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Distracted Driving: A Literature Review

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16. Abstract

With the increased use of electronic devices, distracted driving is assumed to be one of the main causes of crashes. The Illinois Department of Transportation (IDOT) has demonstrated interest in addressing distracted driving. However, the real impact of distracted driving on traffic crashes in Illinois is still unclear because of what appears to be a lack of accurate reporting. The objective of this project is to conduct a literature review, prepare a summary of findings for evaluating the relationship between distracted driver behavior and other factors, and identify best practices to mitigate distracted driving. The research team reviewed articles, reports, websites, advertisements, laws, and media reports in related disciplines, including engineering, safety, health care, psychology, law, etc. They compiled information on the characteristics of distracted driving, factors influencing distracted driving, and its association with crashes/crash risk. They also compiled information on laws restricting cell phone use as well as their enforcement and effectiveness, technologies and resources targeting distracted driving, and campaigns and education programs. This study found that electronic device use is not the only highly frequent distracted driving behavior. Attitude is also an underlying cause of distracted driving. Conclusions of past studies on the impacts of distracted driving on crashes/crash risk are not sound and concrete because of the limitations of their research approaches. Although there are no federal regulations to date, all states in the United States (except Montana) have passed laws to restrict cell phone use to some extent or to certain groups of drivers. High-visibility enforcement may be the best deterrent for distracted driving enforcement but may require additional labor and other resources to achieve the best results. Despite the prevalence of cell phone bans and increased efforts in enforcement, the effectiveness of cell phone bans is arguable. The key to addressing distracted driving is to change driver behavior. Successful traffic safety campaigns to change driver behavior have demonstrated the necessity to adopt a "three Es" approach: enactment of a law, rigorous enforcement of the law, and education of the public about the law. To change distracted driving behavior, the appropriate approach should be "three Es" and technology adoption. Based on the findings of the literature review, recommendations were made on steps to address distracted driving.

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EXECUTIVE SUMMARY

Distracted driving is a global issue. Research has been conducted to identify the underlying causes of distracted driving, the relationship between distracted driving behaviors and other factors, and its association with crashes or crash risk. In addition, many efforts have been made by agencies across the United States to fight distracted driving through laws, enforcement campaigns, and education programs. With the increased use of electronic devices, distracted driving is assumed to be one of the main causes of crashes. The Illinois Department of Transportation (IDOT) has demonstrated interest in addressing the issue of distracted driving. However, the real impact of distracted driving in traffic crashes in Illinois is unclear because of what appears to be a lack of accurate reporting. A need exists to conduct a literature review to better evaluate how IDOT should address this issue.

This study was conducted to better understand distracted driving characteristics, causes, and impacts on safety, as well as offer inputs and suggestions on how to address distracted driving. The objective of this project was to conduct a literature review; summarize findings for evaluating the relationship between distracted driver behaviors and other factors, including roadway and roadside infrastructure; and identify the best practices for mitigating distracted driving.

This project was conducted by researchers at Southern Illinois University Edwardsville for IDOT through the Illinois Center for Transportation (ICT). This study was conducted between April 2019 and April 2020. The goal was to provide information, insight, and suggestions for IDOT to identify the most appropriate approach to address distracted driving in Illinois. Key products of this study are a synthesis of the literature review on distracted driving and recommendations on steps to address distracted driving.

The researchers compiled information on distracted driving behaviors, frequencies, and other characteristics from published literature. Next, they reviewed past studies on influential factors on distracted driving and identified possible causal factors. A review of past studies examining the impacts of distracted driving on crashes or crash risk was then completed. Current distracted driving laws were compiled, along with enforcement practices and studies to evaluate the effectiveness of enforcement. Innovative technologies and resources targeting distracted driving as well as campaigns and education program materials were then summarized. Last, the researchers summarized all key findings and made recommendations based on the results of the literature review.

The primary product of this research is the literature review synthesis, which was imbedded in the summaries of each chapter and highlighted in Chapter 8. The findings from this study provided information on conditions and population groups prone to distracted driving, distracted driving behaviors with high occurrences, and underlying causal factors of distracted driving based on past studies. Useful resources as well as successful enforcement campaigns and educational materials were also identified. Limitations of past studies evaluating distracted driving's impacts on crashes/crash risk and effectiveness of distracted driving laws were identified. To reduce distracted driving, IDOT will develop effective strategies that consider the needs of different population groups, utilize all useful resources, and adopt the most appropriate approach, all of which have been reflected in the study's recommendations.

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CHAPTER 1: INTRODUCTION

Distracted driving is any activity that could divert drivers' attention from the primary task of driving. Distractions include, but are not limited to, using electronic gadgets or the radio, eating, drinking, reading, grooming, and interacting with passengers. Distracted driving is dangerous. For example, cell phone use affects how drivers scan and process information from the roadway. It can also lead to inattentive blindness, in which drivers fail to comprehend or process information from objects in the road, even when they are looking right at them. The National Safety Council (2015) reports that cell phone use while driving leads to 1.6 million crashes each year in the United States. Nearly 390,000 injuries occur each year from the accidents caused by texting while driving (NHTSA 2017). According to NHTSA (2015), in 2016 there was a total of 34,439 fatal crashes in the United States, among which about 9.2% (3,450 fatalities) involved distracted drivers. In addition, there were 562 nonoccupants (pedestrians, bicyclists, and others) killed in distraction-affected crashes. Overall, these statistics underscore the seriousness of distracted driving as a national safety issue.

With the increased use of electronic devices, distracted driving is assumed to be one of the main causes of crashes. The Illinois Department of Transportation (IDOT) has demonstrated interest in addressing this issue to improve transportation safety throughout the state. However, the real impact of distracted driving on traffic crashes in Illinois is still unclear because of what appears to be a lack of accurate reporting. To better evaluate how IDOT should address this issue, a literature review needs to be conducted. The objective of this study is to conduct a literature review and prepare a summary of findings to evaluate the relationship between distracted driver behaviors and other factors, including the roadway and roadside infrastructure.

Because of distracted driving's impacts on society, a literature review of distracted driving is different from a literature review of other transportation topics. In addition to traditional transportation engineering databases and resources, the researchers also reviewed references in health care, psychology, human factors, law, etc. They reviewed journal papers, reports, and proceedings, as well as videos, webpages, news, advertisements, etc. The product of this study is a synthesis of the comprehensive literature review on distracted driving and recommendations on steps to address this issue.

Chapter 2 presents distracted driving characteristics found in the literature review. Chapter 3 describes factors found to influence distracted driving. Chapter 4 summarizes the results of distracted driving's association with crashes and crash risk. Chapter 5 presents a review of current distracted driving laws as well as their enforcement and effectiveness. Chapter 6 includes innovative technologies and resources targeting distracted driving, and Chapter 7 compiles information on distracted driving campaigns and education programs. Chapter 8 summarizes the study, highlights key findings from the literature review synthesis, and makes recommendations on steps to address distracted driving.

CHAPTER 2: DISTRACTED DRIVING CHARACTERISTICS

As a public safety and health issue, distracted driving has interested researchers, organizations, and agencies in many disciplines other than transportation engineering and safety. Stakeholders from public and private sectors have studied distracted driving and have their own definitions of distracted driving. NHTSA (2017) defines distracted driving as any activity that diverts drivers' attention and takes their attention away from driving safely. The AAA (2019) states that distracted driving is the act of a driver operating a vehicle without his or her full attention focused on the physical, mental, and psychological demands of driving. According to FindLaw's website (2019), distracted driving is driving while performing any activity that could potentially distract a driver from the primary task of operating a vehicle. Despite the slight difference in definitions, distracted driving involves physical and mental activities that divert drivers' attention from the primary task of driving.

Usually, driving distractions are broken down into three categories: visual, manual, and cognitive. Visual distractions are anything that take drivers' eyes from the road and change their visual focus from driving, such as reading maps, watching a video, looking at billboard advertisements, looking for items in the car, or grooming. Manual distractions involve drivers taking their hands off the steering wheel, such as eating and/or drinking, operating a navigation system, texting, using a cell phone, adjusting a radio or other listening device, reaching for items in the car, or smoking. Cognitive distractions keep a driver's mind from being focused during driving, such as talking to passengers, listening to the radio or another audio system, daydreaming, or being stressed or tired.

To reduce or prevent distracted driving, distracted driving behaviors and occurrences must be learned among populations with varying sociodemographic characteristics, across geographic regions, and under various traffic and environmental conditions. This chapter compiles the characteristics of distracted driving behaviors from previous studies. Based on the approach from which the distracted driving behavior data were obtained, the reviewed studies were grouped into three subsections: survey, observational, and naturalistic.

2.1 SURVEY STUDIES

Survey studies (paper, phone, or online) are a commonly used approach to study distracted driving behaviors. Recently, State Farm conducted an online survey among drivers aged 18 years and older to examine distracted driving behaviors while driving, particularly cell phone use. The results showed that 91% of all drivers owned a cell phone (among them, 82% talked while driving and 95% texted while driving), 37% had fallen asleep while driving, and 93% talked with other passengers (State Farm 2017). Insurance Zebra also performed a survey regarding driving behaviors and attitudes of 2,000 Americans. The study focused on different age groups, genders, and parents with young children and their attitudes toward distracted behavior. The study reported that 37% of the respondents aged 18 to 34 years felt pressure to reply to work-related messages in contrast to the national average of 25% for all age groups. The survey findings showed that parents with children were more distracted (87%) compared to other adults (74%), and one in three women were engaged in taking photos while driving. This study showed that distracted driving behaviors of individuals change with respect to age, gender, having children, etc. It suggests focusing on the distracted behavior based on different

surrogates such as age group and gender, rather than studying distracted behavior by accumulating all surrogates as one (The Zebra 2019). Similarly, Hoff et al. (2013) distributed a seven-question SurveyMonkey questionnaire to adult drivers to collect data on distracted driving behavior. The results showed a high-reported frequency of distracted driving behaviors: using a cell phone (69%), eating/drinking (67%), and reaching for an in-vehicle object (49%). Other distracted behaviors include operating audio controls, having the driver's attention drawn to something outside the vehicle, and being distracted by other passengers in the vehicle.

Many researchers have surveyed young drivers to study their distracted driving behaviors. Gliklich et al. (2016) conducted a web-based survey among drivers between the ages of 18 and 24 years, examining cell phone reading and writing activities as well as email, social media, and GPS use while driving. In total, 1,211 participants completed a survey from 50 states. Reading texts was the most common behavior (48% of all drivers), while 43% used maps and 33% texted while driving. In a nationwide Youth Risk Behavior survey, data were collected from 195,236 students between the ages of 14 and 18 across 35 states. The results revealed that texting while driving was prevalent, ranging from 26% to 64% of all drivers in Maryland and South Dakota, respectively. The prevalence is also higher in states with many students or teen drivers and a lower learner's permit age. Caucasian students were more likely to engage in texting while driving compared to other races (Li et al. 2015). Studying the distracted driving behaviors of college students, another online anonymous survey of 12 colleges and universities found that distracted driving is highly evident in those who have overconfidence in their own driving skills or who multitask while driving (Hill et al. 2015).

There are also studies that focused on middle-aged adults. Engelberg et al. (2015) conducted an anonymous online survey with 60 distracted driving–related questions on behaviors of 30- to 64-year-old drivers. They found that 65.1% of participants reported texting while stopped at red lights and while driving on the freeway. Also, 20.4% reported that they spent appropriately 25% of their time driving using cell phones. The results showed that being on calls and mobile texting are major distracted behaviors observed for middle-aged adults while driving.

National safety organizations and agencies have also conducted survey studies to examine distracted driving behaviors. The National Safety Council has sponsored research to understand the attitudes and behaviors of US drivers and to explore issues related to distraction and other unsafe driving behaviors. It used a national, online US consumer panel maintained by Survey Sampling International (SSI). A total of 2,409 surveys were completed with drivers aged 15 years and older. Teens aged 15 to 17 years are more likely to use a cell phone while driving compared to other drivers. Most drivers who participated (approximately 72%) have less than a high school education (National Safety Council 2016). The 2015 National Survey on Distracted Driving Attitudes and Behavior (NSDDAB) is the third telephonic survey conducted by NHTSA to analyze distracted driving behaviors. A sample of drivers between the ages of 16 and 34 years were surveyed with 15 questions related to distracted driving through landline and handheld cell phones. Significantly, 90% of the respondents owned a cell phone. Among them, 56% reported using a cell phone while driving, 17% passed their phone to passengers, and 7% pulled over their vehicle to answer the phone (Schroeder et al. 2018).

Some state agencies also conducted research to better understand distracted driving behaviors in their jurisdiction. The Oregon Department of Transportation (ODOT) sponsored a telephonic survey on distracted driving attitudes and behaviors. In this survey, data were collected from 378 residents of Roseburg, Oregon, and analyzed to find the reasons behind distracted driving behaviors. Half of the respondents reported that they answered a phone call while driving and 24.2% reported they texted while driving (Debi et al. 2016).

2.2 OBSERVATIONAL STUDIES

An observational study is an empirical investigation that allows researchers to observe and record drivers' behaviors at study locations. Ortiz et al. (2017) conducted a two-phase observational study to examine distracted driving behaviors such as interactions with passengers in the vehicle and interactions with other road users outside the vehicle. They counted the number of drivers passing the research locations and observed the distraction pattern and prevalence to determine the frequency of potential distraction. The study found that the high prevalence of distractions is due to engaging with other road users, and 20 out of 21 interactions observed between pedestrians and drivers resulted in distractions. They suggested that electronic device use may not be the only important source of distractions and suggested focusing on other reasons causing distractions while driving.

Similarly, Huisingh et al. (2014) conducted an observational survey to estimate the prevalence of distracted driving behaviors. In this study, 11 locations were targeted, and trained investigators were asked to observe passenger vehicles. Data collected included vehicle speed, traffic flow, and driver behavior. Out of 3,265 drivers observed, the most common behaviors were interacting with other passengers (53.2%), talking on the phone (31.4%), and texting and dialing (16.6%). They suggested continuing to study distractions other than texting and talking on the phone, because the public is already aware of these two distractions.

Observational studies have also been implemented to examine the variation of distracted driving behaviors over time. Recently, Kidd and Chaudhary (2018) conducted research to find changes in the sources of distracted driving among northern Virginia drivers in 2014 and 2018 by comparing the results from two roadside observation surveys. They observed drivers of moving or stopped vehicles in 12 different locations and found that there was a 57% increase in 2018 compared to 2014 in the likelihood of cell phone manipulation, which has been linked to crash risk.

2.3 NATURALISTIC STUDIES

Naturalistic observation is a nonexperimental, primarily qualitative research tool to study subjects in their natural settings. The AAA Foundation (2017) sponsored a study to examine teen drivers' distracted driving behaviors during the provisional licensing stage of graduated driver licensing (GDL) using in-vehicle video, audio, and accelerometer data obtained from DriveCam. A total of 52 teens were recruited in the study, and a sample of 7,858 clips were coded for the analysis. They found that teenagers, like adults, engaged in a variety of distracting behaviors while driving. However, all behaviors examined were relatively rare, e.g., using an electronic device (7.6%), loud conversations

(12.2%), and horseplay (6.3%). Substantial individual differences were observed between teenagers in the frequency of distracted behaviors. There was evidence that teenagers tempered these behaviors in settings that place greater demands on the driver (rainy conditions, but no traffic volume/congestion). Both horseplay and loud conversations were particularly common after 9 p.m. on weekends, a time when much of teen driving may be recreational. Electronic device use and other distracted driver behaviors were strongly associated with looking away from the roadway, although electronic device use was only weakly related to serious incidents (Goodwin et al. 2012; Foss and Goodwin 2014).

Other small-scale naturalistic studies emphasized the prevalence of cell phone use. Dingus et al. (2016) used naturalistic driving data from multiple onboard video cameras and sensors to analyze distracted driving. They collected data from 3,500 participants aged 16 to 98 years. The data indicated that handheld electronic devices have high use rates. They also found other behaviors from distractions such as drugs, alcohol, drowsiness, fatigue, emotion, and aggressive driving. In another study by Ponte and Wundersitz (2019), inside and outside video cameras were used at different angles to observe driver behavior while driving. Within a two-hour sample period across four sites, 920 drivers were observed. The study confirmed that most drivers engaged in distracted driving behaviors were using cell phones. Out of 920 drivers, 82 drivers were engaged in distracted driving such as holding a phone, looking for an object, texting, and talking.

2.4 CRASH DATA/POLICE REPORTS

Using data from the 1995 Crashworthiness Data System (CDS), Wang et al. (1996) studied driver inattention and its involvement in crashes. Distractions found in this study include talking, dialing, sleeping, eating, drinking, smoking, adjusting objects, and being distracted by other passengers and moving objects in the vehicle. Above all, daydreaming was found to be the most distracting factor. Note that 1995 is the year that driver attention/inattention was first included in CDs. In the 1990s, smart electronic devices had not been developed and were not prevalent. This study showed the prevalence of distractions other than cell phone use and their association with crashes.

Troopers/officers in a pilot study of distracted drivers used a developed survey form to collect data at crash scenes that involved driver inattention. They found that 63% of crashes occurred in rural areas and 62% and 35% of distractions were inside and outside the vehicle, respectively. The top three distractions observed were “looking at crashes, other roadside incidents, traffic, or other vehicles” (13%), “looking at scenery or landmarks” (10%), and a distraction caused by passengers or children in the vehicle (9%). In the study, alcohol, sleeping, daydreaming, and medical and emotional impairment were listed as types of distractions (Glaze and Ellis 2003).

2.5 SUMMARY

Researchers from academia, public agencies, and private sectors in multiple disciplines, including engineering, safety, human factors, vehicle manufacture, etc., have studied distracted driving behaviors. The definitions and three main categories of distracted driving from different sectors and disciplines are similar, despite slight differences. However, there are no national standard guidelines

on data items and categorization of distracted driving behaviors. Agencies and organizations developed their own data structure for distracted driving data collection, and there are discrepancies about the characteristics and categorization of specific activities, such as drowsiness, fatigue, medical conditions, driving under the influence, etc. A national standard data-coding system is needed on distracted driving.

Survey/interview, roadside observation, and naturalistic observation are the three commonly used approaches to examine distracted driving activities and their frequencies. The inputs for survey/interview studies are mainly respondents/interviewees recapped or expected driving behaviors, which are likely to be underreported/underestimated given the general awareness of the detrimental impacts of distracted driving. Roadside observations remove the bias of underreporting, but the existence of roadside observers may disturb drivers' distracted driving activities and distort the data collected. Compared to the other two methods, naturalistic observations are more reliable, because the observed subjects are in their natural settings. As an intrusive data collection method, the experiment should be designed so that the subjects are not aware of the data collection to achieve a 100% natural setting. However, this is difficult to carry out, given high privacy protection in the United States.

Not surprisingly, electronic device use (talking on the phone, texting, dialing, etc.) is a highly frequent distracted driving behavior observed in both young and middle-aged adults, particularly young adult drivers. The prevalence of texting while driving varies across states, with the frequency lower in eastern states and higher in mountainous areas. It increases as the number of students and teen drivers increase and the learner's permit age decreases. Previous studies also indicate texting while driving is highly associated with young Caucasian drivers and low education levels. Substantial individual differences were observed between teenagers in the frequency of distracted behaviors, meaning a small number of teenage drivers counted for a large part of the high frequency of texting while driving.

Besides electronic device use, other highly frequent distracted driving behaviors were also observed, including interacting with other passengers, loud conversations, horseplay, etc. In some studies, the frequency of those activities was even higher than talking on the phone or texting and dialing. This indicates that electronic device use may not be the only important source of distractions. It is suggested to focus on other distractions while driving as well.

CHAPTER 3: FACTORS INFLUENCING DISTRACTED DRIVING

To fight against distracted driving, the reasons why drivers could not concentrate on the primary task of driving must first be investigated. A better understanding is needed for underlying causes for distracted driving as well as the sources of distraction that divert drivers' attention. Several studies have explored the causes and influencing factors of distracted driving. This chapter presents the related findings categorized into task workload, emotion, attitude/willingness, medical condition, and other factors.

3.1. TASK WORKLOAD

Researchers have studied the workload of mental, visual, and verbal tasks and their impacts on drivers' visual search, detection, and response-selection capabilities. They obtained similar results. For instance, Recarte and Nunes (2003) conducted a field experiment to study the workload of different tasks on driving performance. They used 12 participants who drove an instrumented car in real traffic. Their findings verified the work of Luoma (1986, 1988), Just et al. (2001), and Wickens (1984, 1992). Recarte and Nunes found that increased workload from visual searches and mental tasks produced spatial-gaze concentration and visual-detection impairment, although no tunnel vision occurred. This impairment was due to late detection and poor identification rather than a response to selection. Verbal-acquisition tasks were innocuous compared with production tasks; while complex conversations, whether by phone or with a passenger, were dangerous for road safety (Recarte and Nunes 2003). Apparently, a comparable optimization of visual resources in real driving conditions are desired. When more irrelevant objects are in the visual field, eye fixation on traffic targets will be significantly reduced, which will impair drivers' detection performance.

3.2. EMOTION

Emotion is also a significant factor influencing distracted driving. Investigations were conducted on how emotions could affect driver behavior. Steinhauser et al. (2018) performed a driving simulator study to examine the impact of emotion on drivers by playing music and through autobiographical imagination. They found that emotion either directly influences driving behaviors or indirectly affects drivers' attentional processes while driving, e.g., anger leads to aggressive driving. Abdu et al. (2012) conducted a similar driving simulator–based experiment to study the impact of emotion on driving. In this study, 15 licensed drivers were asked to drive a simulator twice and different emotions were introduced in each task. When using the driving simulator, participants' moods were compared during angry and neutral states using paired t-tests. They concluded that aggressive driving is a frustration-driven instrumental behavior of distracted driving.

Pêcher et al. (2009) also performed similar work, focusing on how loud music inside a vehicle affects driver behavior and performance. They found that sad music made drivers drive more slowly and happy music kept drivers more distracted than other music. Drivers may also get distracted when they see roadside billboards containing negative and positive emotional content, influencing driver behavior toward driving (Chan and Singhal 2014; Edquist et al. 2010).

3.3. ATTITUDE/WILLINGNESS

Driver behavior may differ because of variations in sociodemographic profiles, driving habits, and perceptual patterns (Fountas et al. 2019). Hejazi et al. (2017) studied texting while driving behavior (TWD) in college students. According to the Theory of Planned Behavior (TPB), human behavior is guided by a) the propensity to engage in the behavior (intention); b) beliefs about the outcome of the behavior and evaluation of these outcomes (attitude); c) beliefs about the expectations of others (normative belief); d) motivation to comply with these expectations (subjective norm); and e) beliefs about factors that can either facilitate or hinder the performance of the behavior, and the perceived power of these factors (perceived behavioral control) (Hejazi et al. 2017). In this theory, an individual's behavior is determined by his or her intention to perform the behavior. In this study, 243 male and female college students enrolled in the 2013–2014 academic year in the College of Health, Human Services & Nursing completed a survey on TWD. They found that the attitude of students is the strongest predictor of intention while TWD. This means that most of the students' behavioral interventions are causing distracted driving because of their willingness to read and reply to text messages they receive during driving compared to older drivers (Hejazi et al. 2017). In a survey study conducted among college students, Ruppa et al. (2016) found that that even though drivers perceive distracted driving as a risk, they continue to do so. These results signify a need to develop a technique to bring people's perceptions in agreement with their attitudes to limit distracted driving among college-aged drivers.

Similar findings were obtained from a survey study conducted by State Farm. Significant reasons found behind drivers' distracted behaviors were improved efficiency, need to stay in touch, habit, searching for information on the internet, and seeing something they wanted to share (State Farm 2017). Willingness to use cell phones was also reflected in a survey study by ODOT. In the responses, most drivers reported that they only answer calls from someone they know and only make work-related calls (Debi et al. 2016). Kim (2018) conducted a study to evaluate the relationship between texting bans and perceived legal and moral norms among younger drivers. Kim observed a negative relationship with attitude toward and intention of texting while driving. Hence, policy makers must be encouraged to regulate young drivers' texting while driving with a strategy that appeals to their moral beliefs, rather than simply forcing them to comply with the law.

Olsen et al. (2013) conducted a study on TWD and other risky motor vehicle behaviors among US high school students. They used data from the Centers for Disease Control and Prevention's 2011 national Youth Risk Behavior Survey. The 2011 survey evaluated TWD for 30 days of 8,505 students aged 16 years from a nationally representative sample. They discovered that the ubiquity of TWD on more than one day during the 30 days before the survey was 44.5%. They also observed that students who engaged in TWD tended to be more engaged in other risky vehicle behaviors, such as not wearing a seatbelt, riding with a driver who had been drinking alcohol, and drinking alcohol and driving. The study highlighted the association of teen drivers' risk-taking attitudes with their distracted driving behaviors. Zhao et al. (2019) conducted a simulator study to collect driving behavior data along with a survey to gather driving attitude data. They found that the main factor that influences distracted drivers' behaviors is the attitude related to basic driver characteristics. In another online anonymous survey of students from 12 colleges and universities, Hill et al. (2015) found that distracted driving is highly evident in those who have overconfidence in their driving skills and who multitask while

driving. Many students reported that laws impacting driving privilege and increasing fines and insurance rates would influence their behavior.

3.4. MEDICAL CONDITION

Attention Deficit Hyperactivity Disorder (ADHD) is a medical condition known to affect the regulation of attention. Scientific literature well documents driving risks and impairments associated with ADHD. Several studies have been conducted to investigate the association between ADHD and distracted driving. Reimer et al. (2010) performed a driving simulator experiment to examine the impact of cognitive secondary tasks on young adult drivers with ADHD. Two secondary tasks and two driving scenarios were employed in the study: a hands-free phone task in a high-stimulus urban setting and a working memory task during low-stimulus highway driving. Secondary task performance data and driving performance data were collected from a validated driving simulation before, during, and after participation in a secondary cognitive task. The results showed that drivers with ADHD had more difficulty with the telephone task but did not show an increased decrement in driving performance greater than control participants in a high-demanding setting. In contrast, participants with ADHD showed a larger decline in driving performance than control participants during a secondary task in a low-demand setting. The results suggest that the interaction of the nature of the driving context and the secondary task have a significant influence on how drivers with ADHD allocate attention and, in turn, on the relative impact on driving performance. Drivers with ADHD appear particularly susceptible to distraction during periods of low-stimulus driving.

Similarly, Stavrinos et al. (2015) examined the effect of talking on a cell phone or text messaging while driving in teens with and without ADHD. Teens (average age 17 years) with a diagnosis of ADHD (N = 16) were matched with typically developing control participants (N = 18). All participants operated a driving simulator while conversing on a cell phone, text messaging, and with no distractions during a baseline condition. Driving performance data were recorded during the study. The results showed that significantly greater variation in lane position occurred in the texting task compared to the no distractions and cell phone tasks for both groups. While texting, teens with ADHD took significantly less time to complete the scenario. No significant effects were found per group. Generally, participants with ADHD did not differ regarding driving performance when compared to control participants, with the exception of time to complete scenario. These findings suggest that distracted driving impairs the driving performance of teen drivers, regardless of ADHD status. Texting while driving had the greatest negative impact on driving performance, particularly regarding variability in lane position.

3.5 OTHER FACTORS

Wu and Xu (2018) studied 557 trips completed by 155 drivers to analyze the effects of familiarity on the involvement of secondary tasks and driving operation using naturalistic driving study (NDS) data. In this study, the data were extracted from face videos, which included 501 trips on familiar roads and 56 trips on unfamiliar roads. The data showed that performing secondary activities while driving was more frequent on familiar roads than unfamiliar roads. The study also focused on the difference in behavioral responses while driving on familiar and unfamiliar roads. Distracted driving was more

common while driving on familiar roads. The study suggests that people must be made aware of driver behavior concerning familiar roads and develop a countermeasure to reduce crashes due to familiarity (Wu and Xu 2018). A naturalistic study sponsored by AAA examined teen drivers' distracted driving behaviors during the provisional licensing stage of GDL. In the study, teenagers tempered these behaviors in settings that place greater demands on the driver, e.g., under rainy conditions (Goodwin et al. 2012). However, traffic volume or traffic congestion did not impact teenagers' distracted driving behaviors.

3.6. SUMMARY

External and internal causes for distracted driving were identified during the literature review. Studies have found that increased visual and mental task workloads on drivers can affect driving performance and produce distraction. External objects also affected drivers' emotions and moods, influencing their attention to driving. For example, aggressive driving is a frustration-driven instrumental behavior of distracted driving, and roadside billboards containing negative and positive emotional content distract drivers' attention. Accordingly, to mitigate distracted driving due to the abovementioned external causes, transportation agencies could provide a comparable optimization of visual resources in our roadway system, e.g., limit the number of signs and signals, remove irrelevant information/objects, census roadside billboards content, etc.

A key internal cause of distracted driving is a driver's attitude and willingness toward distracted driving related to their sociodemographic profile. For example, studies have found that attitude of young drivers is the strongest predictor of intention to text while driving. This indicates that most young drivers' behavioral interventions are causing distracted driving because of their willingness to read and reply to text messages they receive during driving, as compared to older drivers. Another internal cause of distracted driving is special medical conditions. For instance, studies have shown that young adult drivers with ADHD are more susceptible to distractions. The best approach to mitigate distracted driving due to internal causes is through the joint efforts of enforcement, campaign, and education. Particularly, to deal with ADHD's adverse impacts, doctors should educate patients/drivers about the increased risk of adverse outcomes among untreated individuals with ADHD and the role of medication in potentially improving driving performance.

CHAPTER 4: IMPACT OF DISTRACTED DRIVING ON SAFETY

Distractions divert drivers' attention, impair driving performance, and create safety issues. Crash statistics show an increasing percentage of fatalities and injuries involving distracted driving (National Safety Council 2020), but the impact of distracted driving on safety still needs to be researched systematically. This chapter reviews past studies on the association of distracted driving with crashes and crash risk. Based on the research approach, the studies can be categorized by crash data analysis, driving simulator studies, and naturalistic studies.

4.1. CRASH DATA ANALYSIS

Crash data analysis is the most straightforward way to study the impact of distracted driving on safety. In 1995, the Crashworthiness Data System (CDS) introduced a new data variable named driver distraction/inattention to driving (DD/ID). Using 1995 CDS data, Wang et al. (1996) studied driver inattention and its involvement in crashes. The DD/ID variable data were retrieved and compared to other important crash variables such as crash type, crash severity, hour of day, atmospheric condition, and light conditions. Combining all driver inattention categories, they estimated that 13.8% of driver involvements in 1995 passenger vehicle tow-away crashes and 23.8% of the crashes themselves involved driver inattentiveness as a causal factor. Redelmeier and Tibshirani (1997) studied whether using a cell phone while driving increases motor crashes. They studied behaviors of 699 drivers who had cell phones and who were involved in motor vehicle collisions resulting in substantial property damage but no personal injury. Data from each driver's call list on the day of the collision and the previous week were taken and analyzed. They found that using a cell phone can increase the high risk of collision occurrence when compared to participants not using cell phones while driving.

In Australia, Lam et al. (2002) analyzed crash data to examine the association between distraction and injuries. In this study, Lam investigated driver distractions inside and outside the vehicle. Data used were from the Traffic Accident Database System (TADS) by the Roads and Traffic Authority of New South Wales (NSW), Australia. A total of 414,136 crashes were analyzed, of which 63,779 crashes were fatal. Distractions from inside the vehicle were found to be more harmful compared to outside distractions. Also, a significant increase in the risk of crash injury due to handheld phone usage only occurred to drivers aged 24 to 29 years. Ivers et al. (2009) obtained similar results on high crash risk among young drivers with distractions. A detailed questionnaire about drivers' behaviors and perceptions was developed, and a sample of drivers aged 17 to 24 years were surveyed. After analyzing the survey results and police-reported crash data, they found that risky driving behavior is strongly linked to crash risk among young drivers.

Peng and Boyle (2012) targeted the behaviors of drivers of large trucks and their association with crashes. They conducted a logistic analysis from 2006 to 2009, using large-truck crash data from Washington State Department of Transportation. The logistic model predicted the effects of truck driver distraction, inattention, speeding, seat belt usage, and drowsiness and fatigue on the likelihood of a runoff road crash involving injury or fatality. Other factors, such as environmental conditions, roadway types, and truck-related factors, were controlled in the model. Results indicated that

distraction and inattention, along with speeding, drowsiness, and fatigue, strongly affected increasing crash severity.

4.2 SIMULATOR STUDIES

A simulator study is a common approach to examine distracted driving behavior, given the crash risk of drivers under distraction in real road experiment conditions. Oviedo-Trespalacios et al. (2018) conducted a driving simulator experiment to investigate the relationship between self-regulatory secondary task performance and driving. In this study, 35 drivers aged 18 to 29 years were observed under three phone-use conditions: non-distraction (no phone use), hands-free, and visual-manual interactions. They found that engagement in the secondary task influences both longitudinal and lateral control of vehicles. Hands-free and visual-manual interactions result in engaging in lower and higher speeds, respectively. Another simulator study conducted by Bowden et al. (2018) found that participants in all conditions (cognitive, cognitive+manual, cognitive+visual+manual) exhibited some degree of distraction impairment. Only those in the cognitive+visual+manual condition reduced their speed when distracted.

Choudhary and Velaga (2017) used a simulator study to analyze and model the effects of cell phone distraction upon the reaction time of Indian drivers belonging to three age groups. Two types of hazardous events, pedestrian crossing and road crossing by parked vehicles, were included for measuring drivers' reaction times. The results showed that in the case of pedestrian crossing events, the phone-use tasks of simple conversation, complex conversation, simple texting, and complex texting caused 40%, 95%, 137%, and 204% increments in reaction times, respectively. In the case of road crossing events by parked vehicles, the tasks caused 48%, 65%, 121%, and 171% increments in reaction times, respectively. Thus, all phone-use conditions proved to be the most significant factors in decreasing driving performance.

Zhang et al. (2019) conducted a driving simulator study with 48 young participants aged 18 to 20 years to determine the effect of presence of passengers and distractions among young drivers. The participants went through three tasks comprising of visual, cognitive, or combined, as well as a no-distraction phase in each task while traversing a highway. For visual tasks, the drivers were asked to dial a number. For cognitive tasks, two conditions of driving were analyzed, i.e., when drivers were alone and when they had passengers. For combined tasks, the drivers were shown a series of arrows representing a direction and were asked follow-up questions about the direction of the arrows. The results showed that distractions impaired drivers' performance while driving. Driving performance changed with respect to length of friendship and stimulating companionship. Gender also influenced driving performance based on distraction types, but gender combination of driver passenger did not have any effect on driving behavior. The impairment on driving performance due to distractions have been confirmed by a simulator study conducted by Louie and Mouloua (2019). They found that participants were significantly slower at braking when a yellow traffic light appeared and during sudden braking events when distracted.

Research has been conducted on distracted drivers' impacts on other drivers in traffic. Xu and Lin (2018) conducted a study to find the impact of distracted drivers on individual and group behavior of

following vehicles using a networked multi-driver simulator. This study examined the impact of a low-task load distraction (cell phone-texting task) not only on the specific distracted driving behavior but also on how this behavior influences other drivers, individually and collectively, through a networked driving simulation platform. The concept of interactive driving and the implications of virtual environments using a networked multi-driver simulation platform were the two major facilitating factors for carrying out this study. The performance indicators from 12 driver groups (three drivers per group) in a car-following situation with a distracted driver involved were analyzed and compared with a no-distraction trial. The results showed that the impacts of a phone-texting distraction in traffic flow differ when observing drivers individually or as a four-driver platoon. This implementation has the potential to lay a foundation for continued interactive driving experiment design and can serve as an experimental tool for new vehicle technology applications that consider collective vehicle behavior.

4.3 NATURALISTIC STUDIES

Klauer et al. (2006) performed a 100-car naturalistic driving study sponsored by NHTSA to analyze driver inattention. The data were collected over a time frame of 18 months and represented normal travel behavior of individuals in a metropolitan area. To analyze the impact of inattention on crash risk, two databases were used: the 100-car study and baseline databases. The baseline database had 20,000 6-sec segments from 6.3 terabytes of driving data randomly selected from the dataset pool comprising of total number of crashes, near crashes, and related incidents. The results showed that driving while being drowsy increases crash risk by four to six times and involvement in distracting activities resulted in a three times higher crash risk than being attentive while driving. Brief glances away from the roadway below 2 sec to analyze the environment decreased crash risk. However, longer glances increased the risks by twofold.

A SHRP2 naturalistic driving study (Victor et al. 2014) produced data that researchers used to examine the impacts of driving distractions on safety. As part of the SHRP2 naturalistic driving study, Victor et al. (2014) carried out an analysis of people's driving behavior and crash risk. The Roadway Information Database (RID), created simultaneously with the naturalistic driving study (NDS), was used in the study. RID contained information about roadway characteristics, while NDS investigated driver behavior and driving before crash or near-crash conditions. NDS had a pool of more than 3,000 volunteer passenger-vehicle drivers during a three-year period. A logistic model was employed to model crashes and near-crash events with driver behavior and environment. The results indicate a strong association between eyes-off-road occurrence and crash risk. Recently, Arvin et al. (2019) explored the relation of precrash driver instability to crash intensity, using SHRP2 NDS data. They identified that distracted and aggressive driving boosted crash probability.

Besides using NDS data, there are other distracted driving studies that collected driver behavior data through in-vehicle cameras. The AAA Foundation has sponsored a study to examine teen drivers' distracted driving behaviors during the provisional licensing stage of GDL using in-vehicle video, audio, and accelerometer data obtained from DriveCam. A total of 52 teens were recruited in the study and a sample of 7,858 clips were coded for the analysis. The study found that electronic device use was only weakly related to serious incidents (Goodwin et al. 2012). Using cameras and sensors,

Guo et al. (2017) collected driving activity data from 3,542 drivers. They found that teenagers, young adult drivers, and senior drivers are more adversely impacted by visual tasks like texting, gaming, or watching videos on cell phones.

4.4 SUMMARY

Many studies have been performed to study the association between distracted driving and crashes. Similar conclusions were drawn that distracted driving behaviors were highly associated with crashes and injuries/fatalities. The research approach used by almost all previous studies is to examine the percentage involvement of distracted driving in crashes or injuries (fatalities) or to compare percentage involvement of distracted and non-distracted driving in crashes. However, without a proper control of other possible influencing factors, simple crash involvement percentages or simple comparisons could not fully describe the association between driving distraction and crashes. Also, vehicle crashes are rare events, in addition to crashes occurred or reported, there were more occurrences of near-crash events for both distracted and non-distracted driving conditions. Only analyzing crash data would distort the comparison of real crash risk of distracted driving and non-distracted driving. Moreover, crash risk is a probability concept, and the simple percentage involvement of distracted driving in crashes is not equal to crash risk of distracted driving.

The advantage of a driving simulator study is it can simulate traffic and roadway conditions and test different types or combinations of distractions. The main limitation of using a driving simulator to research the impact of distracted driving on crashes or crash risk is that it cannot simulate real-world crashes, injuries, or fatalities. That is why all simulator studies use surrogate measurements, e.g., speed, lane keeping, reaction time, etc., to describe crash risk.

A naturalistic study is a more appropriate approach to examine the crash risk of distracted driving compared to crash data analysis and driving simulator studies. Previous research has shown that distractions impair drivers' performance, and they have a high percentage of involvement in crashes. However, limited research has been conducted on how specific distracted driving behaviors impact crashes and crash risk. With properly designed experiments, naturalistic studies will be able to quantify the crash risk of distraction behaviors and their influences on other factors, such as traffic and roadway conditions, sociodemographic characteristics, etc. Note that a naturalistic study is costly and time-consuming. With the prevalence of cell phone and texting bans, the results of naturalistic studies on driving distractions' impact on crash risk will also be affected.

CHAPTER 5: RESTRICTION LAWS AND ENFORCEMENT

Given the detrimental impacts of distracted driving on roadway safety and the prevalence of cell phone use while driving, agencies across the United States have passed, enacted, and enforced restriction laws regarding cell phone use while driving. This chapter presents the literature review on agencies' efforts to reduce distracted driving. First, recent cell phone restriction laws are summarized. Then, agencies' efforts on the enforcement of restriction laws are presented. Finally, previous studies on the effectiveness of restriction laws are reviewed.

5.1 RESTRICTION LAWS

In 2001, New York became the first state in the United States to enact laws that ban conversations on handheld phones while driving. After that, cell phone bans were widespread in the United States. As of 2019, 21 states and the District of Columbia have handheld cell phone bans (Figure 1), texting is banned for all drivers in 48 states and the District of Columbia (Figure 2), and 38 states and the District of Columbia restrict cell phone use by young drivers (Figure 3).

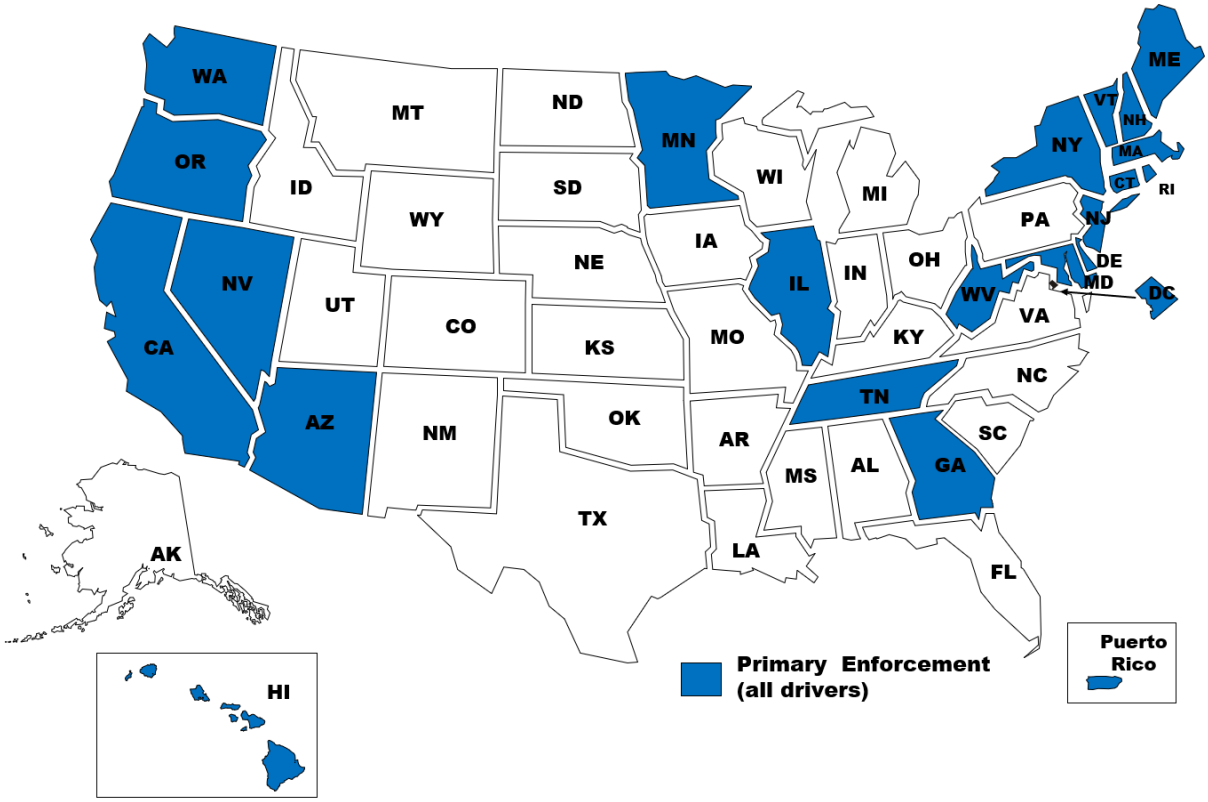

Figure 1. Handheld phone bans in the United States (NHTSA 2020).

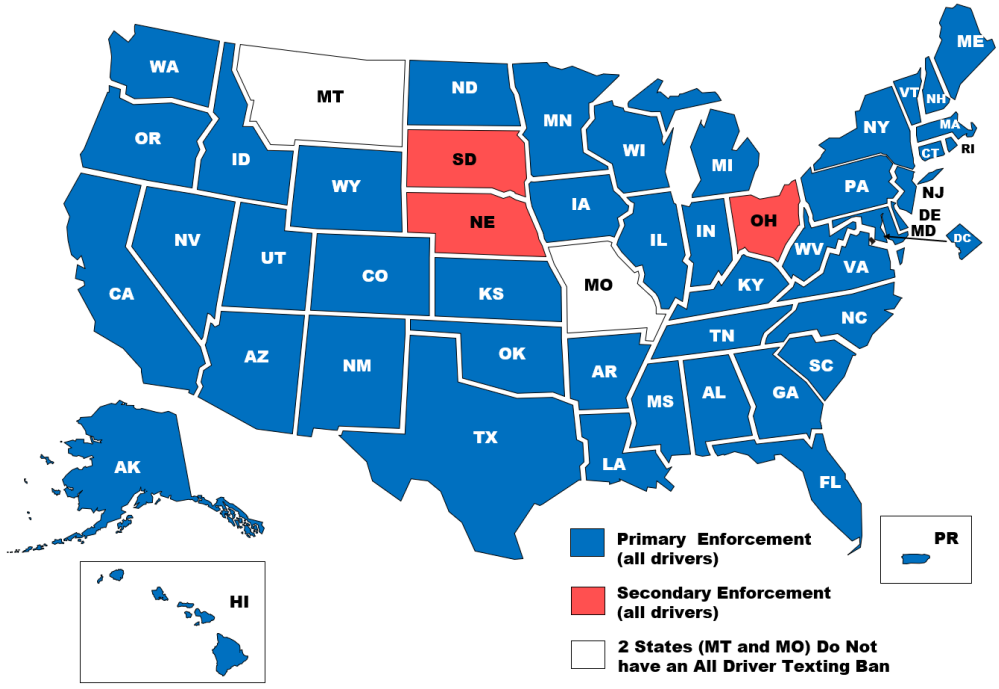

Figure 2. Texting bans in the United States (NHTSA 2020).

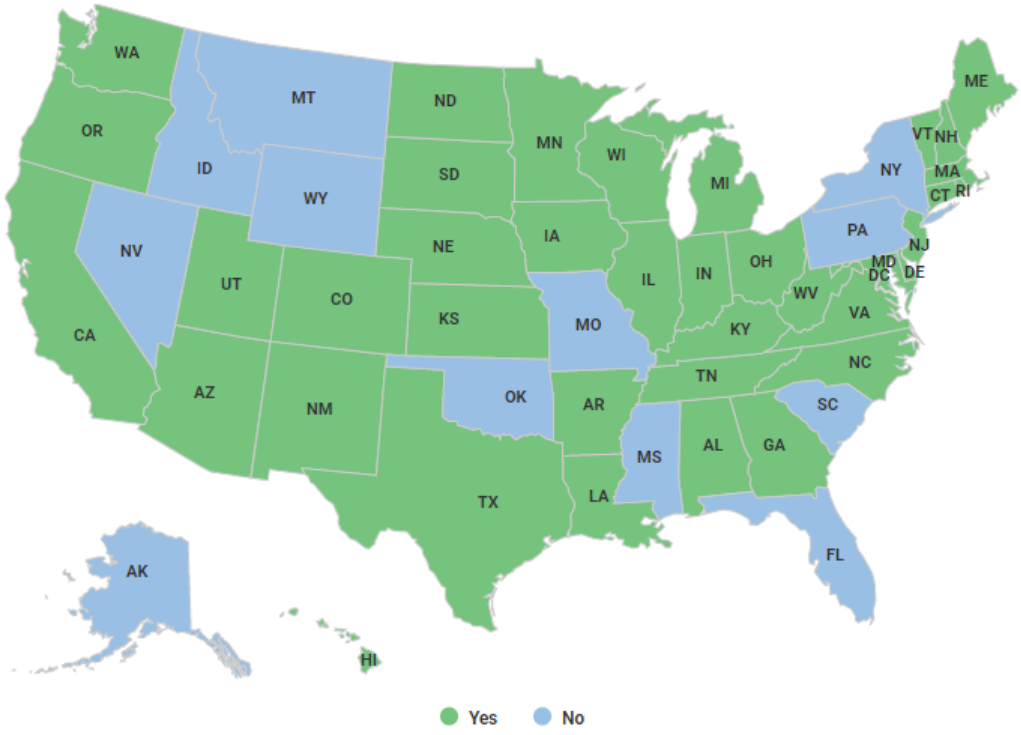

Figure 3. Young-driver phone bans in the United States (Insurance Institute of Highway Safety 2019).

Cell phone restriction laws have evolved over time with the purpose of improving enforcement and effectiveness. For instance, in 2010, at the urging of safety advocates and to address distracted driving, Georgia banned texting while driving and prohibited anyone under 18 with a learner's permit from using any electronic device while driving. However, police say the law is hard to enforce, because they often cannot tell whether a driver is dialing a phone number—which is permitted under the law—or texting. So, in 2018, lawmakers passed the Hands-Free Georgia Act. Under the law, drivers will still be able to make calls, dictate texts, and otherwise use their phone if they use hands-free technology. The driver may get a citation if police see a phone in a driver's hand (Wickert 2018).

As shown in Figures 1–3, almost all states in the United States (except Montana) have restriction laws against cell phone use while driving. However, the laws differ across states in terms of penalties, enforcement (primary or secondary), to whom they apply, etc. For instance, Arkansas recently refined the state's existing texting ban to include wireless interactive communication such as social media use. The penalty for this offense was increased to a fine of up to $250 for a first violation and up to $500 for subsequent violations. In Colorado, the penalty for texting while driving was increased from $50 to $300 in 2017 (Kitch 2018). In Connecticut, violators of distracted driving laws face a first-time fine of $150, which increases to $300 for a second offense and $500 for any offenses thereafter (Failla 2019). In addition to fines, some states also deduct points for violations. According to the state law of Georgia, the fine for a first conviction is $50 and one point against a driver's license. The fine is $100 and two points for a second conviction, and $150 and three points for three or more convictions. The fines for a second or third offense only apply when the date of the second or third conviction takes place within 24 months of the date of the first conviction. First-time offenders can have the charge dropped by showing the court they have obtained a device that allows them to talk on a phone with hands-free technology or devices (Hill 2019). Table 1 provides detailed information on states' most recent cell phone bans.

Table 1. Summary of States' Cell Phone Bans

State	Handheld Phone Ban	All Cell Phone Ban	Texting Ban	Types of Bills Passed	Effective Dates
Alabama	No	Yes, for drivers ages 16 and 17 years	All drivers	Title 32. Motor Vehicles and Traffic § 32-5A-350	July 10, 2005
Alaska	No	No	All drivers	31st Legislature (2019–2020) Alaska Statutes 2018 AS 28.35.161	2012
Arizona	Yes	Yes, for school bus drivers, for instruction and intermediate permit holders under 18	All drivers	HB2318	January 30, 2019
Arkansas	Yes, school and work zones	Yes, for school bus drivers and drivers younger than 18	All drivers	§ 27-51-1504	July 2, 2005
California	All drivers	Yes, for school and transit bus drivers and drivers younger than 18	All drivers	California Vehicle Code, Division 11: Rules of the Road, Chapter 12: Public Offenses, Article 1: Driving Offenses; Sections 23123 to 23125	July 1, 2011
Colorado	No	Yes, drivers younger than 18	All drivers	Section 42-4-239, C.R.S.	July 8, 2005
Connecticut	Yes	Yes, for school bus drivers and drivers under 18	All drivers	Chapter 248 Vehicle Highway Use Sec. 14-296aa.	July 3, 2005
Delaware	Yes	Yes, for learner's permit or intermediate license holders and school bus drivers	All drivers	§ 4176C Electronic communication devices	
District of Columbia	Yes	Yes, for school bus drivers and learner's permit holders	All drivers	B21-0021	October 12, 2016
Florida	Yes, school and work zones	No	All drivers	Section 316.305, Florida Statutes	July 1, 2019
Georgia	Yes	Yes, for school bus drivers and drivers younger than 18	All drivers	O.C.G.A. § 40-6-241	July 1, 2018
Guam	Yes	No	All drivers		
Hawaii	Yes	Yes, for drivers younger than 18	All drivers	TITLE 17. MOTOR AND OTHER VEHICLES 291C. Statewide Traffic Code 291C-137 Mobile electronic devices	July 2013
Idaho	No	No	All drivers	49-1401A, added 2012, ch. 301, sec. 1, p. 824	July 10, 2005

State	Handheld Phone Ban	All Cell Phone Ban	Texting Ban	Types of Bills Passed	Effective Dates
Illinois	Yes	Yes, for school bus drivers and drivers under 19	All drivers	Public Act 095-0338, (625 ILCS 5/12-610.1) Sec. 12-610.1. Wireless telephones.	March 6, 2008
Indiana	No	Yes, for drivers under the age of 21	All drivers	Indiana code 9-21-8-59	July 1, 2011
Iowa	No	Yes, for learner's permit and intermediate license holders	All drivers	Iowa Code 2019, Section 321.276 (31, 0)	December 8, 2018
Kansas	No	Yes, for learner's permit and intermediate license holders	All drivers	KSA 8-15, 111 and 8-296, 8-2,101	July 8, 2005
Kentucky	No	Yes, for drivers younger than 18 and school bus drivers	All drivers	House Bill 415	April 15, 2010
Louisiana	Yes, for learner's permit or intermediate license holders	Yes, for school bus drivers, drivers with first year of licensure, and drivers under 18	All drivers	LA Rev Stat § 32:300.5	July 1, 2008
Maine	Yes	Yes, for learner's permit and intermediate license holders	All drivers	29-A MRS §2118	September 19, 2019
Maryland	Yes	Yes, for drivers under 18	All drivers	Code Section 21–1124.	July 1, 2005
Massachusetts	Yes	Yes, for school bus drivers and drivers younger than 18	All drivers	Section 13B	July 2, 2005
Michigan	No	Yes, for school bus drivers and level 1 or 2 license holders	All drivers	Section 257.602b, MICHIGAN VEHICLE CODE (EXCERPT) Act 300 of 1949	July 2, 2005
Minnesota	Yes	Yes, for school bus drivers and drivers under 18 with learner or provisional licenses	All drivers	169.475 USE OF WIRELESS COMMUNICATIONS DEVICE	June 30, 2005
Mississippi	No	Yes, for school bus drivers	All drivers	Mississippi Code Title 63. Motor Vehicles & Traffic Regulations § 63-33-1	July 1, 2018
Missouri	No	No	Drivers 21 years or younger	Section 304.820	August 28, 2013
Montana	No	No	No	Sect. 61- 1- 101(27), MCA	January 17, 2012
Nebraska	No	Yes, for school bus drivers and drivers under 18 with learner or intermediate licenses	All drivers	LB40 - Change provisions related to provisional operator's permits, LPD and LPE learner's permits, and interactive wireless communication devices	January 10, 2019

State	Handheld Phone Ban	All Cell Phone Ban	Texting Ban	Types of Bills Passed	Effective Dates
Nevada	Yes	No	All drivers	"Texting while Driving" in Nevada (NRS 484B.165)	October 1, 2011
New Hampshire	Yes	Yes, for drivers younger than 18	All drivers	RSA 265:79-c,	July 1, 2015
New Jersey	Yes	Yes, for school bus drivers and learner's permit and intermediate license holders	All drivers	Title 39 - MOTOR VEHICLES AND TRAFFIC REGULATION Section 39:4-97.3	July 5, 2005
New Mexico	In-state vehicles	Yes, for learner's permit and intermediate license holders	All drivers	Section 4 TRAFFIC LAWS GENERALLY Section 66-7-374	July 6, 2005
New York	Yes	No	All drivers	Title 7 - RULES OF THE ROAD Article 33 - (1210 - 1229-D) MISCELLANEOUS RULES 1225-D - Use of portable electronic devices.	July 5, 2005
North Carolina	No	Yes, for drivers younger than 18 and school bus drivers	All drivers	§ 20-137.4A.	July 7, 2005
North Dakota	No	Yes, for drivers younger than 18	All drivers	North Dakota Century Code 39-08-25	August 1, 2017
Ohio	No	Yes, for drivers younger than 18	All drivers	4511.204 Driving while texting, 4511.991 "Distracted" defined; violations committed while distracted	October 29, 2018
Oklahoma	Yes, for learner's permit and intermediate license holders	No	All drivers	HB 1965, OKLAHOMA	July 7, 2005
Oregon	Yes	Yes, for drivers younger than 18	All drivers	ORS 815.110, – ORS 811.507	July 1, 2018
Pennsylvania	No	No	All drivers	Title 75, § 3316. Prohibiting text-based communications	November 9, 2011
Puerto Rico	Yes	No	All drivers	Sections 1.42-A, 1.97-B, and 10.25 to Act No. 22-2000	October 11, 2011
Rhode Island	Yes	Yes, for school bus drivers and drivers younger than 18	All drivers	Title 31 – Motor and Other vehicles Chapter 31-22 – Miscellaneous Rules Section 31-22-31 – Mobile telephone usage by motor vehicle operators	June 1, 2018
South Carolina	No	No	All drivers	SECTION 56-5-3890, 260 (S.459), Section 1	June 9, 2014
South Dakota	No	Yes, for learner's permit and intermediate license holders	All drivers		

State	Handheld Phone Ban	All Cell Phone Ban	Texting Ban	Types of Bills Passed	Effective Dates
Tennessee	Yes	Yes, for school bus drivers and learner's permit and intermediate license holders	All drivers	TCA 55-8-199	July 2, 2005
Texas	No	Yes, for bus drivers when passengers are younger than 17 and drivers younger than 18	All drivers	Sec. 545.4251. USE OF PORTABLE WIRELESS COMMUNICATION DEVICE FOR ELECTRONIC MESSAGING; OFFENSE	September 1, 2017
Utah	No	Yes, for drivers under the age of 18 and school bus drivers	All drivers	Utah Code § 41-6a-1716(2),	May 13, 2014
Vermont	Yes	Yes, for drivers under the age of 18	All drivers	Subchapter 9: VIOLATIONS AND PENALTIES § 1095b Handheld use of portable electronic device prohibited	July 7, 2005
Virgin Islands	Yes	No	All drivers		
Virginia	Yes, for work zones	Yes, for drivers younger than 18 and school bus drivers	All drivers	46.2-1078.1	July 1, 2009
Washington	Yes	Yes, for learner's permit and intermediate license holders	All drivers	Title 46 - MOTOR VEHICLES 46.61 Rules of the road. 46.61.667	July 8, 2005
West Virginia	Yes	Yes, for drivers younger than 18 who hold either a learner's permit or an intermediate license	All drivers	§17C-14-15. Prohibited use of an electronic communications device driving without handheld features; definitions; exceptions; penalties	July 1, 2013
Wisconsin	Yes, for work zones only	Yes, for learner's permit or intermediate license holders	All drivers	346.89 Inattentive driving., 343.305 (1) (b)	July 1, 2005
Wyoming	No	No	All drivers	TITLE 31 - MOTOR VEHICLES CHAPTER 5 - REGULATION OF TRAFFIC ON HIGHWAYS 31-5-237. Use of handheld electronic wireless communication devices for electronic messaging prohibited; exceptions; penalties.	July 3, 2005

5.2 ENFORCEMENT

The enforcement of cell phone bans is difficult in part because it is hard to prove violations, particularly in states that do not have bans. Also, drivers have become sneakier. They hold their cell phones low to make it more difficult for police to catch cell phone use violations. So, police have been forced to create innovative ways to enforce cell phone bans. In addition, distracted driving campaigns featured with high-visibility joint law enforcement agencies have also been launched to discourage cell phone use while driving.

5.2.1 Strategies

Tag team efforts against distracted driving have been employed in Austin, Texas. The Austin Police Department is doing a double-team operation to catch distracted drivers who often try to hide texting while driving. Officers will ride the local mass transit lines to look for distracted drivers. If they see a driver distracted by a mobile device, they radio local motorcade officers to pull them over for citations. This operation is legal and is not a violation of rights (Skousen et al. 2019).

An article in the *New York Post* described ways police officers have used to catch texting drivers. For instance, state police in Chattanooga, Tennessee, have patrolled from up high in a tractor trailer so they can spot drivers texting behind the wheel. In Bethesda, Maryland, a police officer disguised himself as a homeless man, stood near a busy intersection, and radioed ahead to officers down the road about texting drivers. The Bethesda police gave out 56 tickets in a two-hour enforcement period (Associated Press 2016). In West Bridgewater, Massachusetts, an officer regularly bikes around town, pedals up to drivers at stoplights, and hands them tickets. In New South Wales, Australia, operational police experiences with distracted driving were also reported. One example is Operation Compliance, a statewide high-visibility operation that requires all police, regardless of duty type, to target specific traffic safety offences such as using cell phones and not wearing seatbelts. Another example is the use of motorcycle units to detect the use of handheld phones by drivers, where the elevated position of the rider allows for the interior of the vehicle to be more clearly observed and texting drivers detected. It is believed that this high-visibility policing and the perceived risk of getting caught assists in realigning the driver's attention back to the road (Hartley 2007).

Retting et al. (2017) conducted the study to determine the enforceability of texting laws, test methods for enforcing these laws, and measure the outcome of the enforcement and earned media activity. They analyzed four waves of enforcement during 2013 and 2014 at test and control sites in Massachusetts and Connecticut. Law enforcement agencies used a variety of strategies, including spotter, stationary, and roving patrols. Strategy variations involved one- and two-officer patrols, uniformed and plainclothes officers, marked and unmarked patrol vehicles, and a variety of vehicle types, including SUVs, vans, pickup trucks, motorcycles, and cruisers. This evaluation gathered firsthand insights from the participating officers regarding their experiences enforcing texting laws. Key insights highlighted the importance of conducting officer training, holding roll calls focused on texting enforcement, engaging in preplanning to ensure smooth operation of the strategies, creating partnerships with local and state enforcement agencies to multiply forces and maximize resources, and establishing leadership priority for conducting texting enforcement. The study concludes that

strong distracted driving laws and those that give law enforcement wider latitude in enforcing distracted driving are most effective.

Another study from NHTSA emphasized the importance of pre-deployment training of officers and reallocation of resources in distracted driving enforcement. Distracted driving enforcement is not intrinsic to law enforcement and, to some degree, is contrary to traditional patrol strategies. Traditional patrol strategies involve observing violations as officers routinely patrol their assigned area. The enforcement of distracted driving requires more police officers than traditional patrol strategies and the officers must be more visible to the public. It also requires specialized skills to detect violators who conceal distracting devices. Therefore, pre-deployment training of officers and reallocation of resources are essential components of distracted driving enforcement. Law enforcement officers should be familiar with distracted driving laws in their jurisdictions. Police departments should provide training for officers to detect observable cues of distracted driving as well as how to appropriately document violations (National Traffic Law Center 2017).

5.2.2 High-Visibility Enforcement Campaigns

Distracted driving campaigns featured with high-visibility enforcement have been launched at national, state, and local levels to ensure the implementation of cell phone bans, increase awareness of cell phone bans, and reduce distracted driving. April has been named Distracted Driving Awareness Month by NHTSA. In Illinois, for instance, the City of Naperville participated in the April 2018 distracted driving campaign, and cell phone use behind the wheel in Naperville dropped 88% after the campaign (Newton 2019). Similarly, many counties in Illinois, e.g., Lake County and Kane County, launched campaigns in 2019 as part of Distracted Driving Awareness Month to remind drivers to "drop their phones, slow down, and drive safe" (Kane County 2019). This campaign partnered with IDOT, Illinois State Police, and more than 100 local law enforcement agencies throughout the state. Officers from the county sheriff's office, police departments, and other law enforcement agencies looked for signs of distracted behavior by drivers, including texting, using handheld cell phones, personal grooming, removing jackets, and paying attention to other occupants rather than driving. The Vernon Hills police department also had extra officers on the road in April looking for distracted drivers. Motorists have seen increased patrols and enforcement zones across Illinois throughout the month, and the sheriff's office focused on ticketing drivers who text or use their cell phones while driving. This distracted driving enforcement campaign is supported through federal funds administered by IDOT (Newton 2019; Kane County 2019).

In support of Distracted Driving Awareness Month, the Connecticut Department of Transportation Highway Safety Office, along with state and local law enforcement agencies, partnered with the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA). They partnered from August 1–15 for the national "U Drive, U Text, U Pay" high-visibility enforcement effort, as the second phase of a two-part campaign. The goal of the campaign is to increase enforcement efforts to catch distracted drivers and enforce distracted driving laws. During the first wave of the campaign in April 2019, more than 10,000 citations were issued to motorists who "chose to ignore Connecticut's distracted driving laws" (McCready 2019). The second phase of this two-part campaign also had special patrols aimed at saving lives and protecting the public. More than 50 law enforcement agencies, both state and local police who were previously involved in the April 2019

campaign, again participated (McCready 2019). This is the fifth year the state has participated in the campaign (Failla 2019).

From 2016 to 2017, Michigan saw a 57% increase in distracted driving crashes and a 67% increase in fatalities from those crashes, according to the Michigan State Police (MSP) Criminal Justice Information Center (CJIC) (Wingrove 2019). This increase is why law enforcement agencies around the state are participating in a nationwide distracted driving mobilization period from April 11–15, 2019, in the middle of Distracted Driving Awareness Month. To encourage drivers to remain attentive while driving, the Office of Highway Safety Planning (OHSP) has distributed materials to every law enforcement agency across the state. Agencies across the state have patrolled for distracted drivers during the five-day mobilization period, starting on April 11. Michigan law prohibits a driver from reading, manually typing, or sending a text message while driving. Exceptions are in place for reporting crashes, crimes, or other emergencies (Wingrove 2019). From April 11–15, 2019, law enforcement agencies in Arkansas participated in the "U Drive, You Text, You Pay" campaign, which includes both educational as well as enforcement operations designed to make streets and roads safe. The goal is to reduce traffic crashes caused by distracted driving associated with cell phone use while driving. State police patrols were increased during those days and troopers stopped violators and ticketed them if caught texting and driving (Arkansas State Police 2019).

California set up enforcement of joint law enforcement agencies throughout the state along with awareness efforts by the California Office of Traffic Safety (OTS) to discourage distracted driving. Officers will have a special emphasis in April on enforcing all cell phone and distracted driving laws. April 5 and 13 were designated as the two statewide enforcement dates when many law enforcement agencies increased distracted driving enforcement activities. The California Department of Transportation put distracted driving messages on changeable message signs on freeways during April. Also, extra traffic officers with grant-funded resources were deployed at locations with higher numbers of traffic collisions. This campaign was funded by a grant from the California Office of Traffic Safety, through the National Highway Traffic Safety Administration (Rodriguez 2018; Torrance Police Department 2018).

During the Distracted Driving Awareness Month campaign, steps for a safe driving experience were suggested as below (Newton 2019; Kane County 2019; Arkansas State Police 2019):

- "If you are expecting a text message or need to send one, pull over and park your car in a safe location before you attempt to text."
- "Designate your passenger as your 'designated texter.' Allow them access to your phone to respond to calls or messages."
- "Do not engage in social media scrolling or messaging while driving. Cell phone use can be habit-forming. Struggling to not text and drive? Put the cell phone in the trunk, glove box, or back seat of the vehicle until you arrive at your destination."

In addition to the Distracted Driving Awareness Month campaign, there are also state- and local-level high-visibility enforcement campaigns on distracted driving. One example is a multiagency enforcement action in Michigan called Operation Ghost Rider. More than 50 law enforcement officers

from police departments, sheriff's offices, and the Michigan State Police participated in the campaign. The goal is to reduce distracted driving deaths and injuries. This initiative was coordinated by the Transportation Improvement Association (TIA) and funded by the Michigan Office of Highway Safety Planning. Operation Ghost Rider uses unmarked spotter vehicles containing a law enforcement passenger. When the spotters observe a distracted driver, they radio a fully marked law enforcement unit to initiate a traffic stop.

5.3 EFFECTIVENESS

Studies have been conducted to examine if bans are effective in discouraging cell phone use while driving and reducing crashes involving cell phone use. Inconsistent results were obtained, but some studies showed that cell phone bans had a positive effect.

5.3.1 Cell Phone Use

A study by Rudisill and Zhu (2017) examined whether universal handheld calling while driving bans were associated with lower roadside-observed handheld phone conversations across drivers of different ages (16–24, 25–59, ≥ 60 years), sexes, races (White, African American, or other), setting (suburban, rural, or urban), and regions (Northeast, Midwest, South, and West). They found that the presence of universal handheld cell phone bans was associated with lower handheld phone conversations across all driver subgroups and regions. Handheld phone conversations were particularly lower among female drivers and those from Western states when these bans were in effect. California's toughened law went into effect on January 1, 2017. The California Office of Traffic Safety (2017) released a report after the handheld ban went into effect. It showed that the rate of drivers using handheld devices dropped from 7.6% in 2016 to 3.58% in 2017. Vegega et al. (2013) reported that a high-visibility cell phone and text messaging enforcement campaign conducted by NHTSA with strong law enforcement from officers resulted in decreased use of handheld cell phones. Awareness about the laws also increased at the same time.

However, research and data indicated that despite efforts to discourage the practice, texting has increased in recent years and, in a consensus among police, safety advocates, and drivers, the problem is only getting worse. According to the Associated Press (2016), in New York, texting tickets went from about 9,000 in 2011 to nearly 85,000 in 2015. In Massachusetts, they increased from about 1,100 to a little over 6,100 over the same period. In California, the number of people found guilty of texting while driving increased from under 3,000 in 2009 to over 31,000 in 2015. Similarly, Zendrive's (2018) study found that distracted driving increased in every state except Vermont in 2018. In a study to measure the outcome of the enforcement, Retting et al. (2017) found there was no effect on driver behavior in almost all cases.

Foss et al. (2009) evaluated the short- and long-term effects of cell phone restriction. They analyzed teenagers from 25 high schools in North Carolina (with a young-driver cell phone ban) and 15 high schools in South Carolina (no cell phone ban) at exits of school parking lots or intersections nearby two months before, five months after, and two years after the law took effect. Then, a logistic regression model was used to compare the changes in cell phone use observed in North Carolina and South Carolina. They collected a wide range of driver, passenger, and vehicle data. Their study

suggests that the proportion of teenagers using cell phones did not change significantly (11% before the law took effect, 11.8% after) in North Carolina, while cell phone use among teenage drivers at high schools in South Carolina was stable at about 13%. Another similar study by Goodwin et al. (2012) found that in both states there was a broad decrease in cell phone use, and their logistic regression analysis showed the decrease in cell phone use did not significantly differ between the two states. Overall, the findings from both studies suggest North Carolina's cell phone restriction has had no short- and long-term effects on the behavior of teenage drivers.

Research showed that the effects of cell phone bans were also related to the type of ban. A study by McCartt et al. (2014) found that all-driver bans on handheld phone conversations have resulted in long-term reductions in handheld phone use, and drivers in ban states reported higher rates of hands-free phone use and lower overall phone use compared with drivers in non-ban states. Bans on all phone use by teenage drivers have not been shown to reduce their phone use. The effects of texting bans on the rates of drivers' texting are unknown.

Rudisill and Zhu (2015) conducted a series of studies examining the effectiveness of cell phone bans. First, they investigated the association between texting behaviors of young drivers and state cell phone restriction legislation, using the 2013 Youth Risk Behavior Surveillance System survey. Performed prevalence ratios (PR) determined from log-binomial regression were calculated. Their study concluded that texting violations may be lower in states with both universal texting bans and young-driver, all-phone bans as well as provisions, which delay the full licensure of drivers with intermediate licenses or learner's permits for texting violations. In addition, they discovered that African Americans and Latinos appeared to text and drive considerably less than white non-Hispanics. From the study, it can be assumed that young-driver bans alone, and the laws that applied only to young drivers, were not associated with lower texting violations. For further research purposes, some limitations of this study, such as not sampling all states as well as using no stratified sampling in addition to lack of baseline information, can be mitigated to obtain more accurate results. Later, Rudisill and Zhu (2017) tested the association between universal handheld bans and roadside-observed handheld cell phone conversations using 2008–2013 National Occupant Protection Use Survey (NOPUS) data. The study concluded that the presence of universal handheld cell phone bans was associated with lower handheld cell phone conversations across all driver subgroups and regions.

Most recently, Rudisill et al. (2018) investigated the relationship between statewide cell phone legislation and self-reported phone-use behaviors among adolescent and adult drivers, using 2011–2014 Traffic Safety Culture Index survey data. Risk ratios from Poisson regression were obtained to analyze the data. They concluded that universal handheld calling bans may discourage adolescents from engaging in handheld phone conversations, whereas universal texting bans may not fully discourage texting behaviors. Also, they observed that universal texting bans were not associated with lower texting behaviors in adult drivers. Men and those of other racial/ethnic origins were 13% and 33% less likely to engage in texting behaviors if a universal texting ban was effective in their state, and universal handheld calling bans were associated with lower self-reported handheld phone conversations across every subgroup. Hence, the study concludes that universal handheld calling bans were associated with lower self-reported cell phone conversations for adult drivers (Rudisill et al. 2019).

Regarding the effects of bans on crashes, research results are also inconsistent and inconclusive. Some reported data did show that crashes and injuries decreased after the enactment of cell phone bans. In 2016, Georgia became the sixteenth state to ban handheld wireless devices while driving. In 2017, a total of 2,446 wrecks were investigated within LaGrange, Georgia, which resulted in 445 individuals being injured and one traffic fatality being investigated. In 2018, the city investigated 2,290 motor vehicle collisions, with 377 injuries being reported and two fatalities being investigated. "This equates to nearly a 7% reduction in motor vehicle collisions and nearly a 15% reduction in injuries being reported" (Hill 2019). Similarly, Connecticut reported a 9% decrease in distracted driving fatalities from 2016 to 2017 (Failla 2019). The study by Vegega et al. (2013) also indicated that high-visibility cell phone and texting enforcement campaigns conducted by NHTSA have been effective to reduce crashes to some extent. But no systematic analysis was conducted on those data and there were no proper controls to prove the reduction in crashes and injuries resulting from the cell phone use ban.

5.3.2 Crashes

Researchers have conducted statistical analysis to evaluate the association between cell phone bans and crashes. Abouk and Adams (2013) conducted a linear regression analysis to examine the association between texting bans and fatal crashes using Fatality Analysis Reporting System (FARS) data from 2007 to 2010. They found that bans appear moderately successful at reducing single-vehicle, single-occupant accidents if they are universally applied and enforced as a primary offense. However, bans enforced as secondary offenses have no effect on accidents. In addition, any reduction in accidents following texting bans is short lived, with accidents returning to near-former levels within a few months. The study did not block other confounding factors that may affect fatal accident numbers or rates. Also, the study used all states with bans as treatment states and the rest as control states, which were not similar enough for comparison. Furthermore, they did not screen the FARS data, as some fatal crashes did not involve cell phone use. Lim and Chi (2013) used a negative binomial model to investigate the association between the number of young drivers (14 to 20 years old) involved in fatal non-alcohol-related motor vehicle crashes and cell phone bans. Their study showed that handheld cell phone bans targeting all drivers reduced fatal crashes involving young drivers, but there was insufficient evidence that complete cell phone bans targeting only young drivers reduced fatal crashes. The study did not have a control group and did not block other confounding factors that may affect accident numbers. Furthermore, they did not screen the accidents to be only related to cell phone use and did not consider compliance rates.

Nikolaev et al. (2010) performed one-tailed t-tests on fatal crash and injury crash-rate data in New York before and after the statewide cell phone ban took effect in 2001. They found that 10 of 62 counties in New York experienced significantly lower fatal accident rates and 42 counties experienced significantly lower injury accident rates after banning handheld cell phone use while driving. Although the study showed promising results, researchers should be cautious to draw the conclusion that the cell phone ban in New York is effective because of the research limitations. For example, they did not have a control study, did not screen phone-use-related crashes, and did not consider compliance rate. Building on Nikolaev et al.'s research, Jacobson et al. (2012) used Pennsylvania as a control and employed a linear regression model to test the effectiveness of New York's cell phone ban. Their study suggests that the handheld devices ban in New York was effective in reducing accidents in all

but very rural counties, and the ban was more effective in counties with higher driver densities. Furthermore, the study advocated that handheld bans may have a detrimental effect on accident rates immediately following their enactment, but that these bans become effective at reducing accident rates after several years have passed. However, the study assumed a linear decrease in the accident rate over time, which is not the case. There are still other possible confounding factors that were not considered, and they did not screen crashes related to cell phone use and did not consider compliance rate.

Kwon et al. (2014) studied six-year crash data from 2006–2010 in California to identify the major turning point in the trend of crashes related to cell phones. The results showed that the turning point coincides with the ban of handheld cell phones in California, but no proper control of other possible factors was made in the research. McCartt et al. (2014) reviewed 11 peer-reviewed papers or technical reports on all-driver handheld phone bans and texting bans, including both single-state studies examining crash measures before and after a state ban and national or multi-state studies comparing crashes in states with and without bans over time. The results varied widely. The lack of appropriate controls and other challenges in conducting strong evaluations limited the findings of some studies. Thus, despite the proliferation of laws limiting drivers' cell phone use, it is unclear whether they are having the desired effects on safety. Chaudhary et al. (2015) discovered that there was no apparent effect on the incidence of distraction-related crashes in the study period. There was an increase in awareness of cell phone laws, and they observed that drivers' handheld phone use dropped.

5.3.3 Limitations of Handheld Cell Phone Bans

Some research noted the limitations of handheld cell phone bans. Ibrahim et al. (2011) investigated 50 state laws restricting use of mobile communications devices (MCD) that were in effect from January 1, 1992 to November 1, 2010. They discovered that 39 states and the District of Columbia had at least one law restricting the usage of MCD in effect at that time. But the results showed that no state banned MCDs fully, and laws varied in accordance with types of communication devices and selected driver group such as novice drivers, inexperienced drivers, young drivers, and many more, which may present legal questions. Although many studies showed MCD use as a major risk in driving or as a major cause of distracted driving, no state law prohibited the complete use of such devices while driving. Most laws focused on prohibiting handheld devices but did not account for the risk associated with cognitive engagement while conversing with someone when not holding a device. Previous studies showed no proof of mitigating crash risk through the bans of handheld cell phones in places like California, Connecticut, Washington DC, and New York in comparison with other places. In addition, identifying the use of MCD as the sole cause of distracted driving is also difficult for police officers, as it can be distorted in court because of lack of evidential support. Most research shows support from the public to ban all MCDs. However, this is not demonstrated in the personal lives of individuals, as most drivers are engaged in distracted driving from MCDs at least once. Hence, laws that depict bans of MCDs must be studied comprehensively to develop more defining laws that ban all MCDs fully, rather than banning them based on type, usage, or driver.

Ibrahim's point has been echoed by other researchers. Liu et al. (2019) studied the effectiveness of California's ban on cell phone use while driving. They reported that the ban has been effective in

reducing the frequency and proportion of crashes. However, they also found that drivers switched from handheld devices to hands-free devices, thus having no significant change in crash severity. Hence, the study signifies the need for a complete ban on all communication devices regardless of device types. Bradish et al. (2019) predicted post-law cell phone use among young adults based on prior use. In this study, they focused on the characteristics of individuals to predict illegal and dangerous cell phone use while driving during the post-law period. The study stated that habit is the major reason for such instances to occur, as one is not able to change his/her habit even if the law intervenes. They suggested that the way to mitigate use of handheld phones in young adults is to prevent them from developing a habit of using cell phones while driving. In addition, a pervasive law banning all handheld cell phones should be implemented immediately, which will result in less usage of cell phones in the future, emulating the use of the seat belt, which has become a norm.

5.4 SUMMARY

At the urging of safety advocates aiming to address distracted driving, all states in the United States (except Montana) have passed laws to restrict cell phone use to some extent or to certain groups of drivers. To date, no federal laws ban cell phone use while driving, but NHTSA has issued guidelines on distracted driving enforcement, initiated Distracted Driving Awareness Month campaigns, and the federal government has allocated funding resources reserved for distracted driving. Cell phone bans across states vary in terms of penalties, enforcement, applicable groups, etc. Research showed that all-driver bans on handheld phone conversations have resulted in long-term reductions in handheld phone use. Bans on all-phone use by teenage drivers have not been shown to reduce their phone use. Also, restriction laws on cell phone use while driving have evolved over time. The trend is to have universal cell phone bans, increased fines and penalty points, and primary enforcement.

The enforcement of cell phone bans is difficult, as it requires more resources than traditional enforcement and needs to deal with drivers who try to hide their cell phones. Creative ways have been implemented to enforce cell phone bans, including spotter, stationary, and roving patrols; double-team patrols; disguised officers; unmarked patrol vehicles; and a variety of vehicle types (tractor trailers, bikes, motorcycles, transit, etc.). Joint agencies' high-visibility enforcement has been practiced in many states, including Illinois, particularly during Distracted Driving Awareness Month. Agencies made increased, highly visible efforts during the campaign, along with distracted driving messages/slogans and steps/suggestions to increase awareness of distracted driving and improve roadway safety. High-visibility enforcement may provide the best deterrent for distracted driving enforcement but may require additional labor and resources to achieve the best results.

Despite the prevalence of cell phone bans and increased efforts in enforcement, the effectiveness of cell phone bans is arguable. The literature reported both increased and decreased cell phone use while driving after the bans were enacted. No systematic analysis has been conducted to prove if the decrease in cell phone use while driving is due to cell phone bans. The lack of appropriate controls and other challenges in conducting strong evaluations (underreported crashes involving distraction, different types of bans, etc.) limited the findings of studies comparing crashes with and without bans. Thus, despite the proliferation of laws limiting drivers' cell phone use, it is unclear whether they are having the desired effects on safety. The prevalence of distracted driving behaviors other than cell

phone use also makes the safety benefits of cell phone restriction laws questionable. The limitations of handheld cell phone bans were also pointed out by researchers in comparison with a complete electronic communication device ban.

CHAPTER 6: TECHNOLOGIES AND RESOURCES

Innovative technologies have been explored and developed to address distracted driving in addition to restriction laws and enforcement. There are also funding and data resources available for distracted driving research, mitigation, and prevention. This chapter summarizes the literature review results on technologies and resources targeting distracted driving.

6.1. TECHNOLOGIES

In April 2010, the National Highway Traffic Safety Administration (NHTSA) called for the development of voluntary guidelines addressing driver distraction caused by in-vehicle systems and portable devices. In November 2016, NHTSA issued voluntary guidelines for portable device manufacturers to address driver distraction. The guidelines are organized into two phases. Phase I guidelines list tasks that can be performed by the driver while driving that meet the time-based, eye-glance task acceptance criteria to avoid driving imbalance. This increases the efficient processes that focus on improving the usability and ease of connecting a driver's portable device with their in-vehicle system. Some of the tasks are listed below:

- Displaying video not related to driving.
- Displaying certain graphical or photographic images.
- Displaying automatically scrolling text.
- Manual text entry for the purpose of text-based messaging, other communication, or internet browsing.
- Displaying text for reading from books, periodical publications, webpage content, social media content, text-based advertising and marketing, or text-based messages.
- Automatically activating the portable device's Driver Mode.

Phase II guidelines provide recommendations for aftermarket devices that are intended to be permanently installed in the vehicle but have not been addressed in Phase I.

6.1.1 Textalyzer

"Textalyzer" technology attempts to address problems associated with illegal cell phone usage and texting while driving (McNeila 2018). Textalyzer is an electronic scanning device that can assess if a cell phone or any portable electronic device was used in the moments leading up to a crash. Developed by Cellebrite Digital Intelligence Solutions, Textalyzer is designed to help law enforcement prove whether a driver was using her/his cell phone while driving, particularly when the driver is involved in a crash (Governor's Traffic Safety Committee 2017; Mayer 2019). Just like a Breathalyzer measures a driver's blood alcohol level, Textalyzer would allow police to see if electronic device use related to distracted driving occurred during an accident. Currently, if police want to see if cell phone use was involved in a crash, they must subpoena a driver's cell phone records, which involves the time-consuming and difficult process of obtaining a warrant. By contrast, Textalyzer would allow them to scan a phone instantly. The technology would not allow law enforcement to see the content

of messages, only data on when and how the phone had been used. In New York, some lawmakers proposed equipping police with Textalyzer. They hope to move Textalyzer forward by operating under implied consent, meaning that by getting a license, a driver agrees to have their phone searched for signs of use if they are in an accident (Associated Press 2016; Lone Star Advocate 2017). The technology is referenced in a bill, known as Evan's Law (S.2306/A.3955), from the New York State Senate, which would allow for the screening of mobile devices at a crash scene at the request of law enforcement (New York State Senate 2017). The use of Textalyzer is creating some legal arguments and concerns for privacy advocates and civil libertarians. The primary concern is the Fourth Amendment and invasion of privacy. There are also questions about the need for a warrant to use the device and what happens if a driver refuses.

6.1.2. TRUCE Technology

An application called TRUCE, introduced in 2009 by Capterra EHS Management, has been used by companies to help employees drive safely. TRUCE is designed to manage a driver's mobile device use while driving through the contextual mobile device management that makes devices smarter, workplaces more efficient, and employees safer (TRUCE 2009). It delays the use of distracting apps while employees are on the road, which protects employees and the communities in which they live and work. TRUCE makes sure that if a person is not driving, he or she has full usage of their apps, but no access to apps when he or she is driving. It uses the front and rear cameras on the mobile device to determine a person's position in the car. If a person is in the passenger seat or backseat, then the app automatically turns on all distracting apps. If a person is in the driver's seat, then TRUCE protects the driver from having his or her attention divided by turning off all distracting apps (TRUCE 2019). TRUCE technology also has a similar issue with invasion of privacy as Textalyzer. Even though employers cannot "see" the data in their employee's mobile device, the software's built-in data collection and reporting tool provides actionable insights into employee's behavior and trends. TRUCE has a rating of 4.2/5 according to multiple sites that do software reviews (e.g. GetApp, Capterra, Software Advice, etc.) and a high user satisfaction.

6.1.3 Laser Technology

Laser Technology was introduced by Laser Technology, Inc. (LTI) to pave the way for traffic safety solutions. The lasers have pinpoint targeting and accuracy validation software, which measure and enforce speeds as well as tailgating and distracted driving violations. Law enforcement officers have previously only been able to visually observe offending drivers. Using this technology, officers can combat distracted driving by measuring and collecting time and date-stamped images of distracted driving violations, seatbelt use, etc. The TruSpeed Sxb speed measurement and mapping laser can be used by officers to witness distracted driving. Using it with LTI's LaserSoft SpeedCapture app will allow officers to take images of what is seen through the laser's scope. The TruCAM II with tailgating firmware is another solution to combat distracted driving, because it can measure speed, distance between vehicles, and capture digital images of violations (Laser Technology, Inc. 2019).

6.1.4 Other Technologies

Other technologies were reported in the literature to detect or block distracted behaviors. In a simulator study conducted by Dehzangi et al. (2019) to characterize and identify distractions during

naturalistic driving, 15 participants drove the simulator wearing a physiological sensor (available in smart watches). The study reported that the galvanic skin responses (GSR) quantified by the physiological sensor is an effective method to indicate distracted inattentions of drivers. In another driving simulator study, Dumitru et al. (2018) investigated the influence of advanced driver assistance systems (ADAS) on driver behavior when distracted by social networking applications. Statistical analysis of the observed data showed that the use of the ADAS application reduced driving transgressions on average by 43.43% compared to the condition where ADAS is not used. This study shows that the usage of ADAS is vehicles might be a way to combat distracted driving.

Crawford (2016) reported three solutions for reducing the use of electronic devices while driving. The first solution is a motion analyzer, which detects whether a vehicle is in motion. The second is a "scenery" analyzer, which determines whether the electronic device is located within a safe operating area based on photographic and/or video data. The third is a lock-out mechanism, which reacts to outputs from the motion analyzer and scenery analyzer other two components. Other technologies explored to reduce the use of electronic devices while driving include a connected vehicles program and cell phone blockers while in motion (Vegega et al. 2013).

6.2 FUNDING RESOURCES

Under the FAST Act, Section 405 is the National Priority Safety Program, which provides grant funding to address selected national priorities for reducing highway deaths and injuries. Previously authorized under MAP-21, the FAST Act made changes to the Alcohol-Ignition Interlock Law and Distracted Driving and Graduated Driver Licensing Incentive grants. The FAST Act added two new grants, 24–7 Sobriety Program and Nonnotarized Safety. All are administered by NHTSA at the federal level and the State Highway Safety Offices (SHSOs) at the state level. With respect to distracted driving, Section 405(e): Distracted Driving says that 8.5% of Section 405 funds are reserved for distracted driving incentive grants. The FAST Act amended the qualifications, revised the Comprehensive Distracted Driving grant to provide more flexibility, and established a new Special Distracted Driving grant for two fiscal years for states that do not qualify for the comprehensive grant. States must enact and enforce a prohibition on texting as well as a ban of the use of all electronic devices for all drivers aged 18 and younger, plus additional requirements. Eligible states can use 50% of the funds for Section 405 purposes and 50% for distracted driving purposes. The FAST Act allows states with distracted driving data that conforms to the most recent Model Minimum Uniform Crash Criteria (MMUCC) to use 75% of the funds for Section 405 purposes. A total of $5 million of these funds are reserved for a national media campaign on distracted driving (Governors Highway Safety Association 2019).

6.3 DATA RESOURCES

Many databases or data systems have been used in research on distracted driving, mainly crash, driver survey, and cell phone use data. Also, state texting and cell phone laws and demographic data were used in conjunction with other data sources to examine the effectiveness of texting and cell phone bans. Table 1 summarizes state cell phone laws, and the Census Bureau is the main resource for most updated demographic data.

In addition, NHTSA's *Blueprint for Ending Distracted Driving* (2012) contains fatal traffic crash data reports on leadership models, visions, and strategies for raising awareness, strengthening enforcement for reducing distracted driving. These efforts might improve safety, although further evidence is needed to prove their effectiveness.

6.3.1 Crash Databases

Fatality Analysis Reporting System (FARS) is a national fatal crash database maintained by NHTSA. It records data on all road fatalities that occurred on public roads in the United States since 1999. Many studies have employed the database because FARS is accessible to the general public. For instance, Wilson and Stimpson (2010) examined trends in distracted driving fatalities and their relation to cell phone use and texting volume.

California Highway Patrol Panel Accident Data is an open-access crash database operated by the state of California. All state agencies maintain their own crash database, which are usually not accessible to the public. California Highway Patrol Panel Accident Data contains the Statewide Integrated Traffic Records System (SWITRS) database and collision data. Burger et al. (2014) have employed this database to investigate the effectiveness of California's handheld cell phone ban in reducing accidents.

6.3.2 Survey Data

Conducted by the National Highway Traffic Safety Administration (NHTSA), the **National Occupant Protection Use Survey** (NOPUS) is the only nationally representative roadside-observed survey. It is conducted annually to assess driver and passenger safety behavior, including seat belt/child restraint use, motorcycle helmet use, and electronic device use. Data pertaining to drivers' cell phone use has been collected since 2000. The data were made available and permitted for use upon request from the NHTSA's Office of Behavioral Research. In NOPUS, roadside observers categorize drivers' cell phone use while driving into four categories after 10 seconds of observation: 1) driver was not using a cell phone, 2) driver was holding a handheld cell phone to their ear and conversing, 3) driver was manipulating a handheld device, or 4) driver was using a hands-free device. Also, handheld devices in NOPUS can include electronic devices, which may not always be a cell phone (Rudisill and Zhu 2017).

The Traffic Safety Culture Index, administered by the AAA Foundation for Traffic Safety, is an annual survey conducted in June or September that assesses individuals' self-reported behaviors and beliefs regarding traffic safety. Survey participants are randomly selected from a panel of 58,000 individuals. This panel is nationally representative of all US households, which are reachable by phone or mail. Survey respondents are $\geq$ 16 years of age. In some years, participants < 19 years may be recruited through parents/guardians who are panel members. Because respondents may or may not currently drive, the survey may not be representative of all US drivers. Approximately 3,000 individuals participate annually (AAA Foundation for Safety 2017).

2013 Youth Risk Behavior Surveillance System (YRBSS) monitors six types of health-risk behaviors that contribute to the leading causes of death and disability among youth and adults, including: behaviors that contribute to unintentional injuries and violence; sexual behaviors that contribute to unintended pregnancy and sexually transmitted diseases (STDs), including HIV infection; alcohol and

other drug use; tobacco use; unhealthy dietary behaviors; and inadequate physical activity. YRBSS also measures the prevalence of obesity and asthma among youth and young adults. YRBSS includes a national school-based survey conducted by the Centers for Disease Control and Prevention (2011) and state, territorial, tribal, and local surveys conducted by state, territorial, and local education and health agencies and tribal governments. Zhu et al. (2016) has examined the frequency of distracted driving behavior after introducing legislation using the YRBSS survey data.

6.4 SUMMARY

New technologies have been introduced to mitigate distracted driving or reduce its detrimental impacts. In-vehicle voice command and Bluetooth technologies make hands-free manipulation of mobile devices possible, which reduces the risks of secondary tasks of using mobile devices while driving. TRUCE has been used by employers to manage their employees' mobile device use while driving, which delays access to mobile device apps if employees are at the wheel. Incorporating those new technologies will be a trend for vehicle manufactures and mobile device developers.

Textalyzer technology has been reported in the literature to facilitate text and cell phone ban enforcement. Like a Breathalyzer test measures a driver's blood alcohol level, the technology would allow police to see if drivers were using their cell phones prior to an accident. But the use of the Textalyzer is creating some legal arguments and concerns for privacy advocates and civil libertarians. The primary concern is the Fourth Amendment and invasion of privacy.

Note that TRUCE is more acceptable and effective than Textalyzer, although it has the same issues with invasion of privacy. The authority that is enforcing the mobile device ban may make it more effective. Textalyzer would be used by state police to enforce the law. Hence, the enforcing authority is not directly related to the person, in which case the person has nothing to lose or fear and the person is not monitored individually. TRUCE would be enforced by the employer of the person, in which case the authority is directly connected to the person, the person is directly affected by his or her actions, and he or she has fewer choices, as they are monitored individually. Future research should be conducted on using the workplace to enforce mobile device laws and strategies that can be implemented at or through the workplace.

There are many resources targeting distracted driving. In the recently authorized FAST Act, a larger amount of funds is reserved for distracted driving incentive grants. The FAST Act amended the qualifications, revised the Comprehensive Distracted Driving grant to provide more flexibility, and established a new Special Distracted Driving grant for states that do not qualify for the comprehensive grant. Also, NHTSA (2012) pulled together the *Blueprint for Ending Distracted Driving*, which contains fatal traffic crash data and reports on leadership models, visions, and strategies for raising awareness, strengthening enforcement for reducing distracted driving. Specifically, there are nationwide crash, driving behavior, and safety culture survey data available for research on drivers' attitudes toward distracted driving, the association of distracted driving behavior with texting/cell phone use and safety/crash risks, and the effectiveness of texting and cell phone use bans.

CHAPTER 7: EDUCATION, SOCIAL MEDIA, AND CAMPAIGNS

The key to addressing distracted driving is to change driver behavior. Successful traffic safety campaigns to change driver behavior have demonstrated the necessity to adopt a "three Es" approach: enactment of a law, rigorous enforcement of the law, and education of the public about the law. Federal, state, and local agencies have responded to this distracted driving public safety problem with education, media exposure, and campaigns, in addition to laws, enforcement, and engineering solutions. This chapter summarizes those efforts reported in the literature.

7.1. EDUCATION

NHTSA (2012) issued the *Blueprint for Ending Distracted Driving*, presenting a comprehensive approach to the problem. The three steps outlined in the blueprint include: enacting and enforcing tough state laws on distracted driving, addressing technology, and better educating young drivers. It states that a teen driver is more likely than those in other age groups to be involved in a fatal crash where distraction is reported. NHTSA has been working with the American Driver and Traffic Safety Education Association (ADTSEA) to update its driver education model curriculum to include the latest information on driver distraction. The curriculum, designed to educate young novice drivers with the latest teaching techniques and technology, is widely used in many states.

Besides the ADTSEA education model, there are other distracted driving education programs available. Modernization of Driving Licensing and Education introduced an education program for learners and newly licensed drivers. In this program, they provided a list of topics for training, including distracted driving. The topics include causes of distraction, texting and driving, dialing numbers/answering phones while driving, GPS navigation, looking at devices while driving, eating and drinking while driving, talking to passengers that want eye contact while driving, passenger and children disturbances while driving, and animals in a vehicle while driving (Automobile Safety Foundation 2013). The National Safety Council (2019) offers a distracted driving online course to motivate drivers to change their risky behaviors and attitudes about distracted driving. The course offers an interactive format to educate drivers about the risks, dangers, and consequences of cell phone use while driving. Participants learn about the science and impact of distracted driving, myths about multitasking, financial and legal ramifications, and state and federal laws (National Safety Council 2019).

Approaches other than curriculum and training material are reported in the literature. For instance, the Nassau County Distracted Driver Education program allows offenders to install a specialized device in their vehicle, which monitors their use of cell phones while in motion. If after 90 days, the enrollee has not flunked out of the program, the marks against his or her record are expunged (Eidam 2017). Cellcontrol, the world's leading provider of solutions that promote safe driving and stop distracted driving, has developed a program with Nassau County, New York, to provide its Drive ID technology to drivers ticketed for distracted driving. As part of the program, which formally began in June 2016, Nassau County prosecutors can offer ticketed individuals a chance to keep points for the offense off their license by going through the program. Since the program began, it has recorded a 98% success rate (Cellcontrol 2017). In Nassau County, New York, motorists charged with prohibited

use of a cell phone or electronic device must appear in court. At the court appearance, the opportunity to enter the Distracted Driver Education Program may be offered. If offered and agreed to, the motorist is required to sign an agreement and acknowledge it before a judicial hearing officer (Nassau County 2019).

Distracted driving education materials are also available through options other than NHTSA. For instance, the Decide to Drive (2019) website created by the Auto Alliance for Driving Innovation and American Academy of Orthopedic Surgeons spread awareness about distracted driving. This page contains information about campaigns, trainings, technologies, trends, videos, etc. related to distracted driving. This site is about the driver and lists things people can do to avoid all forms of distracted driving and stay safer behind the wheel. They also included some facts and tools on this site. One can join the conversation to talk about distracted driving. One can also report distracted driving they have seen. The Federal Communication Commissions (FCC) (2019) created a website to let people know facts about distracted driving. It presents information on Distracted Driving Awareness Month along with ways to stay safe on the roads. Some tips are provided by the website to reduce distracted driving, including:

- Silence or turn off your cell phone or any other wireless device before you start your car and keep it that way while you're driving.
- If you absolutely need to send a text or call someone, pull over to a safe place before doing so.
- Lead by example. Encourage new and younger drivers to be responsible and to keep their eyes on the road, not on their devices.

EndDD is an organization with a mission to save lives from distracted driving through advocacy, education, and action, funded by the Casey Feldman Memorial Foundation. It created science-based presentations on distracted driving, amassed a network of 500 speakers, and gave talks to over 375,000 students nationwide, all without cost to schools. It also created a bystander intervention program to teach teens how to effectively speak up when driven to distraction by others. EndDD also provided free educational materials, including safe driving agreements, quizzes, and surveys. The organization also developed public service announcement videos, sponsored teen distracted driving videos and meme contests, and designed presentations for parents to help model distraction-free driving for their children (End Distracted Driving 2009).

7.2. SOCIAL MEDIA

Social media has become an inevitable part of most people's daily lives, particularly young people. Transportation agencies have taken advantage of social media to promote awareness of distracted driving. As part of the Better Educating Young Drivers program in the *Blueprint for Ending Distracted Driving*, the US Department of Transportation (USDOT) announced the Distracted Driving Design Challenge in April 2012 to encourage high school students to spread the word about distracted driving by designing a creative icon that can be shared on Facebook, Twitter, Tumblr, and other social networks (NHTSA 2012).

In addition, agencies have developed video ads with different slogans broadcasted on TV or social media to promote awareness of distracted driving. Traffic Safety Marketing (2019a) by the USDOT has compiled those ads, which are listed below:

1. Distracted Driving—Male Driver by CTDOT
2. Eyes on Road
3. On the Road, Off the Phone by Washington Traffic Safety Commission
4. Distracted Driving—Female Driver by CTDOT
5. Distracted Driving Pull Over Here by CTDOT
6. Distracted Driving Cell Phone by CTDOT
7. Preventing Distracted Driving by NY Governor's Traffic Safety Committee
8. Sam Howell's Journey: The Dangers of Distracted Driving
9. Just Drive by EOPSS—A New England Partnership
10. What Kind of Driver Are You Rising? By NYS DMV
11. The Speed Zone by Washington Traffic Safety Commission
12. Smart Phone Dumb Idea by NYS DMV
13. History of Bad Ideas by Iowa Governor's Traffic Safety Bureau
14. Distracted Driving by SD Office of Highway Safety SDOHS
15. The Dangers of Distracted Driving by Michigan OHSP
16. Coin by Maine Bureau of Highway Safety
17. Funeral by Maine Bureau of Highway Safety
18. Windshield by Maine Bureau of Highway Safety
19. Eyes on the Road by Maine Bureau of Highway Safety
20. Shame Excuses by CT DOT

7.3. CAMPAIGNS

Distracted driving is a first offense in many states and continues to gain recognition across the United States as an issue. Under the leadership of US Secretary of Transportation Ray LaHood, the Department of Transportation has launched national campaigns since 2009 to end distracted driving, specifically texting and cell phone use behind the wheel (U.S. Department of Transportation 2015). "U Drive, U Text, U Pay" is a campaign promoted by USDOT, which centered on aiding law enforcement officers in their efforts to keep distracted drivers off the road. This campaign targets men and women 18 to 34 years old, with a skew toward women (Traffic Safety Marketing 2019e). Campaign materials provided include banner ads, sample sheet, sample news releases (pre-event and post-event), a sample opposite the editorial page (OpEd), logo, and posters for both general and Hispanic audiences. "Phone in One Hand—Ticket in the Other" is another campaign launched in April 2010 by

UDSOT to enhance and update local enforcement efforts. It offered animated banner ads, billboards, and logos, as well as posters and radio ads for enforcement (Traffic Safety Marketing 2019c). The pilot campaigns were the first in the United States to test whether increased law enforcement efforts combined with public service announcements could get distracted drivers to put their cell phones down and focus on the road.

The Evergreen Campaign is a distracted driving awareness campaign promoted by USDOT. It uses general/generic resources to reach communities about distracted driving on a year-round basis. Materials provided include banner ads, reports on how to plan for a successful distracted driving awareness campaign and driver electronic device use, posters, radio ads, and distracted driving fact sheets (Traffic Safety Marketing 2019d). Because the youngest and most inexperienced drivers are most at risk for crashes related to distracted driving, USDOT promoted the "One Text or Call Could Wreck It All" campaign to raise awareness on the dangers of distracted driving, particularly targeting young drivers. Materials provided included animated banner ads, earned media, logos, parent-teen driving contact and pledge form, posters, print ads, social media, and web videos (Traffic Safety Marketing 2019b).

Many states have participated in Distracted Driving Awareness Month. For instance, Connecticut has participated in the national "U Drive, U Text, U Pay" campaign five times to crack down on motorists who text, talk, or use a handheld mobile device while driving (Failla 2019). Missouri has also been involved in Distracted Driving Awareness Month activities. It developed a website for this campaign through the Missouri Coalition for Roadway Safety (2019). Slogans used by Missouri for promoting distracted driving awareness include "Focusing on the road and the task of driving is priority one when behind the wheel"; "Your life, the lives of those in your vehicle and around you, depend on it"; and "Buckle Up Phone Down—every trip, every time, everyone!" (Missouri Coalition for Roadway Safety 2019).

In addition to agencies and law enforcement, nonprofit organizations have been involved in campaigns to promote awareness of distracted driving. In Delaware, state officials, law enforcement agencies, and the AAA are appealing to high school students to stop distracted driving. The pledge comes from AAA Mid-Atlantic, which is launching a campaign in Delaware called "Don't Drive Intoxicated. Don't Drive Intexticated." It appealed to teens to help make distracted driving socially unacceptable. The pledge distributed by AAA implores drivers to place their mobile devices out of sight while driving; to speak out if others are driving distracted; not to use social media, check emails, or send texts while driving; and not to call or text others they know to be driving (Schmidt 2019).

7.4 SUMMARY

Awareness is the first step in curbing distracted driving, and education plays a key role in altering driver behavior. The United States federal and state governments have responded to the public safety problem of distracted driving with education programs, media propagation, and campaigns, as well as policies and laws. The latest information on driver distraction has been included in the American Driver and Traffic Safety Education Association's driver education model curriculum

through the efforts of NHTSA. Many states and agencies have also developed courses, materials, and programs to educate drivers on the risk of distracted driving.

USDOT has launched several campaigns to aid law enforcement or promote awareness of distracted driving. Those campaigns considered different age groups and non-English-speaking populations. A variety of campaign materials were provided, including video ads, logos, radio ads, posters, etc. Both traditional media (e.g., TV, radio, billboard, poster, etc.) and new social media (e.g., Facebook, Twitter, Tumblr) have been used to reach out to the general public. States and nonprofit organizations have also participated in the national campaigns, particularly during April's Distracted Driving Awareness Month.

All education programs, media propagation, and awareness campaigns are targeted to make distracted driving socially unacceptable. To date, no studies have been conducted to evaluate if they reduce distracted driving. But, based on previous experiences on safety initiatives, education programs and campaigns to promote awareness of distracted driving will help alter driver behavior. Open access to education programs and campaign materials make it easy for agencies or organizations to start or update their own programs. The review shows that campaigns involving multiple agencies/organizations and using various media is a popular way to reach out to people in spreading awareness about distracted driving and showing a visible impact on the public towards distracted driving.

CHAPTER 8: SUMMARY AND RECOMMENDATIONS

8.1 SUMMARY

Distracted driving has been of much interest to academia, public agencies, nonprofit organizations, and private sectors in multiple disciplines, including engineering, safety, human factors, vehicle manufacturers, health care, etc., because of the public health and safety issues it causes. Despite slightly different definitions, distracted driving is commonly accepted as any activity that diverts attention from driving. Distracted driving can be separated into three categories: visual, manual, and cognitive. Lacking national standard guidelines, there are discrepancies about the characteristics and categorization of some specific activities in the literature, such as drowsiness, fatigue, medical conditions, driving under the influence, etc. Some studies interchange distracted driving and inattentive driving. Commonly reported driving distractions include electronic device use (talking on the phone, texting, dialing, etc.), interacting with other passengers, loud conversations, horseplay, etc. Note that some studies reported higher frequencies of non-cell phone-use distractions than ones with cell phone use, indicating cell phone use is not the only important source of distracted driving.

Distracted driving could have internal and external causes. Heavy task loads, surrounding environments, and medical conditions could all cause distracted driving. There are many influential factors found in the literature on distracted driving behaviors, such as age, gender, having children, race, education, geographic location, etc. Previous studies indicate texting while driving is highly associated with young Caucasian drivers and low education levels. Substantial individual differences were also pointed out, meaning a small number of drivers counted for a large part of the high frequency of texting while driving. Those distracted drivers were also highly involved in other aggressive driving behaviors (e.g., speeding, running a red light, etc.). But, most importantly, the literature review found that attitude is the main cause of distracted driving, e.g., most young drivers are willing to read and reply to text messages they receive during driving, even when they perceive the risk of doing so. The key is to align drivers' attitudes with their perceptions and change their behaviors.

Studies have examined the percentage of distracted driving's involvement in total crashes and crash severity levels. They have also compared it with situations not involving distracted driving. They concluded that distracted driving increases crash risk. Those conclusions are not sound and concrete, because of the limitations of their research approaches (e.g., crash data did not count for near-crash events, driving simulators could not simulate crashes and severity levels, and crash percentage involvement is not equal to crash risk). To get an understanding of how distracted driving affects safety, further research is needed to investigate at what intensity secondary distraction tasks will cause potential crashes and the crash risk of various distractions under different traffic/roadway conditions and with different driver sociodemographic characteristics.

Although there are no federal regulations to date, all states in the United States (except Montana) have passed laws to restrict cell phone use to some extent or to certain groups of drivers. Cell phone bans across states vary in terms of penalties, enforcement, applicable groups, etc. The trend is to have universal cell phone bans, increased fines and penalty points, and primary enforcement. The

enforcement of cell phone bans is difficult. Therefore, creative ways have been implemented for cell phone ban enforcement, including spotter, stationary and roving patrols; double-team patrols; disguised officers; unmarked patrol vehicles; and a variety of vehicle types (tractor trailers, bikes, motorcycles, transit, etc.). Joint agencies' high-visibility enforcement has been practiced in many states, including Illinois, particularly during Distracted Driving Awareness Month. High-visibility enforcement may provide the best deterrent for distracted driving enforcement but may require additional labor and resources to achieve the best results. Despite the prevalence of cell phone bans and increased efforts in enforcement, the effectiveness of cell phone bans is arguable. Lack of appropriate controls and other challenges in conducting strong evaluations (underreported crashes involving distraction, different types of bans, etc.) limited the findings of studies comparing crashes with and without bans. Thus, despite the proliferation of laws limiting drivers' cell phone use, it is unclear whether they are having the desired effect on safety. The prevalence of distracted driving behaviors other than cell phone use also makes the safety benefits of cell phone restriction laws questionable.

The key to addressing distracted driving is to change driver behavior. Successful traffic safety campaigns to change driver behavior have demonstrated the necessity to adopt a "three Es" approach: enactment of a law, rigorous enforcement of the law, and education of the public about the law. To change distracted driving behavior, the appropriate approach should be "three Es" and technology adoption. The federal government has issued guidelines on distracted driving enforcement, initiated Distracted Driving Awareness Month campaigns, and allocated funding resources reserved for distracted driving. Also, NHTSA (2012) pulled together the *Blueprint for Ending Distracted Driving*, which contains fatal traffic crash data and reports on leadership model, vision, and strategies for raising awareness, strengthening enforcement for reducing distracted driving. In addition, the latest information on driver distraction has been included in the American Driver and Traffic Safety Education Association's driver education model curriculum through the efforts of NHTSA. Many states and agencies have also developed courses to educate drivers on the risk of distracted driving. April has been deemed Distracted Driving Awareness Month, and the USDOT has launched several campaigns to aid law enforcement or promote awareness of distracted driving. Those campaigns consider different age groups and non-English-speaking populations. A variety of campaign materials were provided, including video ads, logos, radio ads, posters, etc. Both traditional media (e.g., TV, radio, billboard, poster, etc.) and social media (e.g., Facebook, Twitter, Tumblr) have been used to reach out to the general public. States and nonprofit organizations have also participated in the national campaigns, particularly during Distracted Driving Awareness Month. Open access to education and campaign materials make it easy for agencies or organizations to start or update their own programs. New technologies have been introduced to reduce distracted driving or mitigate their adverse impacts, including in-vehicle voice command, Bluetooth technologies, laser technologies, TRUCE, Textalyzer, etc. Those technologies could help agencies/employers to guide drivers' cell phone use while driving or facilitate cell phone ban enforcement.

8.2 RECOMMENDATIONS

The first step to fight against distracted driving is to understand distracted driving characteristics and driver attitudes and perceptions toward it in the state. An observational study and a survey/interview

study can be performed in parallel to acquire the information. Distracted driving data items need to be clearly defined/determined and a standard distracted driving data collection form needs to be developed before the observational study. The state-maintained crash database, crash reports, and distracted driving data collection form should be consistent in terms of distracted driving data items, format, and coding. The survey/interview questions should cover basic sociodemographic information, driving exposure, distracted driving behaviors, causes/reasons of distracted driving, attitude and perception toward distracted driving and restriction laws, etc. The sampling of the observational and survey/interview study should consider the representation of geographic location, age, gender, race, education, employment, number of children, and other social demographic characteristics. The results of the observational and survey/interview study will help acquire information on which groups of people are likely to be involved in what type(s) of distracted behaviors and what are the underlying cause(s) for distracted driving in the state. The information will be useful for determining strategies and developing education/campaign materials targeting specific groups to achieve the maximum benefits. Conducting observational and survey/interview studies once every few years will help gather data to evaluate the short- and long-term effectiveness of cell phone bans in the state.

Using the above observational study data along with other data sources, the effectiveness of cell phone bans in the state could be evaluated. If the distracted driving behavior data in the state are available before the enaction of cell phone bans, a before-and-after study can be conducted to test the bans' effectiveness with proper controls and comparisons. If the before-ban data are not available, observational data over a few years can be used to develop trends in cell phone use. Statistical tests can be run to test if cell phone bans are associated with a significant decrease in cell phone use while driving with proper control of other factors. Combining with crash data, the effectiveness of cell phone bans can also be tested in terms of the significance in decrease/change in distraction involved crashes/injuries/fatalities before and after the ban or over the years with the implementation of the bans. The key is to control the effects of other possible factors on cell phone use and crashes involving cell phone use.

The effect of cell phone bans on reducing distracted driving is controversial. Enforcing cell phone bans will help increase awareness of the adverse impacts of cell phone use while driving and reduce distracted driving behaviors in the long run. Creative enforcement methods can be tested at selected locations in the state during Distracted Driving Awareness Month. Then, an effective new enforcement approach that is suitable for the state can be introduced to agencies throughout the state and included with regular enforcement. Continued participation in high-visibility enforcement campaigns with the support of federal funds will help build a culture where cell phone use while driving is unacceptable. Besides public agencies, nonprofit organizations, insurance companies, and schools can also be involved in the campaign. New slogans, signs, and other campaign materials can be developed using the open-access resources reviewed in the report and propagated on TV, radio channels, and social media, as well as brochures, flyers, billboards, etc.

Note that TRUCE is more acceptable and effective than Textalyzer, although though it has the same issues with invasion of privacy. The authority that is enforcing the mobile device ban may make it more effective. Textalyzer would be used by state police to enforce the law. Hence, the enforcing

authority is not directly related to the person, in which case the person has nothing to lose or fear and the person is not monitored individually. TRUCE would be enforced by the employer of the person, in which case the authority is directly connected to the person, the person is directly affected by his or her actions, and he or she has fewer choices, as they are monitored individually. Future research should be conducted on how the workplace is more effective for enforcing mobile device laws and strategies that can be implemented at/through the workplace.

Education is a key component of the 3E approach to alter distracted driving behaviors and build a safety culture free from distracted driving. Available distracted driving education curriculum and material reviewed in the study can be used directly or used as references to develop courses suitable for the state. Based on results from the abovementioned observational and survey/interview studies, education materials can be developed to target specific groups inclined to distracted driving behaviors. By providing insurance companies, DMVs, and trucker companies with those educational materials, drivers can get the most up-to-date information on distracted driving. Incorporating the distracted driving education material into IDOT's existing education outreach program (e.g., Summer Transportation Institute, K–12 safety education, etc.), kids in schools will be exposed to the issue of distracted driving and be aware of its detrimental impacts on safety before they are eligible to drive. There are also ways to combine distracted driving education and enforcement campaigns, e.g., competitions on logo/slogan development among high school students.

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