will be de-identified in the research (i.e., you will be assigned to a unique participant ID). However, we will not be able to access the data without your authorization. Your approval is sincerely appreciated by the research team!

Q3. Please download the authorization form and upload a signed copy with your handwritten signature (i.e., pdf file, a scanned image, or picture).

[Download Authorization Form.docx]

[Upload a signed copy in here]

Q4: Has your driver's license ever been suspended in the past five years?

- □ Yes
- □ No

If yes, please specify the reason(s) _____

Q5: Has your driver's license ever been revoked in the past five years?

- □ Yes
- □ No

If yes, please specify the reason(s) _____

Q6: Do you possess other types of driver's license, in addition to regular (i.e. Class D in Minnesota) driver's license? (**Select all that may apply**)

- □ Only regular driver's license
- □ Motorcycle license
- □ Any type of commercial driver's license (e.g., Class A, Class B, or Class C in Minnesota)
- □ Other, feel free to specify _____

Q7: Since you have had your driver's license (e.g., independent driving), how many times have you been involved in any reportable traffic accidents/crashes (e.g., reported to police, insurance, or required auto body repair)?

- ☐ None
- ☐ Once
- ☐ Twice
- ☐ More than twice (specify the total number_____)

Q8: Please indicate the type and number(s) of traffic ACCIDENTS/CRASHES that you have been issued, since you have had your driver's license:

Type of Accident/Crash	Yes	No	Number
I rear-ended another vehicle. (1)	o	o	
I hit another vehicle, but it was not a rear end collision. (2)	o	o	
I hit a stationary object, e.g., a parked car, tree, lamp post, parking lot object, etc. (3)	o	o	
I hit another road user that was not a vehicle, e.g., pedestrian, bicycle, etc. (4)	o	o	
Another vehicle hit me—any crash type (5)	o	o	
Not in a collision with anything, e.g., rollover, run-off-road, etc. (6)			
Other (7)	o	o	

Q9. Since you have had your driver's license, how many times have you received CITATIONS/TICKETS for traffic offenses?

- ☐ None
- ☐ Once
- ☐ Twice
- ☐ More than twice (specify the total number_____)

Q10. Please indicate the type and number(s) of traffic CITATIONS/TICKETS that you have been involved in the past five years.

	Yes	No	Number
Speeding (1)	o	o	
Stop sign violation (2)	o	o	
Disobey traffic signal/sign (such as ran a red light No Turn on Red (3)	o	o	
Not wearing a seat belt (4)	o	o	
Driving under the impairment of alcohol or drugs (5)	o	o	
Careless/dangerous driving (6)	o	o	
Graduated Driver Licensing violation (teen passenger, curfew violation midnight to 5 a.m.) (7)	o	o	
Texting, talking or otherwise interacting with a phone while driving (8)	o	o	
Received a warning for one of the above offenses (but not a ticket) (9)	o	o	
Non-moving offenses, e.g., registration, parking violations, etc. (10)	o	o	
Other (11)			

If you have received any WARNING(S) from police, please specify the reason(s)_____

PART II: DEMOGRAPHIC INFORMATION

The following questions collect information on your demographics, your work status, and your vehicle status. All answers are CONFIDENTIAL.

Q1: Please provide your date of birth: MM: _____/ DD: _____/ YYYY: _____

Q2: Please select your gender:

- ☐ Male
- ☐ Female
- ☐ Other (feel free to specify)_____

Q3: Please select your ethnicity:

- ☐ White
- ☐ Black or African American
- ☐ Asian
- ☐ Hispanic or Latino
- ☐ Other

Q4: What is the highest level of education you have received or **are currently working towards**?

- ☐ Some high school – no diploma
- ☐ High school graduate or equivalent
- ☐ Some college or Associate' degree
- ☐ Bachelor's degree
- ☐ Advanced degree (e.g., M.S., Ph.D., etc.)
- ☐ Other, feel free to specify_____

Q5: If you are currently a student, what is your cumulative GPA this academic year?

- ☐ Less than 2.5
- ☐ ≥ 2.5 and < 3.0
- ☐ ≥ 3.0 and < 3.3
- ☐ ≥ 3.3 and < 3.7
- ☐ Equal to or greater than 3.7

Q6: Please state your work status during the first year(s) of your provisional driver's license (i.e., drive independently) or **before 18 years old**:

- ☐ No, I didn't have a job
- ☐ Yes, I had a part-time or full-time job

If yes for Q6, in general, were the following statements true or not?

	Yes	**No**
I worked only during the summer	☐	☐
I worked only on weekends	☐	☐
I worked during:		
Day shift (i.e., 6:00 am-2:00 pm)	☐	☐
Afternoon shift (i.e., 2:00 pm-10:00 pm)	☐	☐
Night shift (i.e., 10:00 pm -6:00 am)	☐	☐
I drove a car to and from work	☐	☐
My job involved operating a vehicle, e.g., drove forklift, commercial driver, etc.	☐	☐

Q7: Please state your work status in the past two years or **between 19 to 22 years old**:

- ☐ No, I didn't have a job at any time
- ☐ Yes, I had a part-time or full-time job for one year
- ☐ Yes, I had a part-time or full-time job during both years

If yes for Q7, in general, were the following statements true or not during the year(s) that you worked:

	Yes	**No**
I worked only during the summer	☐	☐
I worked only on weekends	☐	☐
I worked during:		
Day shift (i.e., 6:00 am-2:00 pm)	☐	☐
Afternoon shift (i.e., 2:00 pm-10:00 pm)	☐	☐
Night shift (i.e., 10:00 pm -6:00 am)	☐	☐
I drove a car to and from work	☐	☐
My job involved operating a vehicle, e.g., drove forklift, commercial driver, Uber driver, etc.	☐	☐

Q8: In general, what is your vehicle status during the below times in the past year?

During SUMMER:

- ☐ I don't have a car with me
- ☐ I drive my own vehicle.
- ☐ I drive a shared vehicle with family members or friends
- ☐ Carpool
- ☐ Other, please specify _____

During SCHOOL SEMESTER(S):

- ☐ I don't have a car with me
- ☐ I drive my own vehicle.
- ☐ I drive a shared vehicle with family members or friends
- ☐ Carpool
- ☐ Other, please specify _____

Q9: What type of vehicle(s) do you drive most frequently? (**Select all that may apply**)

- ☐ Passenger Car or Sedan
- ☐ Pick-up Truck
- ☐ Sports Utility Vehicle (SUV)
- ☐ Van or Minivan
- ☐ Motorcycle
- ☐ Others, please specify_____

Q10: Have you ever experienced any major life event since you received your driver's license?

- ☐ Personal events (e.g., severe injury, mental diagnosis, got married or pregnant, etc.)
- ☐ Parent-related events (e.g., Loss of a parent, parental divorce or marriage, etc.)
- ☐ Changes in the financial state of your family (e.g., bankrupted, ran into debts, etc.)
- ☐ None of the above
- ☐ If yes, please briefly specify the event(s) _____

Participant ID:_____ Date of Participation:___/___/_____(MM/DD/YYYY) Version: #05

PART III: DRIVING FREQUENCY

The following questions survey your driving experience in the **PAST 12 MONTHS**.

Questions	During SUMMER	During SCHOOL SEMESTER(S)
Q1: On average, how often did you drive per week?	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week
Q2: In general, what was the **main purpose** for you to drive? **(Select One)**	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____
Q3: On average, how many days per week did you drive at DAWN or DUSK?	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week

Q4: In general, what was the **main purpose** for you to drive at DAWN or DUSK? **(Select One)**	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____
Questions	**During SUMMER**	**During SCHOOL SEMESTER(S)**
Q5. On average, how many days per week did you drive in the evening between 9:00 P.M. and MIDNIGHT?	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week	☐ Not at all ☐ 1-2 days a week ☐ 3-4 days a week ☐ 5-6 days a week ☐ Every day of the week
Q6. In general, what was the **main purpose** for you to drive in the evening between 9:00 P.M. and MIDNIGHT? **(Select One)**	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ N/A ☐ Other, please specify_____

Q7. On average, how many days per **month** did you drive between MIDNIGHT and 5:00 A.M.?	☐ Not at all ☐ Once a month ☐ Twice a month ☐ More than three times a month ☐ Very frequently driving during the month ☐ Other, please specify_____	☐ Not at all ☐ Once a month ☐ Twice a month ☐ More than three times a month ☐ Very frequently driving during the month ☐ Other, please specify_____
Q8. What was the main purpose for you to drive in the evening between MIDNIGHT and 5:00 A.M.? **(Select One)**	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ Long distance travel ☐ N/A ☐ Other, please specify_____	☐ Travel to or from work-related events ☐ Travel to or from school-related events ☐ Go for grocery, shopping, eating, etc. ☐ Pick up friends and family members ☐ Travel to or from social events, e.g., parties, movies. ☐ Go to or from the bars ☐ Long distance travel ☐ N/A ☐ Other, please specify_____
Questions	**During SUMMER**	**During SCHOOL SEMESTER(S)**
Q9. Please provide an estimated percentage for each type of the roads that you might drive on in the past 12 months:	Out of the time I was driving, I drove on… ☐ Neighborhood roads (≤ 30mph) _____% of the time ☐ Urban roads (30mph-45mph)_____% of the time ☐ State/Interstate Highway and freeways (45mph-60mph)_____% of the time ☐ Rural roads (≥ 60mph) _____% of the time	Out of the time I was driving, I drove on… ☐ Neighborhood roads (≤ 30mph) _____% of the time ☐ Urban roads (30mph-45mph)_____% of the time ☐ State/Interstate Highway and freeways (45mph-60mph)_____% of the time ☐ Rural roads (≥ 60mph) _____% of the time

Participant ID:_____ Date of Participation:___/___/_____(MM/DD/YYYY) Version: #05

PART IV: DRIVING BEHAVIORS

In general, on the days you drove, how often did you do the following while driving?

Driving Behaviors	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
Exceed the speed limit in residential or school zones (1)	o	o	o	o	o
Drive 10 to 19 miles per hour over the speed limit (2)	o	o	o	o	o
Drive 20 miles per hour over the speed limit (3)	o	o	o	o	o
Purposely tailgate or follow someone too closely (4)	o	o	o	o	o
Switch lanes to weave through other traffic (5)	o	o	o	o	o
Change lanes without enough room between cars (6)	o	o	o	o	o
Cut in front of a car to turn (7)	o	o	o	o	o
Pull out into traffic without waiting for a large space between vehicles (8)	o	o	o	o	o
Make an illegal U-turn (9)	o	o	o	o	o
Go through an intersection when the light was yellow or just turning yellow (10)	o	o	o	o	o
Go through an intersection when the light was red or just turning red (11)	o	o	o	o	o
Go through a stop sign without stopping completely (12)	o	o	o	o	o
Drive after drinking alcohol or using illegal drugs (13)	o	o	o	o	o
Change lanes without signaling (14)	o	o	o	o	o
Play the radio so loudly you can't hear other vehicle horns or sirens (15)	o	o	o	o	o
Drive without wearing a seat belt (16)	o	o	o	o	o
Race another vehicle, even for just a short distance (17)	o	o	o	o	o
Read, eat, talk on a cell phone, put on makeup, horse around with passengers, or other such activities while driving (18)	o	o	o	o	o
Drive in a way to show off to other people (19)	o	o	o	o	o

Insist your passengers to wear their seat belts if they haven't done so (20)	o	o	o	o	o
Driving Behaviors	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
Talk on your cell phone while driving (21)	o	o	o	o	o
Send text messages while driving (22)	o	o	o	o	o
Drive between midnight and 5 a.m. (23)	o	o	o	o	o
Drive between 9 p.m. and midnight (24)	o	o	o	o	o
Drive too fast for the conditions (e.g., bad weather) (25)	o	o	o	o	o
Drive tired and sleepy (to the point of nodding off) (26)	o	o	o	o	o

Specifically, how often did you engage with cellular devices under the following circumstances?

When your vehicle was <u>NOT in motion</u> (e.g., when stopped at a red light, or when in stop-and-go traffic):	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Often (4)**	**Always (5)**
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	o	o	o	o	o
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	o	o	o	o	o
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	o	o	o	o	o
Change the music on/change songs	o	o	o	o	o
Navigate maps on the phone	o	o	o	o	o
When your vehicle <u>was in motion</u> (e.g., drove at low-speed roads of less than 30 mph, or when there are no other cars around)	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Often (4)**	**Always (5)**
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	o	o	o	o	o
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	o	o	o	o	o
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	o	o	o	o	o

Change the music on/change songs	o	o	o	o	o
Navigate maps on the phone	o	o	o	o	o

PART V: DRIVING RISKS

Q1. Please indicate how strongly you would agree on the following statements regarding PASSENGERS:

Statements on Passengers	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The presence of the passenger(s) does not affect my driving in general	○	○	○	○	○
Multiple passengers are distracting to my driving	○	○	○	○	○
Having conversations with the passenger(s) is overwhelming, especially when I drive on urban roads	○	○	○	○	○
Having conversations with the passenger(s) protects me from mind wandering and keeps me concentrated, especially when I drive on highways or freeways	○	○	○	○	○
I am less influenced by the passenger(s) now compared to when I was a teenage driver	○	○	○	○	○

Q2 to Q5 ask about your general opinions on alcohol consumption and driving:

Q2. How much alcohol can you drink within one hour and feel comfortable driving after drinking?
- □ 0 drink
- □ 1 drink
- □ 2 drinks
- □ 3-4 drinks
- □ More than 4 drinks

Q3. On the days you drove, how often have you driven after having ONE alcoholic drink in the previous hour?
- □ Never
- □ Once in a month
- □ Twice in a month
- □ More than twice in a month
- □ Other, feel free to specify_____

Q4. On the days you drove, how often have you driven after TWO OR MORE alcoholic drinks in the previous hour?
- □ Never
- □ Once in a month
- □ Twice in a month
- □ More than twice in a month
- □ Other, feel free to specify_____

Q5. How often do you use alternative transportation after drinking? (e.g., designated driver, Uber, public transit, etc.)
- □ Never (0% of the time)
- □ Hardly Ever (1%-10% of the time)
- □ Occasionally/Sometimes (11%-50% of the time)
- □ Quite Often (50%-75% of the time)
- □ Frequently (76%-90% of the time)
- □ Nearly all the time (91%-100% of the time)

Q6 to Q8 inquire some of your additional feedback on how you may engage with cellular devices in the vehicle:

Q6. In general, WHEN did you engage with cellular devices? **(Select no more than TWO)**

- ☐ I engaged with my cellular devices whenever needed.
- ☐ When there were no other cars nearby
- ☐ When I drove on low-speed roads (≤30 mph)
- ☐ When I drove at any speed
- ☐ When in stop-and-go traffic
- ☐ When stopped at a red light
- ☐ N/A
- ☐ Other, please specify_____

Q7. In general, WHERE did you hold your phone in the car when using it (e.g., navigation, change music, etc.)?

- ☐ In a fixed phone mount
- ☐ In your lap
- ☐ In the cup holder
- ☐ Hold the phone in your hand
- ☐ On the passenger seat
- ☐ N/A
- ☐ Other, feel free to specify_____

Q8. In general, what types of information/instructions did you rely on when using NAVIGATION on the phone while driving?

- ☐ I relied on audio instructions only, and I didn't need to check on maps.
- ☐ I had to check on maps occasionally while listening to the audio information/instructions
- ☐ I mainly relied on maps rather than audio information/instructions
- ☐ I turned off audio information/instructions
- ☐ N/A
- ☐ Other, feel free to specify_____

Q9. Please indicate to what extent you would agree on the following statements regarding YOUR DRIVING PERFORMANCE AND SAFETY:

Statements on Your Driving Performance	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
In general, I feel I can drive safely while feeling fatigued and drowsy.	○	○	○	○	○
In general, I feel I can drive safely in the morning (i.e., after sunrise and before 9:00 am the next day) after a night of heavy drinking.	○	○	○	○	○
In general, I feel I can drive safely in the afternoon (i.e., after 12:00 pm the next day) a night of heavy drinking.	○	○	○	○	○
I think my driving skills are better than the average.	○	○	○	○	○
I think I have adopted safer driving habits than the average.	○	○	○	○	○
Compared to my peers, I feel I am less distracted by passengers or cellular devices when I drive.	○	○	○	○	○
Compared to my peers, I feel I comply more with the traffic rules when I drive.	○	○	○	○	○

Q10. In reference to the Posted Speed Limit (PSL), please provide an estimated speed on how fast you would generally drive for each type of the roads/conditions listed in the below table (excluding the condition of traffic congestion):

Type of Road/Condition	Below the PSL	Equal to the PSL	1-3 mph above the PSL	3-7 mph above the PSL	7-10 mph above the PSL	10-15 mph above the PSL	15-20 mph above the PSL
Neighborhood Roads (≤ 30mph)	o	o	o	o	o	o	o
Urban roads (30mph-45mph)	o	o	o	o	o	o	o
State/Interstate Highways or Freeways (45mph-60mph)	o	o	o	o	o	o	o
Rural Roads (≥ 60mph)	o	o	o	o	o	o	o
School Zone (15mph-25mph)	o	o	o	o	o	o	o
Highway Work Zone (≤40mph)	o	o	o	o	o	o	o

Q11: How many of YOUR FRIENDS would you estimate have experienced the following things?

Driving Behaviors	Number of Friends				
	0	1-2	3-4	5-6	≥ 7
Drive after having one alcoholic drink in the previous hour	o	o	o	o	o
Drive after having two or more alcoholic drinks in the previous hour	o	o	o	o	o
Exceed speed limits over 10 to 19 miles	o	o	o	o	o
Do not use their seat belt while driving as a driver or passenger	o	o	o	o	o
Have been convicted of traffic offenses (e.g., speeding tickets, etc.) since licensure. (Excluding parking tickets)	o	o	o	o	o

PART VI: RISK PERCEPTION

How much risk for crash or injury do you think are associated with driving under the following conditions? (i.e., circle your answer based on a 1-7 scale, with one being the least dangerous and seven being the most dangerous)

Driving Conditions	From the least (1) to the most dangerous (7)						
Drive under the influence of alcohol (1)	1	2	3	4	5	6	7
Drive while not wearing a seat belt (2)	1	2	3	4	5	6	7
Drive with passengers in the vehicle (3)	1	2	3	4	5	6	7
Drive late at night on the weekend (4)	1	2	3	4	5	6	7
Drive outside of local or familiar areas (5)	1	2	3	4	5	6	7
Drive with one passenger (6)	1	2	3	4	5	6	7
Drive between 9 p.m. and midnight (7)	1	2	3	4	5	6	7
Drive in bad weather (for example, snow, ice, heavy rain) (8)	1	2	3	4	5	6	7
Drive on unfamiliar roads (9)	1	2	3	4	5	6	7
Drive with several passengers on a weekend night (10)	1	2	3	4	5	6	7
Drive late at night during the week (11)	1	2	3	4	5	6	7
Drive on freeways or expressways (12)	1	2	3	4	5	6	7
Exceed the speed limit in residential or school zones (12)	1	2	3	4	5	6	7
Drive 10 to 19 miles per hour over the speed limit (13)	1	2	3	4	5	6	7
Drive 20 miles per hour over the speed limit (14)	1	2	3	4	5	6	7
Drive drowsy and sleepy (to the point of nodding off) (15)	1	2	3	4	5	6	7
Disobey traffic sign/signal (e.g., running stop sign, make an illegal U-turn, etc.) (16)	1	2	3	4	5	6	7
Drive carelessly (e.g., fail to detect road hazards) (17)	1	2	3	4	5	6	7

Exhibit road rage or drive aggressively (18)	1	2	3	4	5	6	7
Demonstrate poor driving habits (e.g., change lanes without signaling) (19)	1	2	3	4	5	6	7

Specifically, how much risk for crash or injury do you think are associated with engaging with cellular devices? (i.e., circle your answer based on a 1-7 scale, with 1 being the least dangerous and 7 being the most dangerous)

When your vehicle was <u>NOT in motion</u> (e.g., when stopped at a red light, when in stop-and-go traffic):	**From the least (1) to the most dangerous (7)**						
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	1	2	3	4	5	6	7
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	1	2	3	4	5	6	7
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	1	2	3	4	5	6	7
Change the music on/change songs	1	2	3	4	5	6	7
Navigate maps on the phone	1	2	3	4	5	6	7
When your vehicle <u>was in motion</u> (e.g., drove at low-speed roads of less than 30 mph, or when there are no other cars around)	**From the least (1) to the most dangerous (7)**						
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	1	2	3	4	5	6	7
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	1	2	3	4	5	6	7
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	1	2	3	4	5	6	7
Change the music on/change songs	1	2	3	4	5	6	7
Navigate maps on the phone	1	2	3	4	5	6	7

PART VII: DRIVER EDUCATION AND IN-VEHICLE TECHNOLOGIES

Q1: Which one(s) of the following motivated you the most to comply with traffic rules? **(Select no more than TWO)**

- ☐ Safety considerations for myself
- ☐ Reduce insurance rate
- ☐ Avoid Fines
- ☐ Parental restrictions
- ☐ Safety considerations for others
- ☐ I am more inclined to comply with traffic rules when all other drivers on the road also comply with traffic rules
- ☐ Other, please specify_____

Q2: What do you think is/are the most effective way(s) for teenage drivers to adopt safe driving SKILLS? **(Select no more than TWO)**

- ☐ Take behind the wheel training with an instructor
- ☐ Take driving classes, e.g., learn traffic rules, watch crash videos, etc.
- ☐ Supervised by a parent/guardian
- ☐ Supervised by an older sibling
- ☐ Provide the in-vehicle driving support system to teens, such as real-time feedback and monitoring
- ☐ Advocate safe driving in the neighborhoods or on the roads
- ☐ Enhance law enforcement, e.g., raise fines, etc.
- ☐ Other, please specify_____

Q3. What do you think is/are the most effective way(s) for teenage drivers to adopt safe driving HABITS? **(Select no more than TWO)**

- ☐ Take behind the wheel training with an instructor
- ☐ Take driving classes, e.g., learn traffic rules, watch crash videos, etc.
- ☐ Supervised by a parent/guardian
- ☐ Supervised by an older sibling
- ☐ Provide the in-vehicle driving support system to teens, such as real-time feedback and monitoring
- ☐ Advocate safe driving in the neighborhoods or on the roads
- ☐ Enhance law enforcement, e.g., raise fines, etc.
- ☐ Other, please specify_____

Q4. What types of in-vehicle technology or smartphone application do you most frequently use while driving? **(Select all that apply)**

- ☐ Bluetooth system
- ☐ Navigation applications, e.g., google maps, apple maps, etc.
- ☐ Other navigation and live traffic applications, e.g., Waze, etc.
- ☐ In-vehicle cameras, e.g., backing up camera, etc.
- ☐ Adaptive Cruise system
- ☐ Emergency Braking assistance
- ☐ Fuel efficiency or mpg monitor
- ☐ Hybrid cars
- ☐ Other, please specify_____

Q5. What novel technology have you heard of and would most like to have in your vehicle? **(Select no more than TWO)**

- ☐ Advanced in-vehicle navigation systems
- ☐ In-vehicle camera systems
- ☐ Blind spot mirrors
- ☐ Emergency Braking, e.g., with pedestrian detection, etc.
- ☐ Fuel efficiency or mpg monitor
- ☐ Advanced hybrid control systems
- ☐ Pilot assistance, i.e., autonomous driving, etc.
- ☐ Other, please specify_____

Please answer Q6 to Q9 based on your experience with the smartphone application (i.e., Teen Driver Support System—TDSS) in the previous project:

Q6. Driving with the TDSS has been beneficial in helping me learn to drive since I received my license. (Please indicate how strongly you agree or disagree).

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Somewhat Disagree
- ☐ Neutral
- ☐ Somewhat Agree
- ☐ Agree
- ☐ Strongly Agree

Q7. Ignoring any issues that might have occurred during the study because of the nature of experimental equipment, what is your overall opinion of the TDSS?

- ☐ Very Poor
- ☐ Poor
- ☐ Fair
- ☐ Good
- ☐ Very Good

Q8. Ignoring any issues that might have occurred during the study because of the experimental nature of the software and equipment, what is your overall opinion of the usefulness of the TDSS?

- ☐ Very Useless
- ☐ Useless
- ☐ Neutral
- ☐ Useful
- ☐ Very Useful

Q9. How likely would you be to recommend the TDSS (if it were a finished product) to other teens and parents for use in the first year of driving?

- ☐ Very Unlikely
- ☐ Unlikely
- ☐ Undecided
- ☐ Likely

☐ Very Likely

[Note: Q6 to Q9 will only be available for the two intervention groups.]

APPENDIX B
SURVEY DATA SUMMARY

SURVEY DATA SUMMARY

The following appendix summarized statistics and trends for reporting various aspects of driving perceptions among the current cohort of young drivers. Several relevant factors that were previously identified via the focus group interviews, such as season, work status and others, were evaluated against the self-reported driving frequency ratings among these drivers. Following that, this summary also provided assessments of the changes on drivers' self-reported risky driving behaviors as well as their perceived risks, through comparing to data extracted from the Month 1, Month 6 and Month 12 surveys in the original study. Drivers' opinions on driving education, in-vehicle technologies, along with their preferences on the TDSS system, were discussed at the end of this summary.

Survey Part III. Driving Frequency

Effect of Season (Table B-1 to Table B-2):

- Consistent with the focus group analysis results, young drivers (averaging across all three experimental groups) in general tended to drive significantly more frequently during summertime compared to school semesters.
- The main effect of season was found to be the greatest for the total driving frequency per week (Mean Score Diff = 0.60, SE = 0.11, $p < 0.0001$), as well as the driving frequency between midnight and 5:00 am per month (Mean Score Diff= 0.54, SE = 0.09, $p < 0.0001$)**.**

Main Driving Purpose (Table B-3 and Table B-4):

- In general, participants were significantly more likely to drive as a result of travelling to or from work-related events during summertime compared to school semesters (OR=4.87, 95% CI=2.28-10.43). However, this trend was reversed for driving after 9:00 pm until 5:00 am, where the main purpose of driving was significantly less likely to be work-relevant during summertime.
- Comparing to the control group, the main driving purpose between midnight and 5:00 am were more prone to be work-relevant among participants in both of the TDSS intervention groups.

Survey Part IV. Driving Behaviors

Self-reported Behavioral Changes over Time (Table B-7):

- As with the increase in follow-up time, young drivers overall were more likely to report a significantly greater frequency for demonstrating all of the risky behaviors, except for "Cut in front of a car to turn", "Rate another vehicle, even for just a short distance", and "Drive in a way to show off to other people".
- None of the TDSS treatment effects or the interaction effects between the survey time and the TDSS group were significant.

Cellular Device Use (Table B-8 and Table B-9):

- The results of the effect of vehicle motion status on participants' cellular device uses were controversial from those suggested by the focus group interviews. Participants overall were found to more frequently engage with cellular devices in a moving vehicle compared to a non-moving vehicle. Consistently, in Table B-17 and Table B-18, greater risks for the use of cellular devices were perceived when the vehicle was in motion versus not.

- Female drivers reported to engage more frequently with the cellular activities of “Change the music on/change songs” and ” Navigate maps on the phone” than male drivers.

Survey Part V. Driving Risks

Influences of Passenger(s) (Table B-10):

- Approximately 60% of the young drivers perceived the presence of passengers did not affect their driving, regardless of the number of passengers. Moreover, 34.0% agreed, and 6.0% even strongly agreed that having conversations with the passenger(s) protected them from mind-wandering and kept them concentrated, especially when driving on highways or freeways.
- Up to 87.3% of the respondents agreed or strongly agreed on the statement of “I am less influenced by the passenger(s) now compared to when I was a teenage driver”.

Alcohol Drinking and Driving (Table B-11):

- On average, 36.7% of the young driver cohort never drove after having one alcoholic drink, and 76.0% never drove after having two alcoholic drinks in the previous hour. 68.0% of the respondents reported to use alternative transportation after drinking frequently or nearly all the time.

Engagement with Cellular Devices (Table B-12):

- Consistent with the results of Table B-7, young drivers reported more frequent engagement with the cellular devices, when stopped at a red light or in stop-and-go traffic. The other common driving conditions for a driver to engage with the cellular devices were when driving on low-speed roads (≤30 mph) and when there was no other vehicle nearby.
- The most common place for holding the phone in the car while using it was found to be in the cup holder, followed by in the participant’s lap, and in a fixed phone mount.
- The majority of young drivers reported that when using the navigation on the phone while driving, they had to look at maps occasionally while listening to the audio information/instructions.

Driving Performance and Safety (Table B-13):

- Young drivers were generally overconfident in their driving performance. In particular, 65.1% of them felt that their driving skills were better than the average driver, whereas 82.0% of them perceived that they had adopted safer driving habits than the average driver. The interpretations of “a safe driver” varied by whether it was referred to driving skills or driving habits.
- More than 70% of the drivers would agree that compared to their peers, they were less distracted by passenger or cellular devices while driving. These drivers also reported that they were more complied with the traffic rules as well.

Perceived Driving Speed (Table B-14):

- Young drivers tended to drive at a higher speed on the road with a greater Posted Speed Limit (i.e., PSL). It was worthwhile to note that 89.3% of them drove at greater than 4-7 mph above the PSL, and 38.0% drove at greater than 8-10 mph above the PSL on the state/interstate highways or freeways (45mph-60mph). For rural roads (≥ 60mph), 80.7% drove at greater than 4-7 mph above the PSL, and 36.7% drove at greater than 8-10 mph above the PSL.

- Drivers were more likely to follow the PSL while driving in the School Zone (i.e., 68.6% of them drove at a speed below or equal to the PSL) and the Highway Work Zone (i.e., 60.7% of them drove at a speed below or equal to the PSL).

Survey Part VI. Risk Perceptions

- The perceived risk for crash or injury was the highest for the driving condition of "under the influence of alcohol," followed by "drive 20 miles per hour over the speed limit", and "drive drowsy and sleeping (to the point of nodding off)". The mean risk scores equal to 6.7, 5.8, and 5.5, respectively, based on a 1 to 7 scale.
- "Drive with one passenger" was associated with the lowest perceived risk for crash and injury (Mean score=1.5).

Survey Part VII: Driver Education and In-Vehicle Technologies

- The top three motivations for participants to comply with traffic rules were ranked as "safety considerations for myself", "safety considerations for others", and "avoid fines".
- Different types of approaches were considered as the most effective interventions for teenage drivers to promote "safe" driving. For adopting safe driving skills, taking behind the wheel training with an instructor or taking driving classes were selected as the top two approaches that were more effective during early driving. In contrast, young drivers perceived that in-vehicle driving support and parental supervision to be the most effective in terms of cultivating safe driving habits.
- Bluetooth system and navigation applications were identified as the most frequently used in-vehicle technologies or applications among these young drivers while driving.
- Regarding novel in-vehicle technology, drivers reported that they would most like to have Blind Spot Mirrors, Emergency Braking, and Advanced in-vehicle navigation systems in their vehicle. Interestingly, the current young driver cohort seemed to hold a conservative attitude on autonomous driving technology, since zero selected Pilot assistance as the most desirable technology to have in a vehicle.
- Positive feedback has been received from the majority of participants in the TDSS intervention groups, regarding the system's capability in helping drivers learn to drive, as well as its overall usefulness.
- Over 90% of the participants in both intervention groups would be likely or very likely to recommend the finished product of the TDSS system to other teens and parents for use in the first year of driving.

The findings of this current research provided better insights into understanding young drivers' opinions on important driving-related information, as well as those impact factors that have been less recognized by previous literature.

Survey Part III. Driving Frequency

For analyses of driving frequency responses in Table B-1 and Table B-2, a weighted score ranging from 1 to 5 was assigned to represent each of the five ordered categories (e.g., Not at all=1, 1-2 days a week=2, 3-4 days a week=3, 5-6 days a week=4, and Every day of the week=5).

Table B-1. Participants' driving frequency in the past 12 months (during summer)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
On average, how often did you drive per week (1)?	n	**%**	n	**%**	n	**%**
Not at all	2	**4.3**	6	**10.3**	1	**2.2**
1-2 days a week	5	**10.6**	2	**3.4**	0	**0.0**
3-4 days a week	4	**8.5**	3	**5.2**	3	**6.7**
5-6 days a week	15	**31.9**	22	**37.9**	13	**28.9**
Every day of the week	21	**44.7**	24	**41.4**	28	**62.2**
On average, how many days per week did you drive at DAWN or DUSK (2)?						
Not at all	4	**8.5**	7	**12.1**	1	**2.2**
1-2 days a week	12	**25.5**	5	**8.6**	5	**11.1**
3-4 days a week	10	**21.3**	24	**41.4**	12	**26.7**
5-6 days a week	13	**27.7**	24	**41.4**	13	**28.9**
Every day of the week	8	**17.0**	7	**12.1**	13	**28.9**
On average, how many days per week did you drive in the evening between 9:00 P.M. and MIDNIGHT (3)?						
Not at all	6	**12.8**	9	**15.5**	2	**4.4**
1-2 days a week	17	**36.2**	21	**36.2**	13	**28.9**
3-4 days a week	13	**27.7**	14	**24.1**	16	**35.6**
5-6 days a week	7	**14.9**	10	**17.2**	9	**20.0**
Every day of the week	4	**8.5**	3	**5.2**	4	**8.9**
On average, how many days *per month* did you drive between MIDNIGHT and 5:00 A.M. (4)?						
Not at all	13	**27.7**	17	**29.3**	3	**6.7**
Once a month	7	**14.9**	7	**12.1**	12	**26.7**
Twice a month	7	**14.9**	7	**12.1**	13	**28.9**
More than three times a month	16	**34.0**	16	**27.6**	10	**22.2**
Very frequently driving during the month	4	**8.5**	6	**10.3**	7	**15.6**

Table B-2. Participants' driving frequency in the past 12 months (during school semesters)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
On average, how often did you drive per week (1)?	n	%	n	%	n	%
Not at all	4	**8.5**	9	**15.5**	3	**6.7**
1-2 days a week	6	**12.8**	10	**17.2**	2	**4.4**
3-4 days a week	10	**21.3**	10	**17.2**	8	**17.8**
5-6 days a week	12	**25.5**	10	**17.2**	16	**35.6**
Every day of the week	14	**29.8**	15	**25.9**	16	**35.6**
On average, how many days per week did you drive at DAWN or DUSK (2)?						
Not at all	8	**17.0**	10	**17.2**	3	**6.7**
1-2 days a week	11	**23.4**	14	**24.1**	9	**20.0**
3-4 days a week	10	**21.3**	12	**20.7**	15	**33.3**
5-6 days a week	8	**17.0**	11	**19.0**	8	**17.8**
Every day of the week	9	**19.1**	8	**13.8**	9	**20.0**
On average, how many days per week did you drive in the evening between 9:00 P.M. and MIDNIGHT (3)?						
Not at all	10	**21.3**	13	**22.4**	3	**6.7**
1-2 days a week	15	**31.9**	20	**34.5**	19	**42.2**
3-4 days a week	13	**27.7**	14	**24.1**	15	**33.3**
5-6 days a week	5	**10.6**	6	**10.3**	4	**8.9**
Every day of the week	3	**6.4**	2	**3.4**	3	**6.7**
On average, how many days *per month* did you drive between MIDNIGHT and 5:00 A.M. (4)?						
Not at all	18	**38.3**	20	**34.5**	11	**24.4**
Once a month	11	**23.4**	11	**19.0**	13	**28.9**
Twice a month	6	**12.8**	11	**19.0**	10	**22.2**
More than three times a month	10	**21.3**	7	**12.1**	9	**20.0**
Very frequently driving during the month	1	**2.1**	6	**10.3**	2	**4.4**

For analyses of the main driving purposes in Table B-3 and Table B-4, the survey responses were further categories into binary outcomes of either work-related or non-work related, to evaluate whether significant differences existed in the traveling purposes by season, particularly those pertaining to work-related events, among these young drivers.

Table B-3. Participants' main purpose for driving in the past 12 months (during summer)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
In general, what was the **main purpose** for you to drive (1)?	n	%	n	%	n	%
Travel to or from work-related events	39	**83.0**	42	**72.4**	38	**84.4**
Travel to or from school-related events	0	**0.0**	0	**0.0**	0	**0.0**
Go for grocery, shopping, eating, etc.	3	**6.4**	5	**8.6**	2	**4.4**
Pick up friends and family members	0	**0.0**	1	**1.7**	0	**0.0**
Travel to or from social events, e.g., parties, movies.	3	**6.4**	5	**8.6**	2	**4.4**

Go to or from the bars	0	**0.0**	0	**0.0**	0	**0.0**
Long distance travel	1	**2.1**	1	**1.7**	3	**6.7**
N/A	1	**2.1**	3	**5.2**	0	**0.0**
Other	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	1	**1.7**	0	**0.0**
Your main purpose to drive at DAWN or DUSK (2)						
Travel to or from work-related events	7	**14.9**	7	**12.1**	12	**26.7**
Travel to or from school-related events	11	**23.4**	13	**22.4**	9	**20.0**
Go for grocery, shopping, eating, etc.	10	**21.3**	11	**19.0**	8	**17.8**
Pick up friends and family members	1	**2.1**	4	**6.9**	2	**4.4**
Travel to or from social events, e.g., parties, movies.	5	**10.6**	9	**15.5**	6	**13.3**
Go to or from the bars	0	**0.0**	0	**0.0**	1	**2.2**
Long distance travel	3	**6.4**	1	**1.7**	3	**6.7**
N/A	6	**12.8**	7	**12.1**	1	**2.2**
Other	1	**2.1**	3	**5.2**	2	**4.4**
Missing	3	**6.4**	3	**5.2**	1	**2.2**
Your main purpose to drive in the evening between 9:00 P.M. and MIDNIGHT (3)						
Travel to or from work-related events	12	**25.5**	8	**13.8**	15	**33.3**
Go for grocery, shopping, eating, etc.	0	**0.0**	5	**8.6**	3	**6.7**
Pick up friends and family members	7	**14.9**	1	**1.7**	4	**8.9**
Travel to or from social events, e.g., parties, movies.	17	**36.2**	34	**58.6**	16	**35.6**
Go to or from the bars	3	**6.4**	2	**3.4**	3	**6.7**
Long distance travel	3	**6.4**	2	**3.4**	2	**4.4**
N/A	5	**10.6**	5	**8.6**	1	**2.2**
Other	0	**0.0**	0	**0.0**	1	**2.2**
Missing	0	**0.0**	1	**1.7**	0	**0.0**
Your main purpose to drive in the evening between MIDNIGHT and 5:00 A.M. (4)						
Travel to or from work-related events	7	**14.9**	10	**17.2**	8	**17.8**
Go for grocery, shopping, eating, etc.	0	**0.0**	1	**1.7**	0	**0.0**
Pick up friends and family members	4	**8.5**	1	**1.7**	5	**11.1**
Travel to or from social events, e.g., parties, movies.	15	**31.9**	20	**34.5**	16	**35.6**
Go to or from the bars	5	**10.6**	3	**5.2**	6	**13.3**
Long distance travel	4	**8.5**	5	**8.6**	3	**6.7**
N/A	11	**23.4**	17	**29.3**	6	**13.3**
Other	1	**2.1**	0	**0.0**	1	**2.2**
Missing	0	**0.0**	1	**1.7**	0	**0.0**

Table B-4. Participants' main purpose for driving in the past 12 months (during school semesters)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
In general, what was the **main purpose** for you to drive (1)?	n	**%**	n	**%**	n	**%**
Travel to or from work-related events	16	**34.0**	10	**17.2**	16	**35.6**
Travel to or from school-related events	17	**36.2**	21	**36.2**	18	**40.0**
Go for grocery, shopping, eating, etc.	7	**14.9**	11	**19.0**	5	**11.1**

Pick up friends and family members	0	**0.0**	1	**1.7**	0	**0.0**
Travel to or from social events, e.g., parties, movies.	1	**2.1**	1	**1.7**	0	**0.0**
Go to or from the bars	0	**0.0**	0	**0.0**	1	**2.2**
Long distance travel	0	**0.0**	2	**3.4**	1	**2.2**
N/A	4	**8.5**	5	**8.6**	1	**2.2**
Other	0	**0.0**	1	**1.7**	1	**2.2**
Missing	2	**4.3**	6	**10.3**	2	**4.4**
Your main purpose to drive at DAWN or DUSK (2)						
Travel to or from work-related events	13	**27.7**	17	**29.3**	17	**37.8**
Travel to or from school-related events	13	**27.7**	10	**17.2**	9	**20.0**
Go for grocery, shopping, eating, etc.	6	**12.8**	8	**13.8**	9	**20.0**
Pick up friends and family members	0	**0.0**	3	**5.2**	0	**0.0**
Travel to or from social events, e.g., parties, movies.	4	**8.5**	3	**5.2**	1	**2.2**
Go to or from the bars	0	**0.0**	0	**0.0**	1	**2.2**
Long distance travel	1	**2.1**	3	**5.2**	2	**4.4**
N/A	7	**14.9**	8	**13.8**	3	**6.7**
Other	1	**2.1**	0	**0.0**	1	**2.2**
Missing	2	**4.3**	6	**10.3**	2	**4.4**
Your main purpose to drive in the evening between 9:00 P.M. and MIDNIGHT (3)						
Travel to or from work-related events	8	**17.0**	5	**8.6**	10	**22.2**
Travel to or from school-related events	3	**6.4**	4	**6.9**	4	**8.9**
Go for grocery, shopping, eating, etc.	3	**6.4**	8	**13.8**	2	**4.4**
Pick up friends and family members	7	**14.9**	3	**5.2**	3	**6.7**
Travel to or from social events, e.g., parties, movies.	10	**21.3**	19	**32.8**	17	**37.8**
Go to or from the bars	5	**10.6**	3	**5.2**	2	**4.4**
Long distance travel	0	**0.0**	1	**1.7**	2	**4.4**
N/A	9	**19.1**	2	**3.4**	2	**4.4**
Other	0	**0.0**	0	**0.0**	1	**2.2**
Missing	2	**4.3**	6	**10.3**	2	**4.4**
Your main purpose to drive in the evening between MIDNIGHT and 5:00 A.M. (4)						
Travel to or from work-related events	4	**8.5**	6	**10.3**	6	**13.3**
Travel to or from school-related events	0	**0.0**	4	**6.9**	1	**2.2**
Go for grocery, shopping, eating, etc.	0	**0.0**	0	**0.0**	1	**2.2**
Pick up friends and family members	6	**12.8**	0	**0.0**	5	**11.1**
Travel to or from social events, e.g., parties, movies.	11	**23.4**	17	**29.3**	11	**24.4**
Go to or from the bars	8	**17.0**	4	**6.9**	4	**8.9**
Long distance travel	0	**0.0**	5	**8.6**	2	**4.4**
N/A	16	**34.0**	16	**27.6**	11	**24.4**
Other	0	**0.0**	0	**0.0**	2	**4.4**
Missing	2	**4.3**	6	**10.3**	2	**4.4**

Table B-5. Estimated percentages for each type of the roads driving in the past 12 months (during summer)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+(*n*=45)	
Type of Road	Mean	**SD**	Mean	**SD**	Mean	**SD**
Neighborhood Roads (≤ 30mph)	22.2	**18.9**	25.9	**22.0**	24.4	**18.8**
Urban Roads (30mph-45mph)	23.3	**16.0**	25.1	**17.6**	23.6	**14.4**
State/Interstate Highway and Freeways (45mph-60mph)	38.8	**22.5**	35.9	**20.9**	37.2	**18.6**
Rural Roads (≥ 60mph)	15.7	**19.7**	9.8	**11.1**	14.8	**15.6**

Table B-6. Estimated percentages for each type of the roads driving in the past 12 months (during school semesters)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+(*n*=45)	
Type of Road	Mean	**SD**	Mean	**SD**	Mean	**SD**
Neighborhood Roads (≤ 30mph)	27.1	**25.5**	24.9	**21.3**	26.5	**21.7**
Urban Roads (30mph-45mph)	23.9	**17.8**	25.9	**21.0**	25.1	**18.6**
State/Interstate Highway and Freeways (45mph-60mph)	29.3	**19.0**	29.6	**21.2**	33.7	**20.6**
Rural Roads (≥ 60mph)	11.8	**17.2**	8.0	**12.3**	12.4	**12.6**

Survey Part IV. Driving Behaviors

Table B-7. Participants' driving behaviors

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Exceed the speed limit in residential or school zones (1)	n	**%**	n	**%**	n	**%**
Never	6	**12.8**	9	**15.5**	9	**20.0**
Rarely	16	**34.0**	21	**36.2**	13	**28.9**
Sometimes	18	**38.3**	19	**32.8**	16	**35.6**
Often	7	**14.9**	9	**15.5**	6	**13.3**
Always	0	**0.0**	0	**0.0**	1	**2.2**
Drive 10 to 19 miles per hour over the speed limit (2)						
Never	12	**25.5**	19	**32.8**	14	**31.1**
Rarely	19	**40.4**	27	**46.6**	23	**51.1**
Sometimes	8	**17.0**	6	**10.3**	7	**15.6**
Often	7	**14.9**	6	**10.3**	1	**2.2**
Always	1	**2.1**	0	**0.0**	0	**0.0**
Drive 20 miles per hour over the speed limit (3)						
Never	34	**72.3**	47	**81.0**	36	**80.0**
Rarely	11	**23.4**	10	**17.2**	9	**20.0**
Sometimes	2	**4.3**	1	**1.7**	0	**0.0**
Often	0	**0.0**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Purposely tailgate or follow someone too closely (4)						
Never	33	**70.2**	35	**60.3**	21	**46.7**
Rarely	10	**21.3**	18	**31.0**	17	**37.8**
Sometimes	4	**8.5**	5	**8.6**	6	**13.3**

Often	0	**0.0**	0	**0.0**	1	**2.2**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Switch lanes to weave through other traffic (5)						
Never	15	**31.9**	22	**37.9**	19	**42.2**
Rarely	17	**36.2**	23	**39.7**	13	**28.9**
Sometimes	10	**21.3**	9	**15.5**	9	**20.0**
Often	5	**10.6**	3	**5.2**	4	**8.9**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	1	**1.7**	0	**0.0**
Change lanes without enough room between cars (6)						
Never	26	**55.3**	44	**75.9**	30	**66.7**
Rarely	17	**36.2**	12	**20.7**	12	**26.7**
Sometimes	4	**8.5**	2	**3.4**	3	**6.7**
Often	0	**0.0**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Cut in front of a car to turn (7)						
Never	33	**70.2**	41	**70.7**	30	**66.7**
Rarely	14	**29.8**	16	**27.6**	14	**31.1**
Sometimes	0	**0.0**	1	**1.7**	1	**2.2**
Often	0	**0.0**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**

Table B-7. Participants' driving behaviors (Continued)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
Pull out into traffic without waiting for a large space between vehicles (8)	n	**%**	n	**%**	n	**%**
Never	15	**31.9**	33	**56.9**	16	**35.6**
Rarely	29	**61.7**	18	**31.0**	19	**42.2**
Sometimes	2	**4.3**	6	**10.3**	8	**17.8**
Often	1	**2.1**	1	**1.7**	1	**2.2**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	0	**0.0**	1	**2.2**
Make an illegal U-turn (9)						
Never	22	**46.8**	24	**41.4**	18	**40.0**
Rarely	16	**34.0**	21	**36.2**	16	**35.6**
Sometimes	7	**14.9**	10	**17.2**	9	**20.0**
Often	2	**4.3**	3	**5.2**	2	**4.4**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Go through an intersection when the light was yellow or just turning yellow (10)						
Never	0	**0.0**	1	**1.7**	0	**0.0**
Rarely	3	**6.4**	6	**10.3**	3	**6.7**
Sometimes	23	**48.9**	21	**36.2**	18	**40.0**
Often	19	**40.4**	27	**46.6**	20	**44.4**
Always	2	**4.3**	3	**5.2**	4	**8.9**
Go through an intersection when the light was red or just turning red (11)						
Never	18	**38.3**	27	**46.6**	20	**44.4**
Rarely	23	**48.9**	27	**46.6**	21	**46.7**

Sometimes	4	**8.5**	4	**6.9**	4	**8.9**
Often	2	**4.3**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Go through a stop sign without stopping completely (12)						
Never	6	**12.8**	20	**34.5**	11	**24.4**
Rarely	14	**29.8**	13	**22.4**	15	**33.3**
Sometimes	14	**29.8**	15	**25.9**	10	**22.2**
Often	10	**21.3**	10	**17.2**	9	**20.0**
Always	3	**6.4**	0	**0.0**	0	**0.0**
Drive after drinking alcohol or using illegal drugs (13)						
Never	30	**63.8**	46	**79.3**	31	**68.9**
Rarely	15	**31.9**	10	**17.2**	10	**22.2**
Sometimes	2	**4.3**	2	**3.4**	3	**6.7**
Often	0	**0.0**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	0	**0.0**	1	**2.2**
Change lanes without signaling (14)						
Never	25	**53.2**	28	**48.3**	21	**46.7**
Rarely	19	**40.4**	20	**34.5**	15	**33.3**
Sometimes	3	**6.4**	7	**12.1**	5	**11.1**
Often	0	**0.0**	3	**5.2**	3	**6.7**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	0.0	0	**0.0**	1	**2.2**

Table B-7. Participants' driving behaviors (Continued)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
Play the radio so loudly you can't hear other vehicle horns or sirens (15)	n	**%**	n	**%**	n	**%**
Never	18	**38.3**	29	**50.0**	12	**26.7**
Rarely	12	**25.5**	8	**13.8**	9	**20.0**
Sometimes	10	**21.3**	14	**24.1**	14	**31.1**
Often	7	**14.9**	7	**12.1**	9	**20.0**
Always	0	**0.0**	0	**0.0**	1	**2.2**
Drive without wearing a seat belt (16)						
Never	41	**87.2**	52	**89.7**	37	**82.2**
Rarely	3	**6.4**	3	**5.2**	5	**11.1**
Sometimes	2	**4.3**	2	**3.4**	2	**4.4**
Often	1	**2.1**	1	**1.7**	1	**2.2**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Race another vehicle, even for just a short distance (17)						
Never	38	**80.9**	45	**77.6**	35	**77.8**
Rarely	7	**14.9**	11	**19.0**	6	**13.3**
Sometimes	2	**4.3**	2	**3.4**	4	**8.9**
Often	0	**0.0**	0	**0.0**	0	**0.0**
Always	0	**0.0**	0	**0.0**	0	**0.0**

Read, eat, talk on a cell phone, put on makeup, horse around with passengers, or other such activities while driving (18)						
Never	4	**8.5**	10	**17.2**	7	**15.6**
Rarely	14	**29.8**	18	**31.0**	14	**31.1**
Sometimes	23	**48.9**	22	**37.9**	16	**35.6**
Often	4	**8.5**	8	**13.8**	8	**17.8**
Always	2	**4.3**	0	**0.0**	0	**0.0**
Drive in a way to show off to other people (19)						
Never	41	**87.2**	49	**84.5**	34	**75.6**
Rarely	6	**12.8**	7	**12.1**	9	**20.0**
Sometimes	0	**0.0**	2	**3.4**	1	**2.2**
Often	0	**0.0**	0	**0.0**	1	**2.2**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Insist your passengers to wear their seat belts if they haven't done so (20)						
Never	4	**8.5**	7	**12.1**	2	**4.4**
Rarely	2	**4.3**	2	**3.4**	2	**4.4**
Sometimes	6	**12.8**	3	**5.2**	6	**13.3**
Often	12	**25.5**	15	**25.9**	10	**22.2**
Always	33	**70.2**	31	**53.4**	25	**55.6**
Talk on your cell phone while driving (21)						
Never	0	**0.0**	7	**12.1**	1	**2.2**
Rarely	16	**34.0**	19	**32.8**	16	**35.6**
Sometimes	22	**46.8**	23	**39.7**	24	**53.3**
Often	8	**17.0**	9	**15.5**	4	**8.9**
Always	1	**2.1**	0	**0.0**	0	**0.0**

Table B-7. Participants' driving behaviors (Continued)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
Send text messages (or similar phone chat activity) while driving (22)	**n**	**%**	n	**%**	n	**%**
Never	14	**29.8**	15	**25.9**	16	**35.6**
Rarely	15	**31.9**	31	**53.4**	12	**26.7**
Sometimes	15	**31.9**	6	**10.3**	14	**31.1**
Often	3	**6.4**	6	**10.3**	3	**6.7**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Drive between midnight and 5 a.m. (23)						
Never	10	**21.3**	12	**20.7**	3	**6.7**
Rarely	20	**42.6**	28	**48.3**	26	**57.8**
Sometimes	13	**27.7**	12	**20.7**	11	**24.4**
Often	4	**8.5**	6	**10.3**	5	**11.1**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Drive between 9 p.m. and midnight (24)						
Never	1	**2.1**	2	**3.4**	0	**0.0**
Rarely	4	**8.5**	8	**13.8**	7	**15.6**

Sometimes	19	**40.4**	28	**48.3**	17	**37.8**
Often	22	**46.8**	19	**32.8**	21	**46.7**
Always	1	**2.1**	1	**1.7**	0	**0.0**
Drive too fast for the conditions (e.g., bad weather) (25)						
Never	16	**34.0**	17	**29.3**	10	**22.2**
Rarely	20	**42.6**	27	**46.6**	28	**62.2**
Sometimes	10	**21.3**	13	**22.4**	6	**13.3**
Often	1	**2.1**	0	**0.0**	1	**2.2**
Always	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	1	**1.7**	1	**2.2**
Drive tired and sleepy (to the point of nodding off) (26)						
Never	28	**59.6**	23	**39.7**	14	**31.1**
Rarely	13	**27.7**	26	**44.8**	21	**46.7**
Sometimes	5	**10.6**	9	**15.5**	8	**17.8**
Often	1	**2.1**	0	**0.0**	2	**4.4**
Always	0	**0.0**	0	**0.0**	0	**0.0**

Table B-8. Frequency of participants' uses of cellular devices when the vehicle is not in motion

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	n	**%**	n	**%**	n	**%**
Never	4	**8.5**	5	**8.7**	7	**15.6**
Rarely	9	**19.1**	17	**29.4**	8	**17.8**
Sometimes	17	**36.2**	22	**38.0**	15	**33.3**
Often	15	**31.9**	10	**17.3**	14	**31.1**
Always	2	**4.3**	4	**6.9**	1	**2.2**
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)						
Never	9	**19.1**	15	**25.9**	14	**31.1**
Rarely	17	**36.2**	16	**27.6**	9	**20.0**
Sometimes	12	**25.5**	17	**29.4**	15	**33.3**
Often	9	**19.1**	7	**12.1**	6	**13.3**
Always	0	**0.0**	3	**5.2**	1	**2.2**
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)						
Never	27	**57.4**	31	**53.5**	27	**60.0**
Rarely	8	**17.0**	10	**17.3**	7	**15.6**
Sometimes	10	**21.3**	10	**17.3**	7	**15.6**
Often	2	**4.3**	4	**6.9**	4	**8.9**
Always	0	**0.0**	3	**5.2**	0	**0.0**
Change the music on/change songs						
Never	2	**4.3**	2	**3.5**	2	**4.4**
Rarely	3	**6.4**	4	**6.9**	2	**4.4**
Sometimes	7	**14.9**	16	**27.6**	13	**28.9**
Often	24	**51.1**	29	**50.0**	23	**51.1**
Always	10	**21.3**	7	**12.1**	5	**11.1**

Navigate maps on the phone						
Never	0	**0.0**	3	**5.2**	1	**2.2**
Rarely	5	**10.6**	2	**3.5**	5	**11.1**
Sometimes	24	**51.1**	27	**46.6**	19	**42.2**
Often	14	**29.8**	22	**38.0**	20	**44.4**
Always	4	**8.5**	4	**6.9**	0	**0.0**

Table B-9. Frequency of participants' uses of cellular devices when the vehicle is in motion

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	n	**%**	n	**%**	n	**%**
Never	11	**23.4**	24	**41.4**	9	**20.0**
Rarely	16	**34.0**	20	**34.5**	17	**37.8**
Sometimes	15	**31.9**	8	**13.8**	17	**37.8**
Often	5	**10.6**	5	**8.7**	2	**4.4**
Always	0	**0.0**	1	**1.8**	0	**0.0**
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)						
Never	20	**42.6**	34	**58.7**	19	**42.2**
Rarely	14	**29.8**	15	**25.9**	15	**33.3**
Sometimes	10	**21.3**	5	**8.7**	10	**22.2**
Often	3	**6.4**	3	**5.2**	1	**2.2**
Always	0	**0.0**	1	**1.8**	0	**0.0**
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)						
Never	30	**63.8**	40	**69.0**	28	**62.2**
Rarely	8	**17.0**	10	**17.3**	10	**22.2**
Sometimes	8	**17.0**	5	**8.7**	5	**11.1**
Often	1	**2.1**	2	**3.5**	1	**2.2**
Always	0	**0.0**	1	**1.8**	0	**0.0**
Missing	0	**0.0**	0	**0.0**	1	**2.2**
Change the music on/change songs						
Never	2	**4.3**	5	**8.7**	5	**11.1**
Rarely	8	**17.0**	5	**8.7**	6	**13.3**
Sometimes	12	**25.5**	23	**39.7**	16	**35.6**
Often	21	**44.7**	21	**36.3**	16	**35.6**
Always	4	**8.5**	4	**6.9**	2	**4.4**
Navigate maps on the phone						
Never	1	**2.1**	6	**10.4**	5	**11.1**
Rarely	13	**27.7**	10	**17.3**	7	**15.6**
Sometimes	23	**48.9**	27	**46.6**	23	**51.1**
Often	6	**12.8**	13	**22.5**	10	**22.2**
Always	4	**8.5**	2	**3.5**	0	**0.0**

Survey Part V: Driving Risks

Table B-10. Participants' general opinions on the influences of passengers in the vehicle

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
The presence of the passenger(s) does not affect my driving in general (1)	n	%	n	%	n	%
Strongly Disagree	3	**6.4**	5	**8.7**	3	**6.7**
Disagree	15	**31.9**	11	**19.0**	10	**22.2**
Neutral	7	**14.9**	6	**10.4**	5	**11.1**
Agree	21	**44.7**	28	**48.3**	23	**51.1**
Strongly Agree	1	**2.1**	8	**13.8**	4	**8.9**
Multiple passengers are distracting to my driving (2)						
Strongly Disagree	2	**4.3**	4	**6.9**	6	**13.3**
Disagree	25	**53.2**	33	**56.9**	18	**40.0**
Neutral	9	**19.1**	13	**22.5**	7	**15.6**
Agree	10	**21.3**	5	**8.7**	14	**31.1**
Strongly Agree	1	**2.1**	2	**3.5**	0	**0.0**
Missing	0	**0.0**	1	**1.8**	0	**0.0**
Having conversations with the passenger(s) is overwhelming, especially when I drive on urban roads (3)						
Strongly Disagree	11	**23.4**	12	**20.7**	10	**22.2**
Disagree	23	**48.9**	29	**50.0**	24	**53.3**
Neutral	6	**12.8**	9	**15.6**	4	**8.9**
Agree	7	**14.9**	8	**13.8**	6	**13.3**
Strongly Agree	0	**0.0**	0	**0.0**	0	**0.0**
Missing	0	**0.0**	0	**0.0**	1	**2.2**
Having conversations with the passenger(s) protects me from mind wandering and keeps me concentrated, especially when I drive on highways or freeways (4)						
Strongly Disagree	2	**4.3**	2	**3.5**	1	**2.2**
Disagree	13	**27.7**	13	**22.5**	8	**17.8**
Neutral	17	**36.2**	16	**27.6**	18	**40.0**
Agree	13	**27.7**	22	**38.0**	16	**35.6**
Strongly Agree	2	**4.3**	5	**8.7**	2	**4.4**
I am less influenced by the passenger(s) now compared to when I was a teenage driver (5)						
Strongly Disagree	0	**0.0**	2	**3.5**	0	**0.0**
Disagree	1	**2.1**	3	**5.2**	3	**6.7**
Neutral	4	**8.5**	5	**8.7**	1	**2.2**
Agree	26	**55.3**	32	**55.2**	24	**53.3**
Strongly Agree	16	**34.0**	16	**27.6**	17	**37.8**

Table B-11. Participants' general opinions on alcohol consumption and driving in the past 12 months

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
How much alcohol can you drink within one hour and feel comfortable driving after drinking? (1)	n	%	n	%	n	%
0 drink	11	**23.4**	13	**22.5**	11	**24.4**

1 drink	23	**48.9**	28	**48.3**	21	**46.7**
2 drinks	8	**17.0**	14	**24.2**	11	**24.4**
3-4 drinks	2	**4.3**	0	**0.0**	1	**2.2**
More than 4 drinks	0	**0.0**	0	**0.0**	0	**0.0**
Other (e.g., do not drink and drive)	3	**6.4**	3	**5.2**	1	**2.2**
On the days you drove, how often have you driven after having ONE alcoholic drink in the previous hour? (2)						
Never	16	**34.0**	26	**44.9**	12	**26.7**
Once in a month	15	**31.9**	13	**22.5**	20	**44.4**
Twice in a month	7	**14.9**	6	**10.4**	8	**17.8**
More than twice in a month	5	**10.6**	4	**6.9**	2	**4.4**
Other	4	**8.5**	6	**10.4**	3	**6.7**
On the days you drove, how often have you driven after TWO OR MORE alcoholic drinks in the previous hour? (3)						
Never	37	**78.7**	44	**75.9**	33	**73.3**
Once in a month	8	**17.0**	10	**17.3**	10	**22.2**
Twice in a month	2	**4.3**	2	**3.5**	0	**0.0**
More than twice in a month	0	**0.0**	1	**1.8**	1	**2.2**
Other	0	**0.0**	1	**1.8**	1	**2.2**
How often do you use alternative transportation after drinking? (e.g., designated driver, Uber, public transit, etc.) (4)						
Never (0% of the time)	4	**8.5**	7	**12.1**	3	**6.7**
Hardly Ever (1%-10% of the time)	2	**4.3**	3	**5.2**	4	**8.9**
Occasionally/Sometimes (11%-50% of the time)	3	**6.4**	7	**12.1**	3	**6.7**
Quite Often (50%-75% of the time)	3	**6.4**	4	**6.9**	5	**11.1**
Frequently (76%-90% of the time)	10	**21.3**	5	**8.7**	3	**6.7**
Nearly all the time (91%-100% of the time)	25	**53.2**	32	**55.2**	27	**60.0**

Table B-12. Participants' opinions on engagement with cellular devices in the vehicle

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
	n	**%**	n	**%**	N	**%**
In general, WHEN did you engage with cellular devices? (select no more than two)						
I engaged with my cellular devices whenever needed.	10	**8.5**	13	**9.9**	11	**11.2**
When there were no other cars nearby	20	**16.9**	23	**17.6**	17	**17.3**
When I drove on low-speed roads (≤30 mph)	17	**14.4**	17	**13**	16	**16.3**
When I drove at any speed	6	**5.1**	2	**1.5**	4	**4.1**
When in stop-and-go traffic	18	**15.3**	25	**19.1**	16	**16.3**
When stopped at a red light	43	**36.4**	49	**37.4**	29	**29.6**
N/A	1	**0.8**	2	**1.5**	4	**4.1**
Other, please specify	3	**2.5**	0	**0.0**	1	**1.0**
In general, WHERE did you hold your phone in the car when using it (e.g., navigation, change music, etc.)?						
In a fixed phone mount	6	**12.8**	6	**10.3**	8	**17.8**
In your lap	10	**21.3**	10	**17.2**	8	**17.8**
In the cup holder	23	**48.9**	20	**34.5**	20	**44.4**
Hold the phone in your hand	4	**8.5**	0	**0.0**	1	**2.2**

On the passenger seat	3	**6.4**	8	**13.8**	3	**6.7**
Other, feel free to specify	1	**2.1**	4	**6.9**	5	**11.1**
In general, what types of information/instructions did you rely on when using NAVIGATION on the phone while driving?						
I relied on audio instructions only, and I didn't need to check on maps.	3	**6.4**	3	**5.2**	5	**11.1**
I had to look at maps occasionally while listening to the audio information/instructions	31	**66.0**	35	**60.3**	26	**57.8**
I mainly relied on maps rather than audio information/instructions	9	**19.1**	10	**17.2**	7	**15.6**
I turned off audio information/instructions and only used the visual maps	4	**8.5**	10	**17.2**	7	**15.6**
N/A	0	**0.0**	0	**0.0**	0	**0.0**
Other, please specify	0	**0.0**	0	**0.0**	0	**0.0**

Table B-13. Participants' general opinions on driving performance and safety

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
In general, I feel I can drive safely while feeling fatigued and drowsy. (1)	n	**%**	n	**%**	N	**%**
Strongly Disagree	1	**2.1**	1	**1.8**	0	**0.0**
Disagree	8	**17.0**	16	**27.6**	11	**24.4**
Somewhat Disagree	11	**23.4**	17	**29.4**	7	**15.6**
Neither Disagree or Agree	4	**8.5**	2	**3.5**	1	**2.2**
Somewhat Agree	15	**31.9**	13	**22.5**	16	**35.6**
Agree	7	**14.9**	8	**13.8**	8	**17.8**
Strongly Agree	1	**2.1**	1	**1.8**	2	**4.4**
In general, I feel I can drive safely in the morning (i.e., after sunrise and before 12:00 pm the next day) after a night of heavy drinking. (2)						
Strongly Disagree	6	**12.8**	6	**10.4**	4	**8.9**
Disagree	8	**17.0**	10	**17.3**	8	**17.8**
Somewhat Disagree	5	**10.6**	10	**17.3**	5	**11.1**
Neither Disagree or Agree	5	**10.6**	5	**8.7**	4	**8.9**
Somewhat Agree	3	**6.4**	9	**15.6**	9	**20.0**
Agree	9	**19.1**	8	**13.8**	9	**20.0**
Strongly Agree	2	**4.3**	1	**1.8**	3	**6.7**
N/A	1	**2.1**	0	**0.0**	0	**0.0**
Missing	8	**17.0**	9	**15.6**	3	**6.7**

Table B-13. Participants' general opinions on driving performance and safety (Continued)

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
In general, I feel I can drive safely in the afternoon (i.e., after 12:00 pm the next day) a night of heavy drinking.	n	**%**	n	**%**	n	**%**
Strongly Disagree	4	**8.5**	2	**3.5**	2	**4.4**
Disagree	2	**4.3**	2	**3.5**	0	**0.0**
Somewhat Disagree	2	**4.3**	4	**6.9**	0	**0.0**
Neither Disagree or Agree	4	**8.5**	2	**3.5**	2	**4.4**

Somewhat Agree	4	**8.5**	8	**13.8**	6	**13.3**
Agree	15	**31.9**	20	**34.5**	18	**40.0**
Strongly Agree	8	**17.0**	10	**17.3**	14	**31.1**
N/A	1	**2.1**	1	**1.8**	0	**0.0**
Missing	7	**14.9**	9	**15.6**	3	**6.7**
I think my driving skills are better than the AVERAGE driver. (4)						
Strongly Disagree	0	**0.0**	1	**1.8**	0	**0.0**
Disagree	1	**2.1**	0	**0.0**	2	**4.4**
Somewhat Disagree	4	**8.5**	4	**6.9**	5	**11.1**
Neither Disagree or Agree	14	**29.8**	13	**22.5**	8	**17.8**
Somewhat Agree	11	**23.4**	17	**29.4**	12	**26.7**
Agree	9	**19.1**	15	**25.9**	13	**28.9**
Strongly Agree	7	**14.9**	8	**13.8**	5	**11.1**
Missing	1	**2.1**	0	**0.0**	0	**0.0**
I think I have adopted safer driving habits than the AVERAGE driver. (5)						
Strongly Disagree	0	**0.0**	0	**0.0**	0	**0.0**
Disagree	0	**0.0**	0	**0.0**	0	**0.0**
Somewhat Disagree	3	**6.4**	1	**1.8**	4	**8.9**
Neither Disagree or Agree	8	**17.0**	5	**8.7**	6	**13.3**
Somewhat Agree	15	**31.9**	22	**38.0**	14	**31.1**
Agree	15	**31.9**	17	**29.4**	14	**31.1**
Strongly Agree	6	**12.8**	13	**22.5**	7	**15.6**
Compared to my peers, I feel I am less distracted by passengers or cellular devices when I drive. (6)						
Strongly Disagree	0	**0.0**	0	**0.0**	0	**0.0**
Disagree	2	**4.3**	1	**1.8**	1	**2.2**
Somewhat Disagree	3	**6.4**	2	**3.5**	2	**4.4**
Neither Disagree or Agree	7	**14.9**	11	**19.0**	7	**15.6**
Somewhat Agree	11	**23.4**	8	**13.8**	10	**22.2**
Agree	17	**36.2**	23	**39.7**	12	**26.7**
Strongly Agree	7	**14.9**	13	**22.5**	13	**28.9**
Compared to my peers, I feel I comply more with the traffic rules when I drive. (7) p=0.058						
Strongly Disagree	0	**0.0**	0	**0.0**	0	**0.0**
Disagree	0	**0.0**	0	**0.0**	2	**4.4**
Somewhat Disagree	2	**4.3**	0	**0.0**	5	**11.1**
Neither Disagree or Agree	7	**14.9**	14	**24.2**	5	**11.1**
Somewhat Agree	16	**34.0**	11	**19.0**	9	**20.0**
Agree	13	**27.7**	20	**34.5**	16	**35.6**
Strongly Agree	9	**19.1**	13	**22.5**	8	**17.8**

Table B-14. Participants' general opinions on driving speed for different type of roads/conditions (excluding traffic congestion)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Neighborhood Roads (≤ 30mph)	n	%	n	%	n	%
Below the PSL	3	**6.4**	6	**10.4**	4	**8.9**
Equal to the PSL	11	**23.4**	16	**27.6**	18	**40.0**
1-3 mph above the PSL	20	**42.6**	18	**31.1**	13	**28.9**
4-7 mph above the PSL	11	**23.4**	18	**31.1**	10	**22.2**
8-10 mph above the PSL	2	**4.3**	0	**0.0**	0	**0.0**
11-15 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
16-20 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
Urban roads (30mph-45mph)						
Below the PSL	0	**0.0**	1	**1.8**	0	**0.0**
Equal to the PSL	3	**6.4**	10	**17.3**	8	**17.8**
1-3 mph above the PSL	13	**27.7**	15	**25.9**	17	**37.8**
4-7 mph above the PSL	25	**53.2**	30	**51.8**	17	**37.8**
8-10 mph above the PSL	6	**12.8**	2	**3.5**	3	**6.7**
11-15 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
16-20 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
State/Interstate Highways or Freeways (45mph-60mph)						
Below the PSL	0	**0.0**	0	**0.0**	0	**0.0**
Equal to the PSL	0	**0.0**	2	**3.5**	1	**2.2**
1-3 mph above the PSL	1	**2.1**	6	**10.4**	6	**13.3**
4-7 mph above the PSL	20	**42.6**	31	**53.5**	26	**57.8**
8-10 mph above the PSL	21	**44.7**	16	**27.6**	11	**24.4**
11-15 mph above the PSL	4	**8.5**	3	**5.2**	1	**2.2**
16-20 mph above the PSL	1	**2.1**	0	**0.0**	0	**0.0**
Rural Roads (≥ 60mph)						
Below the PSL	1	**2.1**	1	**1.8**	0	**0.0**
Equal to the PSL	4	**8.5**	4	**6.9**	4	**8.9**
1-3 mph above the PSL	3	**6.4**	7	**12.1**	5	**11.1**
4-7 mph above the PSL	15	**31.9**	29	**50.0**	22	**48.9**
8-10 mph above the PSL	19	**40.4**	15	**25.9**	13	**28.9**
11-15 mph above the PSL	4	**8.5**	2	**3.5**	1	**2.2**
16-20 mph above the PSL	1	**2.1**	0	**0.0**	0	**0.0**
School Zone (15mph-25mph)						
Below the PSL	4	**8.5**	9	**15.6**	10	**22.2**
Equal to the PSL	25	**53.2**	35	**60.4**	21	**46.7**
1-3 mph above the PSL	17	**36.2**	12	**20.7**	10	**22.2**
4-7 mph above the PSL	1	**2.1**	2	**3.5**	3	**6.7**
8-10 mph above the PSL	0	**0.0**	0	**0.0**	1	**2.2**
11-15 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
16-20 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**

Table B-14. Participants' general opinions on driving speed for different type of roads/conditions (excluding traffic congestion) (Continued)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Highway Work Zone (>55mph)	n	%	n	%	n	%
Below the PSL	3	**6.4**	4	**6.9**	6	**13.3**
Equal to the PSL	23	**48.9**	33	**56.9**	22	**48.9**
1-3 mph above the PSL	16	**34.0**	12	**20.7**	8	**17.8**
4-7 mph above the PSL	5	**10.6**	8	**13.8**	8	**17.8**
8-10 mph above the PSL	0	**0.0**	1	**1.8**	1	**2.2**
11-15 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**
16-20 mph above the PSL	0	**0.0**	0	**0.0**	0	**0.0**

Table B-15. Estimated number of persons close to the participant (e.g., friends, co-workers, family members, etc.) who have experienced risky driving behaviors

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Drive after having one alcoholic drink in the previous hour (1)	n	%	n	%	n	%
None	3	**6.4**	4	**6.9**	0	**0.0**
1-2	8	**17.0**	17	**29.4**	8	**17.8**
3-4	7	**14.9**	13	**22.5**	7	**15.6**
5-6	7	**14.9**	6	**10.4**	9	**20.0**
>=7	22	**46.8**	18	**31.1**	21	**46.7**
Drive after having two or more alcoholic drinks in the previous hour (2)						
None	9	**19.1**	10	**17.3**	3	**6.7**
1-2	19	**40.4**	26	**44.9**	15	**33.3**
3-4	9	**19.1**	11	**19.0**	8	**17.8**
5-6	6	**12.8**	5	**8.7**	10	**22.2**
>=7	4	**8.5**	10	**17.3**	9	**20.0**
Exceed speed limits over 10 to 19 miles (3)						
None	5	**10.6**	8	**13.8**	5	**11.1**
1-2	17	**36.2**	23	**39.7**	18	**40.0**
3-4	7	**14.9**	18	**31.1**	9	**20.0**
5-6	11	**23.4**	5	**8.7**	8	**17.8**
>=7	7	**14.9**	4	**6.9**	5	**11.1**
Do not use their seat belt while driving as a driver or passenger (4)						
None	18	**38.3**	26	**44.9**	16	**35.6**
1-2	23	**48.9**	24	**41.4**	15	**33.3**
3-4	3	**6.4**	7	**12.1**	8	**17.8**
5-6	1	**2.1**	8	**13.8**	5	**11.1**
>=7	1	**2.1**	0	**0.0**	0	**0.0**

Table B-15. Estimated number of persons close to the participant (e.g., friends, co-workers, family members, etc.) who have experienced risky driving behaviors (Continued)

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
Have been convicted of traffic offenses (e.g., speeding tickets, etc.) since licensure. (Excluding parking tickets) (5)	n	%	n	%	n	%
None	1	**2.1**	3	**5.2**	1	**2.2**
1-2	8	**17.0**	17	**29.4**	9	**20.0**
3-4	16	**34.0**	17	**29.4**	18	**40.0**
5-6	8	**17.0**	10	**17.3**	5	**11.1**
>=7	14	**29.8**	11	**19.0**	12	**26.7**

Survey Part IV: Risk Perception

Table B-16. Perceived risk for crash or injury risk associated with 20 driving conditions

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
	Mean	SD	**Mean**	SD	**Mean**	SD
Drive under the influence of alcohol (1)	**6.81**	0.58	**6.66**	0.81	**6.56**	1.03
Drive while not wearing a seat belt (2)	**5.38**	1.74	**5.64**	1.33	**5.31**	1.53
Drive with passengers in the vehicle (3)	**2.34**	1.24	**2.50**	1.40	**2.34**	1.15
Drive late at night on the weekend (4)	**3.09**	1.32	**3.21**	1.37	**3.07**	1.44
Drive outside of local or familiar areas (5)	**3.26**	1.41	**2.98**	1.30	**2.84**	1.38
Drive with one passenger (6)	**1.62**	1.11	**1.50**	1.01	**1.49**	0.79
Drive between 9 p.m. and midnight (7)	**2.45**	1.12	**2.43**	1.26	**2.53**	1.12
Drive in bad weather (for example, snow, ice, heavy rain) (8)	**5.38**	1.19	**5.26**	1.24	**5.29**	1.08
Drive on unfamiliar roads (9)	**3.23**	1.18	**3.24**	1.38	**3.22**	1.20
Drive with several passengers on a weekend night (10)	**3.38**	1.39	**3.35**	1.41	**3.62**	1.59
Drive late at night during the week (11)	**2.34**	1.29	**2.53**	1.37	**2.42**	0.94
Drive on freeways or expressways (12)	**2.47**	1.35	**2.48**	1.42	**2.68**	1.16
Exceed the speed limit in residential or school zones (13)	**3.85**	1.68	**3.45**	1.45	**3.71**	1.58
Drive 10 to 19 miles per hour over the speed limit (14)	**4.81**	1.30	**4.52**	1.42	**5.07**	1.42
Drive 20 miles per hour over the speed limit (15)	**5.94**	1.09	**5.59**	1.21	**5.96**	1.22
Drive drowsy and sleepy (to the point of nodding off) (16)	**6.21**	0.98	**5.84**	1.25	**6.04**	1.02
Disobey traffic sign/signal (e.g., running stop sign, make an illegal U-turn, etc.) (17)	**5.04**	1.41	**4.66**	1.48	**5.02**	1.27
Drive carelessly (e.g., fail to detect road hazards) (18)	**5.68**	1.02	**5.18**	1.26	**5.36**	1.15
Exhibit road rage or drive aggressively (19)	**5.57**	1.43	**5.48**	1.05	**5.36**	1.28
Demonstrate poor driving habits (e.g., change lanes without signaling) (20)	**4.98**	1.33	**4.45**	1.58	**4.71**	1.25

Table B-17. Perceived risk associated will cellular devices when vehicle NOT in motion

	Control (*n*=47)		TDSS (*n*=58)		TDSS+ (*n*=45)	
	Mean	SD	**Mean**	SD	**Mean**	SD

READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	**2.68**	1.27	**3.10**	1.57	**3.07**	1.50
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	**3.51**	1.50	**3.90**	1.65	**3.93**	1.81
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	**3.45**	1.56	**3.81**	1.82	**4.14**	1.84
Change the music on/change songs	**1.91**	0.95	**2.12**	1.27	**2.25**	1.14
Navigate maps on the phone	**2.47**	1.21	**2.45**	1.35	**2.52**	1.07

Table B-18. Perceived risks associated will cellular devices when vehicle was in motion

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
	Mean	SD	**Mean**	SD	**Mean**	SD
READ text messages, read emails or browse news/updates from social media (e.g., Facebook, Twitter)	**4.85**	1.53	**4.67**	1.56	**4.78**	1.29
WRITE text messages, respond to emails, or comment on news/updates from social media (e.g., Facebook, Twitter)	**5.72**	1.22	**5.74**	1.19	**5.78**	1.00
Take pictures/videos or upload pictures/videos (e.g., Instagram, Snapshot)	**5.34**	1.37	**5.43**	1.42	**5.49**	1.38
Change the music on/change songs	**3.15**	1.32	**3.12**	1.48	**3.33**	1.30
Navigate maps on the phone	**3.72**	1.38	**3.45**	1.52	**3.73**	1.19

Survey Part VII: Driver Education and In-Vehicle Technologies

Table B-19. Participants' general opinions on driver education and in-vehicle technologies

	Control (*n*=47)		**TDSS (*n*=58)**		**TDSS+ (*n*=45)**	
Which one(s) of the following motivated you the most to comply with traffic rules? **(Select no more than TWO)**	n	**%**	n	**%**	n	**%**
Safety considerations for myself	34	**38.2**	42	**38.2**	36	**42.9**
Reduce insurance rate	2	**2.2**	5	**4.5**	3	**3.6**
Avoid Fines	21	**23.6**	25	**22.7**	23	**27.4**
Parental restrictions	1	**1.1**	1	**0.9**	1	**1.2**
Safety considerations for others	28	**31.5**	27	**24.5**	18	**21.4**
I am more inclined to comply with traffic rules when all other drivers on the road also comply with traffic rules	2	**2.2**	10	**9.1**	2	**2.4**
Other, please specify	1	**1.1**	0	**0.0**	1	**1.2**
What do you think is/are the most effective way(s) for teenage drivers to adopt safe driving SKILLS? **(Select no more than TWO)**						
Take behind the wheel training with an instructor	29	**32.6**	30	**27**	28	**31.5**
Take driving classes, e.g., learn traffic rules, watch crash videos, etc.	22	**24.7**	28	**25.2**	17	**19.1**
Supervised by a parent/guardian	20	**22.5**	24	**21.6**	16	**18**
Supervised by an older sibling	0	**0**	1	**0.9**	4	**4.5**

Provide the in-vehicle driving support system to teens, such as real-time feedback and monitoring	12	**13.5**	20	**18**	16	**18**
Advocate safe driving in the neighborhoods or on the roads	3	**3.4**	1	**0.9**	2	**2.2**
Enhance law enforcement, e.g., raise fines, etc.	3	**3.4**	6	**5.4**	4	**4.5**
Other	0	**0**	1	**0.9**	2	**2.2**
What do you think is/are the most effective way(s) for teenage drivers to adopt safe driving HABITS? **(Select no more than TWO)**						
Take behind the wheel training with an instructor	11	**12.2**	17	**15.3**	9	**10.1**
Take driving classes, e.g., learn traffic rules, watch crash videos, etc.	12	**13.3**	16	**14.4**	7	**7.9**
Supervised by a parent/guardian	24	**26.7**	25	**22.5**	20	**22.5**
Supervised by an older sibling	1	**1.1**	4	**3.6**	4	**4.5**
Provide the in-vehicle driving support system to teens, such as real-time feedback and monitoring	18	**20**	39	**35.1**	31	**34.8**
Advocate safe driving in the neighborhoods or on the roads	10	**11.1**	2	**1.8**	7	**7.9**
Enhance law enforcement, e.g., raise fines, etc.	13	**14.4**	6	**5.4**	9	**10.1**
Other	1	**1.1**	2	**1.8**	2	**2.2**
What types of in-vehicle technology or smartphone application do you most frequently use while driving? **(Select all that apply)**						
Bluetooth system	24	**22.6**	31	**21.1**	29	**23.4**
Navigation applications, e.g., google maps, apple maps, etc.	40	**37.7**	51	**34.7**	38	**30.6**
Other navigation and live traffic applications, e.g., Waze, etc.	2	**1.9**	7	**4.8**	3	**2.4**
In-vehicle cameras, e.g., backing up camera, etc.	12	**11.3**	9	**6.1**	18	**14.5**
Adaptive Cruise system	13	**12.3**	17	**11.6**	17	**13.7**
Emergency Braking assistance	3	**2.8**	5	**3.4**	5	**4**
Fuel efficiency or mpg monitor	10	**9.4**	22	**15**	13	**10.5**
Hybrid cars	2	**1.9**	3	**2**	0	**0**
Other, please specify	0	**0**	2	**1.4**	1	**0.8**
What novel technology have you heard of and would most like to have in your vehicle? **(Select no more than TWO)**						
Advanced in-vehicle navigation systems	16	**18.4**	23	**22.5**	17	**20.2**
In-vehicle camera systems	12	**13.8**	15	**14.7**	18	**21.4**
Blind spot mirrors	26	**29.9**	32	**31.4**	22	**26.2**
Emergency Braking, e.g., with pedestrian detection, etc	23	**26.4**	21	**20.6**	17	**20.2**
Fuel efficiency or mpg monitor	3	**3.4**	7	**6.9**	5	**6**
Advanced hybrid control systems	5	**5.7**	2	**2**	3	**3.6**
Pilot assistance, i.e., autonomous driving, etc.	0	**0**	0	**0**	0	**0**
Other, please specify	2	**2.3**	2	**2**	2	**2.4**

Table B-20 Participants' overall ratings on the TDSS system

	TDSS (*n*=58)		TDSS+ (*n*=45)	
Driving with the TDSS has been beneficial in helping me learn to drive since I received my license.	n	%	n	%
Strongly Disagree	0	**0.0**	0	**0.0**
Disagree	1	**1.8**	4	**8.9**
Somewhat Disagree	2	**3.5**	2	**4.4**
Neutral	3	**5.2**	2	**4.4**
Somewhat Agree	16	**27.6**	8	**17.8**
Agree	30	**51.8**	22	**48.9**
Strongly Agree	6	**10.4**	7	**15.6**
Your overall opinion of the TDSS				
Very Poor	0	**0.0**	0	**0.0**
Poor	1	**1.8**	1	**2.2**
Fair	7	**12.1**	5	**11.1**
Good	27	**46.6**	25	**55.6**
Very Good	23	**39.7**	14	**31.1**
Your overall opinion of the usefulness of the TDSS				
Very Useless	0	**0.0**	0	**0.0**
Useless	0	**0.0**	1	**2.2**
Neutral	5	**8.7**	3	**6.7**
Useful	38	**65.6**	26	**57.8**
Very Useful	15	**25.9**	15	**33.3**
How likely would you be to recommend the TDSS (if it were a finished product) to other teens and parents for use in the first year of driving?				
Very Unlikely	0	**0.0**	1	**2.2**
Unlikely	1	**1.8**	2	**4.4**
Undecided	5	**8.7**	1	**2.2**
Likely	28	**48.3**	15	**33.3**
Very Likely	24	**41.4**	26	**57.8**