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The Culture of Distracted Driving: Evidence from a Public Opinion Survey in Iowa

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The culture of distracted driving: Evidence from a public opinion survey in Iowa

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ABSTRACT

Traffic safety culture does not merely focus on risky behaviors and their consequences, but also on creating better social norms, values, and beliefs. Past research has recommended establishing a comprehensive program to shape the culture from different aspects of society as the most effective method to create a comprehensive traffic safety culture in the United States (U.S.). In 2011, a cell phone and landline questionnaire survey regarding Iowa traffic safety culture was conducted across the State. The survey gauged opinions from 1088 participants on traffic safety and driving experience in Iowa, which covered a wide range of traffic safety topics including traffic enforcement, driver education program, various driving behaviors, and attitudes toward traffic safety policies, activities and enforcement techniques. A descriptive analysis of the responses revealed a need for in-depth study of the current culture related to distracted driving in Iowa.

A Structural Equation Modeling (SEM) was estimated to define the relationship among individual characteristics (participants' socioeconomic and demographic status), experience and attitudes towards distracted driving. The preliminary model results indicated that the socioeconomic and demographic statuses were explained significantly by age, gender, education, and household income. Four other latent variables: *distractibility* (DB), *self-reported distracted driving behavior* (SDDB), *personal acceptability for distracted driving* (PADD) and *prediction of possible accidents* (PPA) caused by distraction were formed based on the participant's responses on selected distracted driving-related questions. The SEM estimation results suggested that participants' distracted driving attitudes, experiences and behaviors were highly correlated, and also that participants' characteristics were strongly influenced their attitudes, experiences and behaviors on distracted driving. The results of this

study can be useful for developing interventions designed for target groups of drivers (with different individual characteristics) in a bid to transform distracted driving safety culture.

CHAPTER 1. INTRODUCTION

1.1 Research Motivation

Traffic crashes are considered as one of the most serious threats to public health. Figure 1-1 illustrates the trend in the number of fatalities and fatality rates in the United States (U.S.) from 1949 to 2009 (NHTSA, 2012). The number of fatalities have fluctuated during that period and dropped to around 32,000 in 2011. The overall fatality rate has continuously declined over the years.

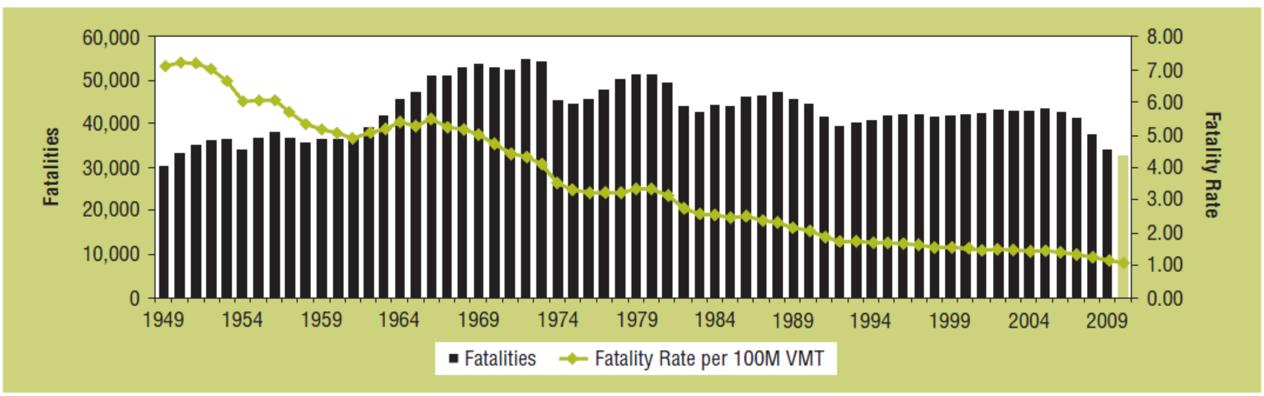


Figure 1-1: Fatalities and fatality rate per 100M VMT nationwide by year (NHTSA, 2012)

The significant reduction in traffic fatality rates can be partly attributed to the better traffic safety culture that has been established nationwide with respect to stricter law enforcement, roadway design as well as vehicle design. However, some specific types of traffic crashes have increased, such as the ones caused by distracted driving. Distracted driving can be simply defined as any activities that could divert driver's attention away from driving. These activities include eating, talking to passengers, listening to the radio, and using cell phone for place a call or texting. According to previous studies (Atchley, Hadlocka, & Lane, 2012; Neyens & Boyle, 2008; Hancock, Lesch, & Simmons, 2003;

Horrey & Wickens, 2006), two major concern areas for distracted driving are younger drivers and cell phone use while driving. Figure 1-2 presents the overall percentage of distracted drivers involved in fatal crashes nationwide. It shows that drivers under 20 years old are involved in most fatal crashes among all the age groups (Vermette, 2010).

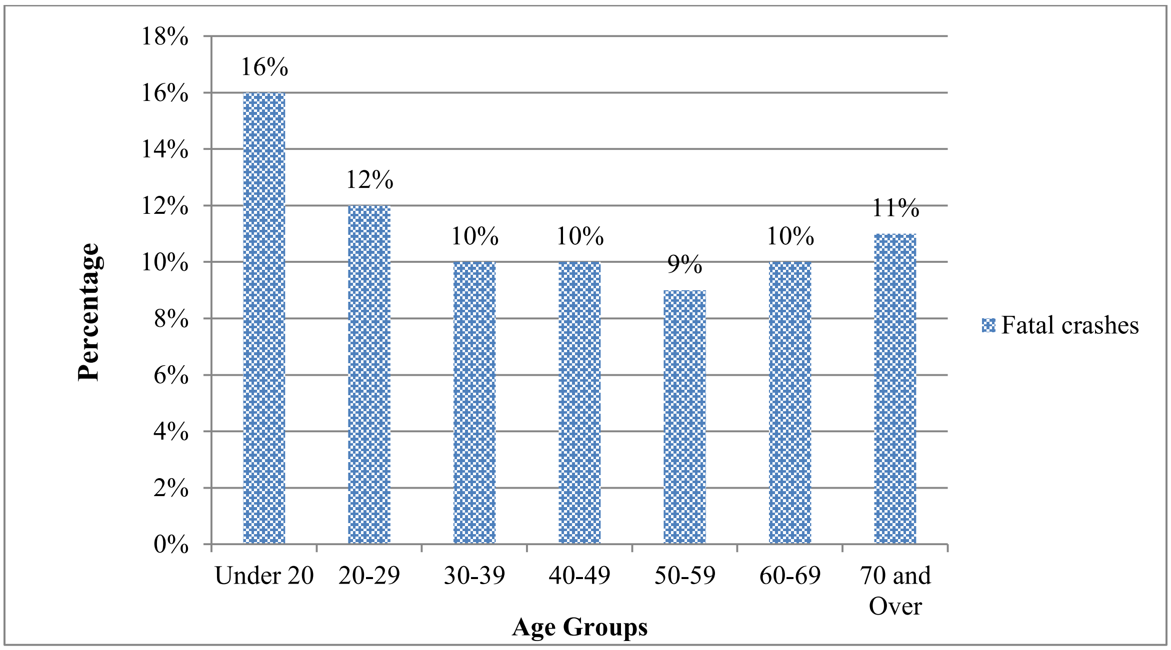
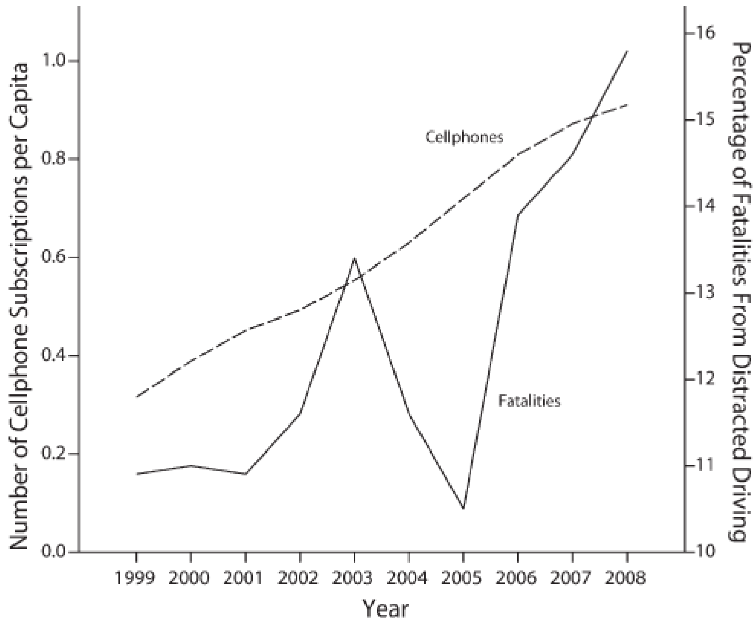


Figure 1-2: Percentage of distracted drivers involved in fatal crashes by age, 2008 (Vermette, 2010)

Regarding using cell phone, Figure 1-3 presents the percentage growth in fatalities caused by distracted driving (Wilson & Stimpson, 2010). Evidently, with the increase in cell phone use over the past decade, the corresponding number of fatalities has increased dramatically.



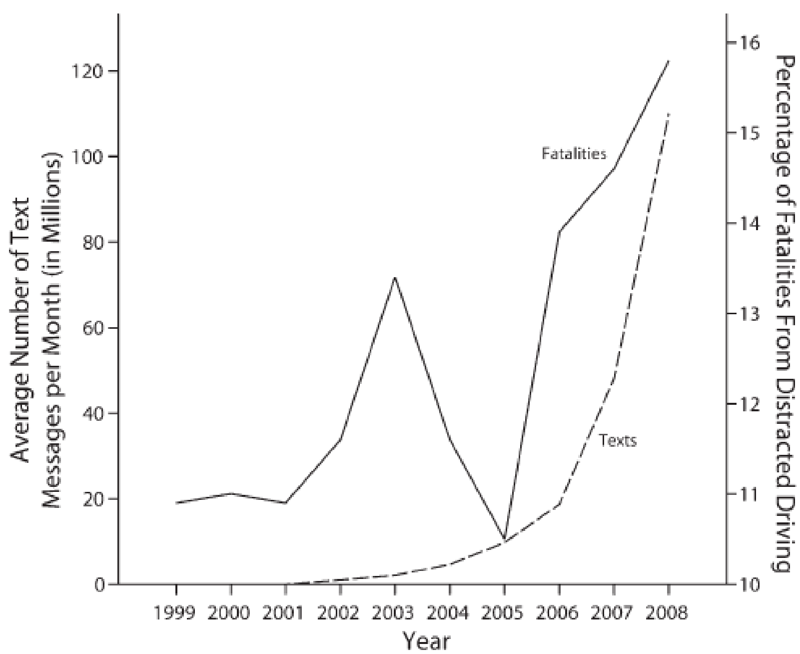


Figure 1-3: Percentage of fatalities resulting from distraction and number of cell phone subscriptions per capita and monthly text messages sent (in millions), by year: Fatality Analysis Reporting System, 1999-2008. Adopted in (Wilson & Stimpson, 2010).

According to Betkey, Jr., Governors Highway Safety Association (GHSA) Chairman, *"We need to develop a traffic safety culture that does not condone driving while distracted much like we have done with drunk driving."* (Vermette, 2010).

Transforming the current traffic safety culture of distracted driving could be one of the solutions to reducing the crashes caused by distracted driving. In 2008, the AAA Foundation for Traffic Safety began conducting a nationwide survey to assess American drivers' attitudes, behaviors, knowledge and opinions of traffic safety culture. According to the most recent 2012 Traffic Safety Culture Index conducted by the AAA Foundation for Traffic Safety (2013), 67% of Americans indicated that distracted driving was a great problem in 2012 compared to three years before, and also ranked distracted driving high in the list of safety concerns including aggressive drivers, drinking and driving, and other.

Similarly, the states of Iowa, Texas, Tennessee, and North Dakota launched statewide traffic safety surveys to solicit public opinions on traffic safety culture. Iowa had conducted a statewide survey of adult drivers in 2000 to solicit their opinions on safety goals and strategies for the state. Eleven years later, an updated traffic safety survey was conducted in Iowa, that included questions on distracted driving-related behaviors, experiences and attitudes, as distracted driving has been a growing safety concern among Iowan drivers. In specific, most adult Iowans (95%) rated distracted driving as a serious threat to traffic safety.

In view of the above, transforming the current culture of distracted driving could be one of the solutions to reduce the crashes caused by distracted driving.

1.2 Thesis Objectives and Framework

The objectives of this thesis are to:

- Explore the concept of traffic safety culture and assess the hazards of distracted driving.
- Investigate the overall traffic safety culture and assess the distracted driving problem in Iowa based on a public opinion survey conducted in 2011.
- Develop a statistical model to identify the factors contributing to distracted driving in Iowa and determine the driver groups that are prone to be involved in distracted driving.

Figure 1-4 shows the thesis framework. The central focus of the thesis will be on the distracted driving culture as it related to cell phone use.

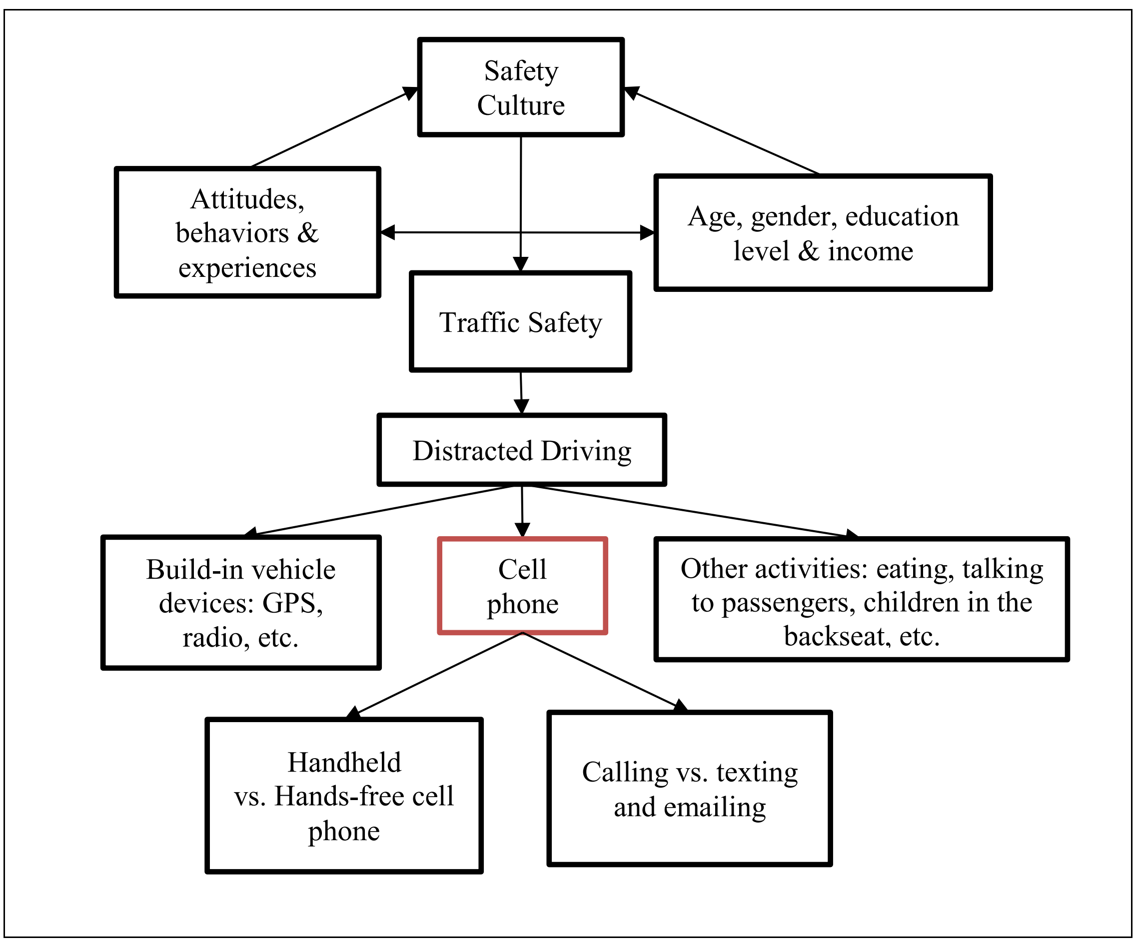


Figure 1-4: Study framework

1.3 Thesis Structure

This thesis includes six chapters:

Chapter 2: *Literature Review* includes an overview of previous studies on traffic safety culture and distracted driving.

Chapter 3: *Data Description* provides a summary of the data on the traffic safety culture in Iowa as stated in a public opinion survey and discussed in detail the responses to distracted driving-related questions.

Chapter 4: *Methodology* discusses the Structure Equation Modeling (SEM) method used in the analysis. A brief history and the fundamental theories of SEM are discussed.

Chapter 5: *Estimation Results and Discussion* presents the estimation results of SEM and discusses the major findings obtained from the analysis

Chapter 6: *Conclusions, Limitations and Recommendations* offers some concluding remarks as well as the limitations of the study, followed by recommendations for future researches.

CHAPTER 2. LITERATURE REVIEW

2.1 Overview

This chapter discusses previous national and international studies of traffic safety culture. Improving traffic safety should not merely be considered as the substantial reduction in traffic crashes, but also achieving a paradigm shift on the way people are thinking about traffic safety issues.

Historically, three traditional strategies have been widely used to reduce traffic fatalities in the U.S., and they are mainly focused on risky behaviors and their consequences. Education aims to train safe drive behaviors; enforcement is used to punish risk behaviors; lastly, road and vehicle design are mainly used to prevent crashes and protect drivers from the consequences of unsafe behaviors (Ward et al., 2010). Although the traditional strategies contributed largely to the reduction in traffic fatalities in the United States (U.S.) over the last several decades, the current slow rate of improvement indicates that the old interventions may not be able to fully address the risky driving behaviors (Ward et al., 2010). Another important missing factor in those three strtegies is “culture”. Lonero (2007) stated that individual driving behaviors were significantly influenced by driving culture, and defined culture as “the common practices, expectations, and informal rules that drivers learn by observation from others in their communities.”

This Chapter explores first the definition and how culture can be used for improving traffic safety in the U.S. and then provides a review of previous national and international studies on the issue of distracted driving.

2.2 Traffic Safety Culture

This section will introduce the overall definition of safety culture and how it can be applied in the transportation field. The evolution of traffic safety culture in the U.S. and the suggested strategies to achieve a better culture for traffic safety are discussed as well.

2.2.1 Overall definition of safety culture

The concept of safety culture was first introduced to industries due to higher and complex safety concerns. Back to 1986, the nuclear accident at Chernobyl first raised the public awareness on the importance of industry safety culture (Zhang et al., 2002). The definitions of safety culture are different in various industries. Table 2-1, which was adopted from a synthesis of safety culture and safety climate research, presents the definitions of safety culture in different industries.

Table 2-1: Definitions of safety culture, adopted from: (Wiegmann et al., 2002)

Source/Industry	Definitions
Carroll (1998) (Nuclear power, US)	Safety culture refers to a high value (priority) placed on worker safety and public (nuclear) safety by everyone in every group and at every level of the plant. It also refers to expectations that people will act to preserve and enhance safety, take personal responsibility for safety, and be rewarded consistent with these values.
Ciavarelli & Figlock (1996) (Naval aviation, US)	Safety culture is defined as the shared values, beliefs, assumptions, and norms which may govern organizational decision making, as well as individual and group attitudes about safety.
Cooper (2000) (Theoretical)	Safety culture is a sub-facet of organizational culture, which is thought to affect member's attitudes and behavior in relation to an organization's ongoing health and safety performance.
Eiff (1999) (Aviation, US)	A safety culture exists within an organization where each individual employee, regardless of their position, assumes an active role in error prevention and that role is supported by the organization.

Table 2-1 (continued)

Cox & Cox (1991) (Industrial gases, European)	Safety culture reflects attitudes, beliefs, perceptions, and values that employees share in relation to safety.
Cox & Flin (1998) (Theoretical) Lee (1998) (Nuclear reprocessing, UK) Wilpert (2000) (Theoretical in context of nuclear power)	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management.
Eiff (1999) (Aviation, US)	A safety culture exists within an organization where each individual employee, regardless of their position, assumes an active role in error prevention and that role is supported by the organization.
Flin, Mearns, Gordon, & Fleming (1998) (Offshore oil and gas, UK) Helmreich & Merritt (1998) (Aviation, US)	Safety Culture refers to entrenched attitudes and opinions which a group of people share with respect to safety. It is more stable [than safety climate] and resistant to change. Safety culture (p 133): a group of individuals guided in their behavior by their joint belief in the importance of safety, and their shared understanding that every member willingly upholds the group's safety norms and will support other members to that common end.
McDonald & Ryan (1992) (Theoretical in context of road transportation) Mearns & Flin (1999) (Theoretical) Pidgeon (1991) (Theoretical) Pidgeon & Oleary (1994) (Theoretical in context of aviation)	Safety culture is defined as the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious.
Mearns, Flin, Gordon, & Fleming (1998) (Offshore oil and gas, UK)	Safety culture is defined as the attitudes, values, norms and beliefs which a particular group of people share with respect to risk and safety.
Meshkati (1997) (Transportation industry, US)	Safety culture is defined as that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.
Minerals Council of Australia (1999) (Mineral industry, Australia)	Safety culture refers to the formal safety issues in the company, dealing with perceptions of management, supervision, management systems and perceptions of the organization.

A comprehensive definition of safety culture, encompassing all the definitions applicable to various industries, as follows:

> *"Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes, and be rewarded in a manner consistent with these values. (Wiegmann et al. 2002)"*

According to white paper on safety culture (Ward et al., 2010), there are three major factors that can be apply to any culture. Figure 2-1 presents these three facets of the culture. Cognition is considered a motivator and guideline to lead the culture-based behaviors. Establishing a better understanding of safety culture is the first step of enforcing a traffic culture paradigm shift.

Before creating or shifting to a better culture, it is important to get a better understanding of the important characteristics for culture. Five attributes of culture that defined by past research are (Moeckli & Lee, 2007):

1. *Culture is never naturally given.*
2. *Culture is never singular.*
3. *Culture is never neutral.*
4. *Culture is always an effect of power.*
5. *Culture is best modified through changes in social practice.*

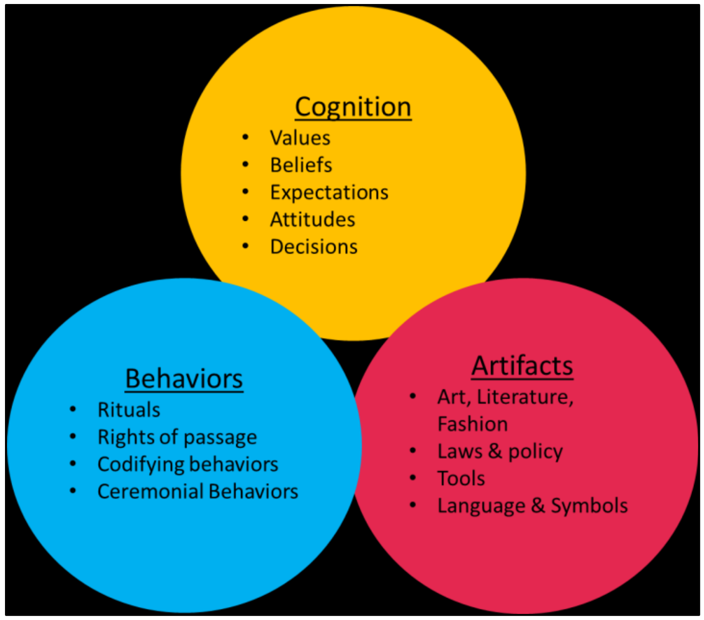


Figure 2-1: Simplified model of major facets that describe culture (Ward, et al., 2010)

Based on the reviews of-previous definitions of safety culture, a well-organized safety culture can be developed for a safe transportation system. Today, improving traffic safety, primarily in terms of reducing crashes, is going through a "bottleneck" period, and the application of the safety culture concept can be deemed as a potential solution.

2.2.2 Evolution of traffic safety culture in the U.S.

Traffic safety gained broad attention from the U.S. government and the public in the late 1960s. Since then, a new safety initiative was established that has shifted from time to time. A substantial road safety paradigm shift took place in 1960s and it contributed significantly to the current high level of traffic safety environment in the U.S. During this period, the major improvement in traffic safety focused on roadway and vehicle design, therefore, the car manufacturers and the state highway authorities played an important role for this significant evolution of traffic safety. As an additional benefit, the interstate highway system was first introduced to the public at that point and it created a new travel mode in the U.S. By the end of 20th century, with better designed vehicles and roadways, this safety paradigm shifting led to a significant reduction in traffic crashes. This extraordinary period provides a precious lesson about the importance of how science, economic, political, bureaucratic interests and other cultural factors can work together to create a suitable environment to extend the newly established safety culture (Lonero, 2007).

According to Lonero (2007), law enforcement has been always recognized as a fundamental part of all traffic safety culture improvement activities, and it reflects the expectation and core values for the whole society. The author argued that driving is civil right with limits, and, "*no rights are absolute, without limits*".

Public hold zero tolerance of risk behavior and better safety consciousness are the final goals of achieving the better traffic safety culture in the U.S.

2.2.3 How to achieve a better traffic safety culture in the U.S.

In a bid to achieve a better traffic safety culture in the U.S., there were plenty of studies that investigated an effective approach to shift the current traffic safety culture from risk-tolerant to risk-averse. Several recommended approaches are discussed in this section.

First of all, an *intervention approach* was recommended by the lessons learned for changing the culture related to solid waste recycling, drug abuse, and tobacco use. These experiences provide practical insights for improving traffic safety culture in the future. According to these lessons, intervention approaches have been implemented to shape a culture through three strategies: *1) education programs addressing home, school and community influences, 2) multilevel strategies addressing social environments and 3)* *interventions addressing social and economic conditions* (McNeely & Gifford, 2007). McNeely et al. (2007) concluded that public education, media campaigns, school program and legislative support were especially effective on producing a better traffic safety culture.

Regarding mass media campaigns, the University of Adelaide evaluated mass media campaigns conducted in different countries from 2001 to 2009 and offered recommendations to make mass media campaigns more effective in changing driving behaviors and shaping a new traffic safety culture, including:

- Conducting scientific evaluations to measure the change in behaviors due to campaigns;
- Combining with other activities such as enforcement to make the campaigns more effective;
- Establishing campaigns based on theories, such as psychological theories;
- Better documenting campaign activities;
- Combining different forms of media, such as television, radio station, newspapers, etc. (Wundersitz, Hutchinson, & Woolley, 2010).

Moeckli and Lee (2007) provided four other theory-based interventions approaches which can be helpful transforming culture in the future.

1. *A place-based approach*: the research suggests that the place plays an important role on people's experiencing traffic safety culture. The place with local customs or different laws would foster various cultures. For example, driving on urban roadways has different norms of vehicle communication and acceptable level of risk behavior

than does driving on rural roadways. Consequently, driving area characteristics are considered as essential factors for shaping the culture.

2. *Cyborg interventions*: with the development of new vehicle design and technologies, the "smart" vehicle could be another solution to today's high traffic fatality rate. This intervention strategy is mainly applying technology on current culture, promoting safety-oriented equipment in vehicles, and making car-driver hybrid as part of solution to achieve a traffic safety culture in the U.S.
3. *A network-based approach*: a network of people, vehicle, organizations and infrastructure is established. The traffic safety culture is constructed, interacted, and transformed across different levels of the network. A strong network would be more influential on the whole society. Promoting the traffic safety culture through the network would facilitate to stabilize the culture over time.
4. *A multilevel control approach*: control at various level of the network by understanding multidisciplinary expertise. A safety-oriented driving culture does not merely depend on drivers, but also the governments, organizations, regulation associates, and other.

According to Johnston (2009), the best practice strategies for shifting the current traffic safety culture can be summed up in the four Cs which are constituency, commitment, cooperation and coordination. Constituency is represented by public-sustained support for actions that shift the current culture; commitment is expressed by the political leaders tending to change the behavioral norms; cooperation requires numerous agencies to work together; and lastly, coordination refers to the integration and synergy across institutional efforts.

Establishing a comprehensive program to shape the culture from different aspects of society has been recommended as the most effective method to create a comprehensive traffic safety culture.

2.3 Distracted Driving

In general, reducing crashes is a priority goal in the process of developing a better traffic safety culture in the U.S. Today, an increasing number of crashes are related to distracted driving, and with the increasing safety concerns, distracted driving has received broad attention from both the public and the government. The distracted driving-related fatalities in the U.S. increased from 10.9% to 15.8% from 1999 to 2008; and specifically, the number of fatalities increased from 2005 to 2008 by 28.4% (Wilson & Stimpson, 2010). Reducing distracted driving can be a key factor to form a better safety culture in the U.S.

To address this problem, many previous studies were aimed to gauge the hazard of distracted driving and how those distraction activities affect the driving behavior among different driver ages groups. The following section will discuss the current state of distracted driving in the U.S. and in Iowa; as well as previous studies on distracted driving.

2.3.1 The state of distracted driving in the U.S. and Iowa

According to DISTRACTION.GOV, 18% of injury crashes were distracted driving-related in 2010. In the same year, 3,092 people were killed and nearly 416,000 were injured in traffic crashes involving distracted drivers. In Iowa, a total of 5,129 motor vehicle crashes from 2001 to 2010 were attributed to cell phone use (Governor's Traffic Safety Bureau, 2010).

Conceptually, distracted driving is defined as any activities that could divert driver’s attention away from driving; those activities greatly increase the risk of driving error and crash involvement. The major distracted activities defined by National Highway Transportation Safety Associate (NHTSA) include: texting and emailing; using cell phone or smartphone; eating and drinking; talking to passengers; grooming; reading, including map; using a navigation system; watching a video; or adjusting a radio, CD player, or MP3 player. All of above activities can be classified to four types of distraction, which are manual, visual, auditory and cognitive (GHSA, 2011). Regarding the frequency of these activities, according to the findings from national phones survey on distracted driving attitudes and behaviors which was conducted in 2011, the most commonly distracted driving activity while driving is talking to other passages in the vehicle, occurring for nearly 80% of all the drivers. Adjusting the radio is another distracted activity that about 65% of people have this experience while driving. Cell phone usage while driving is another serious threat to traffic safety. Almost 40% of drivers admit that they were making or answering phone calls when they were driving. Younger driver (25 or younger) were two to three times more likely than other drivers to read or send text messages or emailing while driving (Tison et al., 2011).

In 2005, a 100-car naturalistic driving study was completed by the Virginia Polytechnic Institute and State University (Virginia Tech), NHTSA, Virginia Department of Transportation, and the Virginia Transportation Research Council. The study collected more than 42,000 hours of data, and covered more than two million vehicles miles. The study indicated that nearly 80% of all crashes involved driver inattention, and younger drivers had the higher rate of distracted-related crashes (Hanowski et al., 2006).

The above statistics reveal that distracted driving is recognized as a serious threat to traffic safety. A review of previous studies on different aspects of distracted driving would provide more insights and assist in identifying the best solution to this epidemic.

2.3.2 Previous simulation-based research on distracted driving

Many of the past studies of distracted driving involved driving on a simulator. In a study by Kaber et al., (2012), 20 healthy young drivers between 16 and 21 years of age (10 females and 10 males) were given two driving tasks (passing and following) as well as various distraction tasks. The results indicated that visual and cognitive driven have independent and combined effect on driving performance, visual behavior and workload.

To combine cognitive and visual distraction impact while driving, the University of Iowa developed a medium-fidelity simulator study to examine driver behavior during four different levels of distractions. A total of sixteen healthy volunteers involved in this study were asked to complete 8-minute drives under four levels of distractions (no distraction, visual distraction, cognitive distraction, and combined visual and cognitive distraction). The results showed that the combined distraction was less detrimental than visual distraction along, but both visual and combined distraction impaired vehicle control, hazard detection and long off-road glances (Liang & Lee, 2010).

Another simulation study used the technology of fictional magnetic resonance imaging (FMRI) to identify the human brain activation associated with driving when listening to someone speak. The results, illustrated in Figure 2-2, show that the driving-related activation in bilateral parietal cortex (blue circle) decreased with the addition of the sentence listening task, and the yellow ovals indicate the listening task cause activation of temporal and prefrontal language areas in the brain (Just et al., 2008). Moreover, a simulation study in the U.K. found that the mean heart rate increased during receiving call while driving. It was shown that cell phone use during driving increased the cognitive demand for drivers (Haigney et al., 2000).

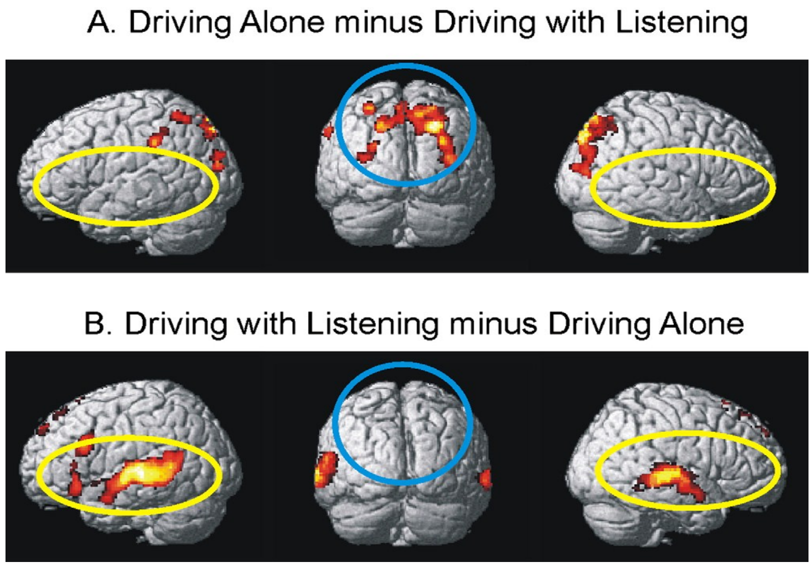


Figure 2-2: Whole brain activation under two different driving situations. Adopted in (Just et al., 2008)

A simulation study conducted in France aimed to assess the different distraction effects between an answerphone and normal hands-free phone. A total of thirty drivers participated in that study and received six calls with answerphone and six calls with normal hands-free phone. The driving performances for answerphone were analyzed for three phases: interaction phase, listening phase, and answering phase. The results showed that answering phone was the most disturbing phase for receiving answerphone call, but in overall, splitting up the conversation into different phases decreases the overall task difficulty for drivers. The statistic of correct reaction and mean responses time while driving for answerphone were all better than regular hands-free phone (Bruyas et al., 2009).

Bayly et al. (2009) summarized several studies of the effects of distraction activities while driving, include radio, CD and MP3 players, video system, email, eating and drinking, etc. The study observed that different in-vehicle source of distractions would affect driver performance. The most common driving behaviors under distractions were both hands off the wheel, glance behavior, difficulty in maintaining lane position, and increase in the braking distance and subjective mental workload. Especially, the e-mail system would cause all of the above behaviors. Both technology devices (such as GPS, cell phone etc.) and personal driving habits (such as eating, talking etc.) are factors that can cause distracting driving behavior.

The Monash University and the National Roads and Motorists Association in Australia conducted a simulator study to measure the effects of distracting driving on the performance of three age groups of drivers: less than 25 years old, between 30 to 45 years old, and between 60 to75 years old. The drivers were given driving tasks under two types of distraction. The first was using hands-free cell phone as auditory (vocal) distraction, and the second was using in-vehicle entertainment/information system as visual or manual distraction. The mean speed and deviation from the posted speed limit for each drive were recorded. The study concluded an important finding that distractions related to an in-car entertainment system had the greatest negative impact on driving performance across the different age groups, while talking on hands-free cell phone was easier for drivers to keep the eyes on the road (Horberry et al., 2006).

2.3.3 Cell phone related studies of distracted driving

With the fast growth of cell phone use, cell phones have become a significant factor for distracted driving. There are many studies on the impact of cell phone use on distracted driving. Figure 2-3 and Figure 2-4 present the overall law restriction on the use of Mobile Communications Devices (MCDs) in the United States in 2010 and 2012 (Ibrahim et al., 2013). In 2010, eleven states in white had no restriction on handheld use of MCDs by all drivers, however, in 2012, this number decreased to five. Iowa prohibited the use of MCDs by young inexperienced driver and texting for all drivers (secondary enforcement).

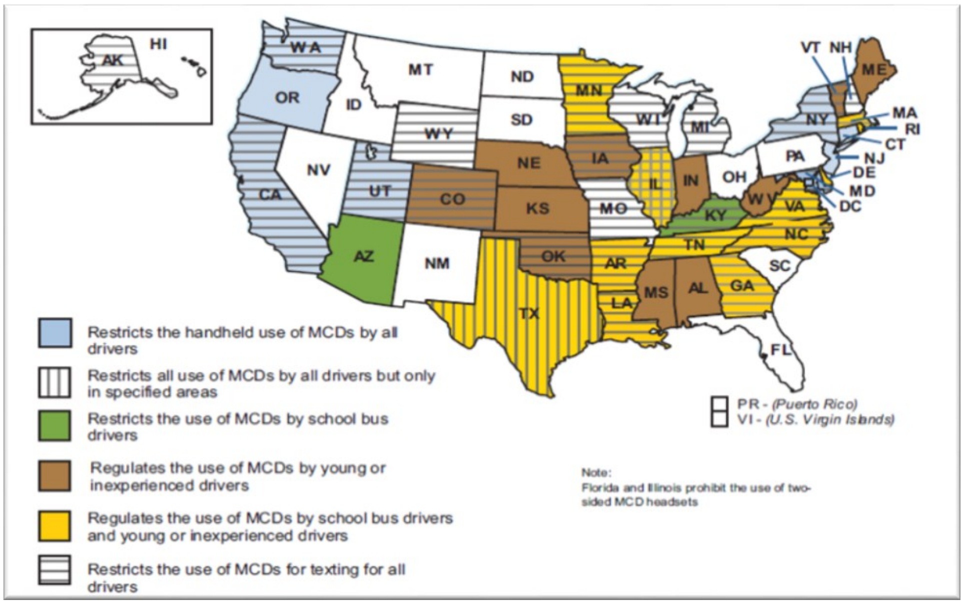


Figure 2-3: Map of laws restricting use of mobile communication devices (MCDs) while driving as of November 2010. Adopted in (Ibrahim et al., 2011)

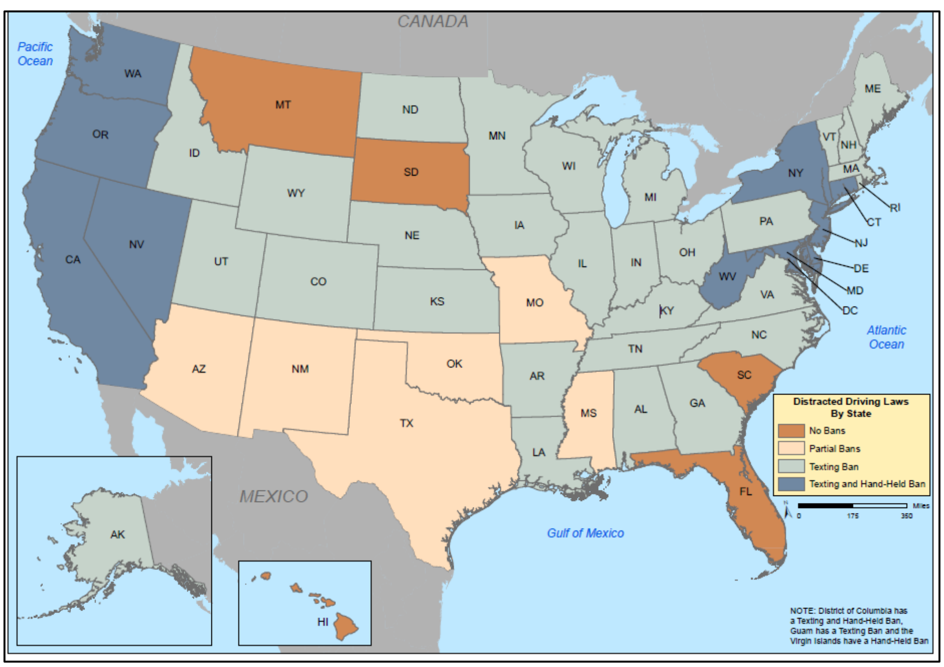


Figure 2-4: Map distracted driving laws by State, 2012. Adopted in (Guarino, 2013)

According to Guarino (2013), the 2009 Omnibus Household Survey (OHS) found that younger people and people of higher household income tend to accept cell phone use while driving more easily than others.

An observational study conducted in Israel on driving performance while using cell phones indicated that drivers who were engaged in talking on the cell phone for either short (less than 11 minutes) or long conversation (16 minutes long) found difficult to keep the proper gap between their own car and the other car ahead of them. Moreover, the observations demonstrated that drivers subconsciously increased speed when the conversation went longer (Rosenbloom, 2006).

An assessment of the difference in the hazards between handheld (HH) cell phone and hands-free (HF) cell phone use has been analyzed in many studies. According to Ishigami and Klein (2009), the results obtained from many of previous studies included both field and simulated driving studies showed that using HH or HF type of cell phone would impair driving performance almost equally. Same conclusion reached in Abdel-Aty (2003) which found that restricting handheld devices but permitting hands-free devices was not likely to reduce distraction from phone conversation as well.

A similar study conducted in Sweden examined the difference in mental workload while driving between simple versus complex conversation by using either hands-free or handheld phone. Forty professional drivers (taxi drivers, couriers) participated in this study. The study used peripheral detection task (PDT) to evaluate the participants' workload while driving, and the results showed that conversation type significantly affected mental load but no differences were found between the two telephone modes, in other words, hands-free cell phone did not provide any benefits over handheld phone in terms of decreasing mental workload (Patten et al., 2004).

Another simulator-based study conducted in Sweden compared the effects of using a cell phone while driving in rural and urban environments. A total of 48 drivers aged between 24 and 60 years old drove while talking using a hands-free or handheld phone. The results indicated that cell phone conversation using either mode impaired work load in both areas. In addition, driving speed was reduced during conversation on a handheld device in all environments, but the effect on speed was less obvious when using a hands-free mode (Tornros & Bolling, 2006).

A study conducted in Miami University investigated the reaction time (RT) in braking response for five distraction conditions while driving. A total of 22 students from Miami University drove in a simulation laboratory station and used a cell phone. The results indicated that phone use caused reaction time to decrease by 19%. In addition, the study found no significant advantage of reducing reaction time that the hands-free phone would provide over the handheld model (Consiglio et al., 2003).

A survey study conducted in France investigated the individual factors that affect cell phone use while driving. A total of 1,973 responses were collected by phone during a summer month in 2003. The results indicated that men, less than 45 years old and married were more exposed to the risk of using cell phone while driving. Also, higher and middle social groups were over-represented in this study (Brusque & Alauzet, 2008).

A case-control study conducted in Perth, Australia assessed the contribution of passenger-related distractions versus cell phone use to motor vehicle crashes. The study investigated a total of 274 drivers involved in a crash with passengers in the car and 456 drivers used a cell phone before the crash happened. The results showed that a driver with passengers was about 60 % more likely to be involved in a crash. Nonetheless, the risk was considerably lower to that of using a cell phone use while driving (McEvoy et al., 2007).

Besides passenger vehicles, a survey study conducted in Denmark investigated the extent and variations in phone use among drivers of heavy vehicles. A totals of 1,044 drivers participated in this study, and over 99% of the drivers claimed that they used cell phones while driving. Approximately 66% of drivers reported having experienced dangerous situations because of cell phone use among other road users. The study indicated that the frequency of using a cell phone while driving was substantially higher among truck drivers than among private drivers. Similarly, the younger truck drivers had higher frequency of cell phone use while driving. Moreover, truck drivers with a higher number of driving hours were more likely to use a cell phone (Troglauer et al., 2006).

2.3.4 Age-oriented research on distracted driving

Another major factor that has been established to influence the driving performance under different distracted conditions is age or driving experience. Previous studies have attempted to assess the performance differences among novice and experienced drivers, and different age groups.

According to the National Highway Traffic Safety Administration (NHTSA), the greatest proportion of distracted drivers was in the under-20 year old age group. Approximately 16% of fatal crashes of all under-20 drivers were distracted driving-related (NHTSA, 2009). The data indicated that younger drivers seem to be more easily involved in distracted driving.

A self-reported study conducted in Finland determined that age was a significant factor affecting the decision of using a cell phone while driving. The survey indicated that the frequency of younger drivers (18-24 years old) responding to phone calls while driving was about 20% more older drivers (50-64 years old). In addition, younger drivers reported experiencing hazards while using a phone eight times more often than older drivers (Pöysti et al., 2005).

Kass et al. (2007) measured the number of driving violations committed: speeding, collisions, pedestrians struck, stop signs missed, and centerline and road edge crossings. The participants included 25 novice drivers (ages 14-16 years old) and 26 experienced drivers (ages 21-52 years old). The results indicated that novice drivers were involved in more driving violations and had lower awareness of the driving situation than experienced drivers. However, the result also found that both novice and experienced drivers suffered somewhat decrements while distracted by cell phone while driving (including hands-free cell phone).

A novice driver's related test was conducted in Griffith University, Australia. Nine novice drivers (18.4 years old on average) holding provisional licenses (with an average driving experience of 19 months) participated in the test. All participants were distracted by hands-free cell phone while driving. The results showed that driver performance degraded in coordination and control in three tasks representative of everyday driving conditions that include cornering, controlled braking, and obstacle avoidance (Treffner & Barrett, 2004).

Another younger driver-related study was conducted by the AAA Foundation for Traffic Safety (Goodwin et al., 2012). As part of the study, a video camera was installed on 38 family vehicles in order to collect data on the driving performance of 38 newly licensed teens, as well as 14 high-school-aged siblings. After six months of data collection, a sample of 7,858 video clips was selected for analysis. The observations showed that younger females were twice as likely as males to use an electronic device. Moreover, the study result indicated that novice drivers were approximately six times more likely to have a serious crash when there was loud conversation in the vehicle.

According to Tractinsky et al. (2013), the most common use of cell phone while driving was answering a call, instead of initiating calls. However, regardless of road conditions, younger drivers (under 20 years old) were more likely to initiate calls than older drivers (over 65 years old) or experienced drivers (24 to 30 years old with at least 7 years of driving experiences). Comparing to younger drivers, older drivers were highly sensitive to varying road conditions (such as heavy traffic flow or winding road) and drove slower. The study found that younger drivers were more likely to underestimate the risk of distracted driving than other experienced and older drivers.

Besides having conversation on a cell phone, texting is another distracting activity that is mainly performed by younger drivers. Hosking et al. (2009) conducted a study to investigate the effects of using a cell phone for receiving and sending text messages while driving for young novice drivers. The study asked twenty young drivers using a cell phone to retrieve and send massages while driving in a simulator. The results showed that texting a message would increase the time of looking off-road up to 400%. Moreover, the likelihood of a driver missing lane changes increased 140% in overall.

Novice (younger) drivers were not the only group whose driving performance is affected by distractions. Middle-aged and elder drivers were also greatly influenced by distracted driving. Thompson et al. (2011) examined distracted driving performance of 86 elderly (72.5 years old on average) and 51 middle-aged (53.7 years old on average) drivers.

The test results showed that middle-aged drivers experienced greater variability in steering control than elderly drivers. Older drivers tended to spend more time to hold the gas pedal steady. Approximately 39 % of elderly and 43% of middle-aged drivers generated more driving safety errors while they were distracted.

A simulation study conducted in Sweden in 1995 indicated that, while following a car and driving under distraction by a cell phone, older drivers (over 60 years old) experienced longer reaction time than younger drivers (less than 60), but both age group did not compensate for it by increasing their headway during the telephone task (Alm & Nilsson, 1995). Similarly, Strayer and Drew (2004) found that using a cell phone has equivalent effects on both younger drivers (18-25 years old) and older drivers (65-74 years old).

According to Fofanova and Vollrath (2011), for different scenarios of driving task performance during distraction, older drivers' performance (60-73 years) was more affected in lane keeping compared to younger drivers (31-44 years old). The results indicated that older drivers had worse driving performance in distraction conditions (d2 Test of Attention) as compared to the younger ones. However, this study suggested that if older drivers became aware of their difficulties in driving under distraction, they would reduce the probability of being involved in distracted driving by self-regulation.

2.3.5 Potential strategies to reduce distracted driving

Knowing the impact of distracted driving on traffic safety, it is important to identify effective strategies to reduce or prevent distracted driving. According to the blueprint for ending distracted driving, which was launched by the National Highway Transportation Safety

Administration (NHTSA, 2012), a series of actions should be taken to build a momentum to end distracted driving, such as:

- Raising public awareness;
- Enacting and enforcing strict state law;
- Addressing preventing distracted driving-related technology;
- Better educating young drivers;
- Getting public and government involved;
- Establishing self-responsibility for traffic safety among all the drivers;
- Advocacy.

With respect to enforcement, NHTSA conducted a high-visibility enforcement program to reduce cell phone related distracted driving in two states, New York and Connecticut. The study showed that strong laws combined with highly-visible police enforcement can significantly reduce cell phone use while driving. (Cosgrove et al., 2011)

According to the Governor Highway Safety Association (GHSA, 2011), additional countermeasures such as technology-related can be implemented for distracted driving. For example, some software applications (apps) can be loaded onto the cell phone and block text message or calls (except emergency calls) while driving. In addition, some devices can be installed in the vehicle which can sense whether a vehicle is moving and then would disable texting, emailing, web surfing and calling from a cell phone.

However, there is no clear evidence that the suggested countermeasures can have a long-term effectiveness on distracted driving. Creating an effective safety culture for distracted driving maybe deemed as solution for this problem.

2.4 Summary

The concept of safety culture and how it can be applied on traffic safety has recently received increased attention by transportation-related associations, institutions and the government. A review of previous studies on traffic safety culture can help future research to enhance traffic safety culture in the U.S. The different strategies to achieve a better traffic safety culture introduced in this chapter are considered a good starting point to shape the new culture in the U.S.

Within the context of overall traffic safety issues, distracted driving is a newly raised concern that requires significant improvements in the future. Cell phone use and novice drivers are two major factors related to distracted driving that often correlate to each other. Many previous studies examined the overall impact of different types of distraction activities on driving. A drawback of previous studies is the lacking of field data to observe distracted driving behaviors.

The next chapter will describe the data collected to document the distracted driving culture in Iowa, as part of a large public opinion survey conducted in the state in 2011. The data include responses to traffic safety topics such as traffic enforcement, driver education program, various driving behaviors, and attitudes toward traffic safety policies, activities and enforcement techniques.

CHAPTER 3. DATA DESCRIPTION

3.1 Overview

In 2011, the University of Northern Iowa, Center for Social & Behavioral Research, designed a cell phone and landline questionnaires survey regarding Iowa traffic safety culture in consultation with the Office of Transportation Safety at the Iowa Department of Transportation and the Institute of Transportation at Iowa State University. The major purpose of the survey was to gauge public opinions on traffic safety and driving experience in Iowa, which covered a wide range of traffic safety topics including traffic enforcement, driver education program, various driving behaviors, experiences and attitudes toward traffic safety policies, activities and enforcement techniques. The survey also included standard questions about the demographic-and socioeconomic-status of participants.

The survey included a total of 50 questions and the data collection lasted over a 10-week period. All the participants were randomly selected from various cities in Iowa, and the qualified participants had to be at least 18 years old. The final-completed interviews were 1088, 684 of which were landline interviews and 404 were contacted by cell phone. The complete survey questionnaire is presented in detail in Appendix B.

Finally, statistical weighting adjustments were made to ensure respondents' answers were representative of the actual attitudes, behaviors, and experiences of adults Iowans. These included adjustments for the sample strata (i.e., landline vs. cell phone number), within household selection probabilities, and demographic characteristics of gender, age, race/ethnicity, and education.

The comprehensive responses collected from the public would provide policy makers with information to help make decisions about which traffic safety policies, practices, and strategies should be maintained or which should modified, and which efforts aimed to improve traffic safety were most likely to be supported by Iowans.

This chapter first discusses briefly the design of the survey questionnaire followed by a summary of the survey results with respect to eleven pre-defined safety goals (Section 3.2). Then, the survey results related to distracted driving and the main objective of this thesis, are discussed in Section 3.3, followed by a summary of the key findings of this chapter (Section 3.4).

3.2 Iowa Telephone Survey

3.2.1 Survey Design

The telephone questionnaire was constructed based on a series of studies, including review of previous traffic safety surveys and literature on safety culture. Furthermore, interviews of experts in traffic safety were essential in developing the telephone questionnaire.

To develop the questions for the survey, experts in traffic safety were interviewed in a bid to solicit their opinions on potential traffic safety improvement activities in Iowa. The interviews helped to form a total of 11 goals that covered potential traffic safety concerns raised in Iowa. The major part of the questionnaire was developed based on the following ten goals:

1. Improve Emergency Medical Service (EMS) Response
2. Toughen Law Enforcement and Prosecution
3. Increase Safety Belt Use

4. Reduce Speeding-Related Crashes
5. Reduce Alcohol-Related Crashes
6. Improve Motorcycle Safety
7. Improve Young Driver Education
8. Improve Older Driver Safety
9. Strength Teenage Licensing Process
10. Reduce Distracted Driving

3.2.2 Survey Results

Overall, the responses showed that about two-third of Iowans believed driving in Iowa were about as safe now as it was five years ago. The following histogram, Figure 3-1 showed the overall responses. Regarding improvement on driving skills, most (72.5%) adult Iowans said they had not made effort to improve or maintain driving skills in the last five years.

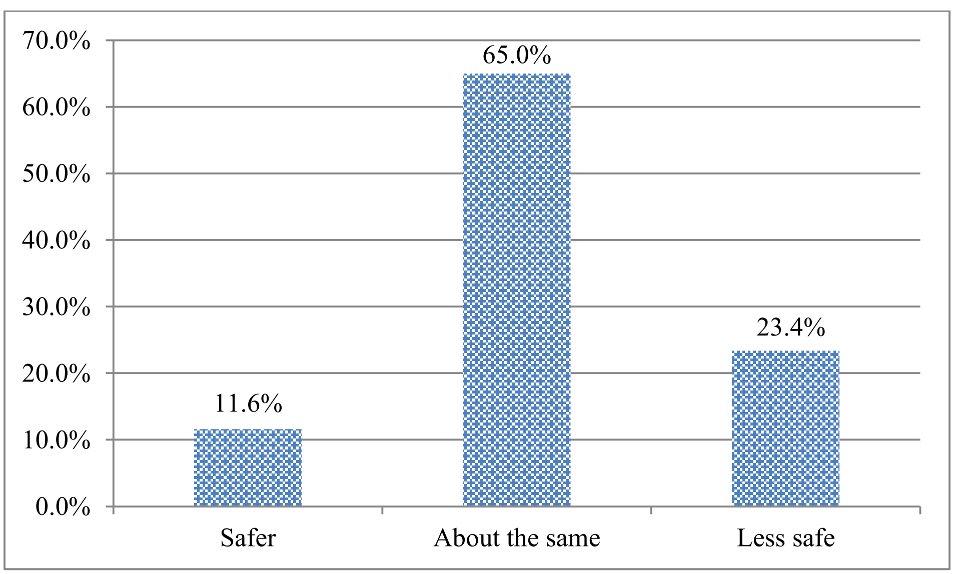


Figure 3-1: Do you think driving in Iowa feels safer, less safe, or about the same as it did 5 years ago?

Among different types of road infrastructure, approximately one half of adult Iowans (46.8%) stated that they felt very safe when driving licensed motor vehicles on highways or interstates in Iowa. City streets ranked second with 43.3% of participants rating them as very safe to drive on. About one-third of adult Iowans (32.9%) rated rural gravel roads as very safe in Iowa.

Several survey questions about maintaining driving skills were included in the survey. About one-fourth (27.5%) of adult Iowans stated that they had made specific effort to improve or maintain their driving skills in the last five years , such as reading about safe driving, looking at the official Iowa driver's manual, or taking a refresher class. Moreover, nearly three-fourths (76.3%) of Iowans said they supported providing insurance discounts or other incentives to licensed drivers to take a refresher class to improve driving skills and knowledge. Meanwhile, approximately 74 % of Iowans supported requiring drivers desiring to renew their licenses to spend 10 to 15 minutes reviewing safe driving tips and updates on laws and road design.

Besides general questions on traffic safety, participants were also asked to state their opinions with respect to the ten pre-defined goals mentioned in section 3.2.1. A concise summary of the overall responses for each goal would be presented in the following sections.

- Emergency Medical Service (EMS)

A total of two Emergency Medical Services (EMS) related questions were included in the questionnaire. Most adult Iowans (90%) were satisfied with the EMS in their living area and close to three-fourths (74%) of the participants stated that the state of Iowa has done in improving EMS well or excellent.

- Law Enforcement and Prosecution

In terms of the public's perceptions about how effective enforcement, education and engineering were in improving traffic safety in Iowa, enforcement such as fines and penalties on speeding and sending text messages was ranked the most effective. Figure 3-2 presented the overall responses on the most effective strategy in making driving in Iowa safer.

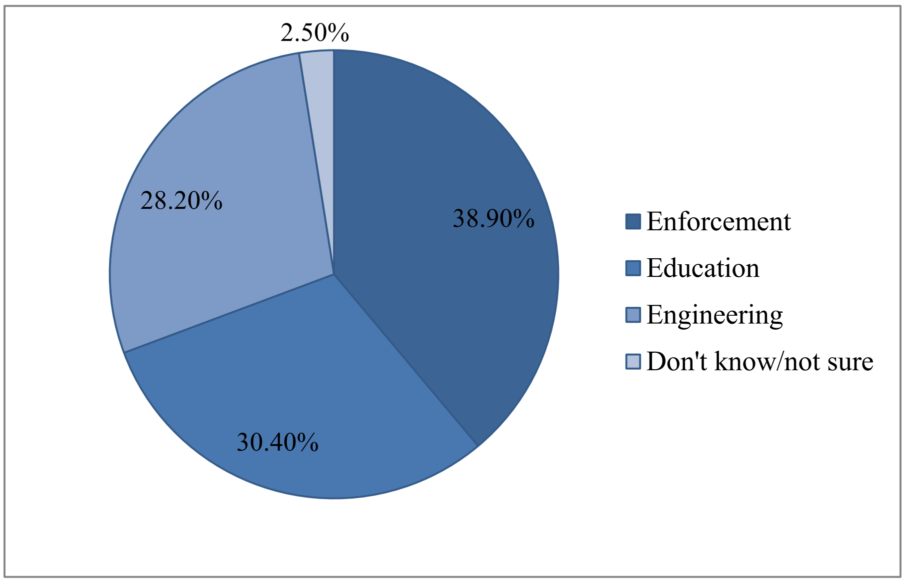


Figure 3-2: Most effective in making driving in Iowa safer

Iowan's opinion on using speed cameras, as another type of automated enforcement techniques, were also solicited in the survey. Over a half of the survey participants agreed with the use of speed cameras on major highways (55.0%) and city streets (56.4%) to reduce speeding. 70.8% of participants were supportive of using cameras to automatically fine drivers who drive through red lights.

- Safety Belt

In terms of safety belt usage, a large majority of adult Iowans (92%) considered driving without wearing seatbelts to be a serious threat to traffic safety. Most participants (66%) also said it should never be acceptable to drive without wearing seatbelt.

- Speeding

The survey included a wide range of questions regarding speeding. About two-thirds of adult Iowans (68%) felt satisfied with the improvement on enforcing the speed limit in Iowa. Over 94% of participants recognized excessive speeding as a serious threat to traffic safety. By exploring the responses on speeding related questions, younger (18-39 years old) male drivers seemed to be a latent safety concern group because they reported higher acceptable level in speeding than other age groups or females.

- Alcohol

Alcohol-impaired driving in Iowa received relatively higher against rate by all the participants. The responses indicate that adult Iowans have pervasive cognition for the hazard of driving under impaired by alcohol. Over 90% of participants rated driving after drinking too much alcohol as a very serious threat to traffic safety. Most (94.6%) participants reported that they would never accept drunk driving. Approximately 93% of participants also indicated that driving after drinking alcohol would increase the chance of crash.

- Motorcycle

Motorcycle safety is another safety concern area in Iowa. Only 6.4% of adult Iowans stated that the state of Iowa has done excellent in improving motorcycle safety in Iowa. Specific questions were also asked about potential extensive training program, helmet use and graduated licensing system. The survey responses indicated that the majority of motorcycle occupants (60%-80%) would not support additional regulations or programs, but large numbers of drivers (50%-70%) would support to improve the overall motorcycle safety in various aspects (helmet law, extensive training, etc.). This big discrepancy would bring huge obstruction in the process of improving motorcycle safety in the future.

- Young Drivers/ Strength Teenage Licensing Process

Approximately 80% of the participants recognized that young drivers pose a somewhat or very serious threat to traffic safety. In terms of the teenage licensing process, more than half of the participants (58.1%) thought the age of 14 is okay to obtain the first driving license. Other than that, 62.4% of participants supported to increase the permit length to 12 months instead of the current length of 6 months. Moreover, nearly three fourth of the participants agreed to limit the newly licensed teen drivers to driving with no more than one teen passenger. Meanwhile, half of the participants (55.4%) also supported to limit driving after 10 pm for newly licensed teen drivers.

- Older Drivers (65 or older)

With the physical limitations of older drivers, over 75% of the participants felt that older drivers were a somewhat or very serious threat to traffic safety.

Last, distracted driving was stated as another potential area if safety concern. The corresponding questions will be discussed in detail in the next sections.

3.3 Distracted Driving

With the growing safety concern of distracted driving, primarily cell phone use, reducing distracted-related crashes has become a national priority. Reducing distracted driving was also identified by the experts in Iowa, and as such, the questionnaire included a total of 13 distracted driving related questions. The corresponding questions and responses are presented in detail in Appendix A: Survey Questions and Responses Related to Distracted Driving.

Most adult Iowans (95%) rated distracted driving as a serious threat to traffic safety. However, with respect to reported self-behavior, many participants indicated high frequency of distracted driving activities that performed by themselves or the other drivers. This result could be deemed as the current distracted driving culture in Iowa: “people failed to match their words with actions”.

Since there are many activities could be treated as distracted driving, in a bid to investigate the degree of distraction on several common driving behaviors, the questionnaire asked participants to provide opinions based on their previous driving experience. Figure 3-3 shows the comparison results for selected activities and indicates that most participants (84.3%) felt very distracted in receiving text messages or emails while driving. Making or receiving cell phone calls was ranked second with 35.5% selection. In general, cell phone usage was recognized as a dangerous distracting driving behavior by most adult Iowans.

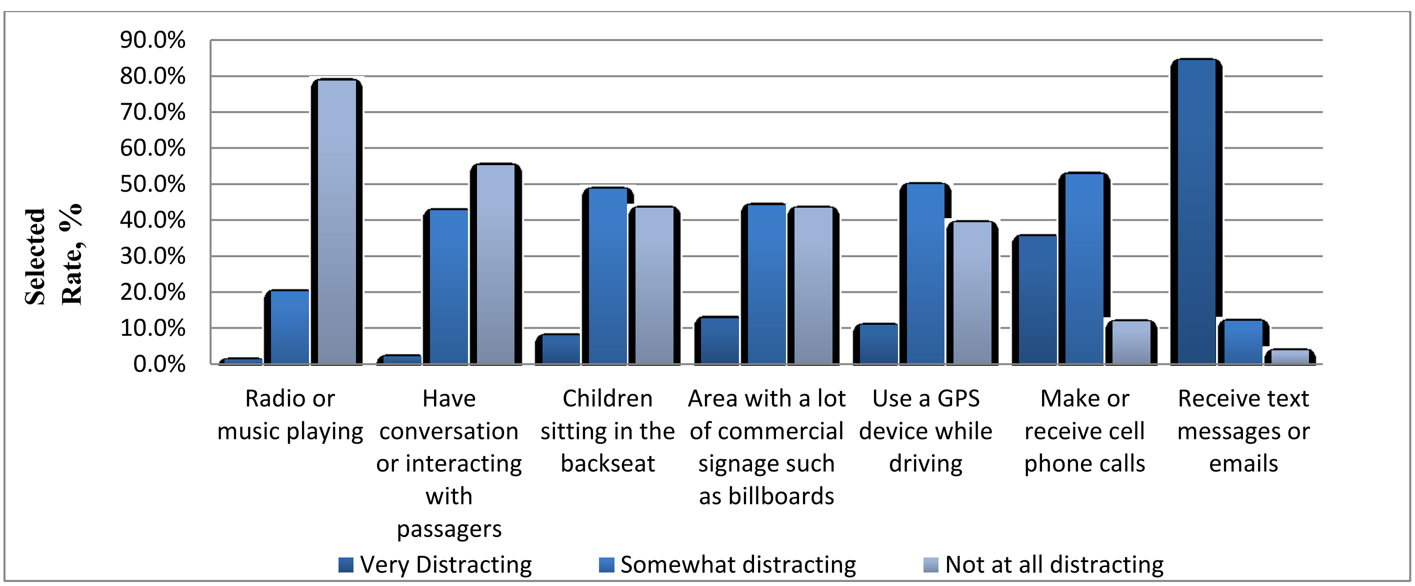


Figure 3-3: Degree of distraction for different actions while driving

With respect to reducing distracted driving in Iowa, about one-third (34.1%) of the participants rated previous improvement activities the state of Iowa had done as good or excellent. In terms of the responses on legal or illegal issue, approximately 86.7% adult Iowans stated it is illegal for driver under 18 to use a cell phone while driving, and most (88.8%) participants viewed the activities of reading, writing, or sending a text message while driving as illegal behaviors. In general, using cell phones while driving was considered somewhat or a very serious threat to traffic safety by more than 89% of the participants. Relatively higher against rate for cell phone usage while driving can be explicitly inferred from the aforementioned results; however, the responses obtained from self-reported driving behavior were quite the opposite ironically.

In the questionnaire, participants were asked to report their personal acceptance for sending messages or emails, talking on a handheld cell phone and talking on a hands-free cell phone while driving. Most (88%) adult Iowans would never accept the activities of sending message or emails while driving, but this against rate decreased to 45.6% for making a call by using handheld cell phone. Moreover, only 17.5% of participants would never accept to talk on a hands-free cell phone while driving.

Regarding observation of the driving behavior of other drivers, more than 90% of participants indicated that they had seen other drivers talking on a cell phone while driving a few times a week or even every day. Approximately 64% adult Iowans had seen other drivers reading or sending a text message or emailing while driving. According to the responses, approximately 66.8% of the participants reported that they had talked on either handheld or hands-free cell while driving in the last 30 days of taking the survey. Nearly 20% of people also reported the activities of “have read or sent text messages or emails while driving”. As mentioned before, people in Iowa had pervasive realization on the hazard of distracted driving, but they were the opposite way which can be obtained from their self-reported driving behaviors.

Two other questions in the survey aimed to investigate the relationship between work and cell phone use frequency while driving. Nearly one-fourth (22.5%) adult Iowans reported that they had been required or expected to talk on their cell phone while driving because of work, and 5% of respondents had been required or expected to send or receive text message or email.

The questionnaire also solicited opinions on three distracted driving related statements. First statement argues that driving while talking on a cell phone would increase the chance of an accident. Most (90%) people agreed or strongly agreed with that statement. Approximately 88% of participants agreed or strongly agreed that driving while eating or drinking would increase the chance of crash. Nearly three-fourth (74%) of adult Iowans agreed or strongly agreed the chance of being caught is small for sending or receiving text message while driving.

The next section investigate the factors that influence Iowan's attitudes towards distracted driving such as age, gender and other factors that might influence their responses.

3.3.1 Age-oriented attitudes towards distracted driving

In a bid to explore the various attitudes among different ages of respondent, the responses for specific questions was classified into three different age groups: younger age group (18 to 39 years old); middle age group (40 to 64 years old); and older age group (greater than 65 years old). Figure 3-5 showed about 34% of participants felt the state of Iowa has done good or excellent in reducing distracted driving, with the participants in the age of 18 to 39 years old reporting higher satisfaction than the other age groups.

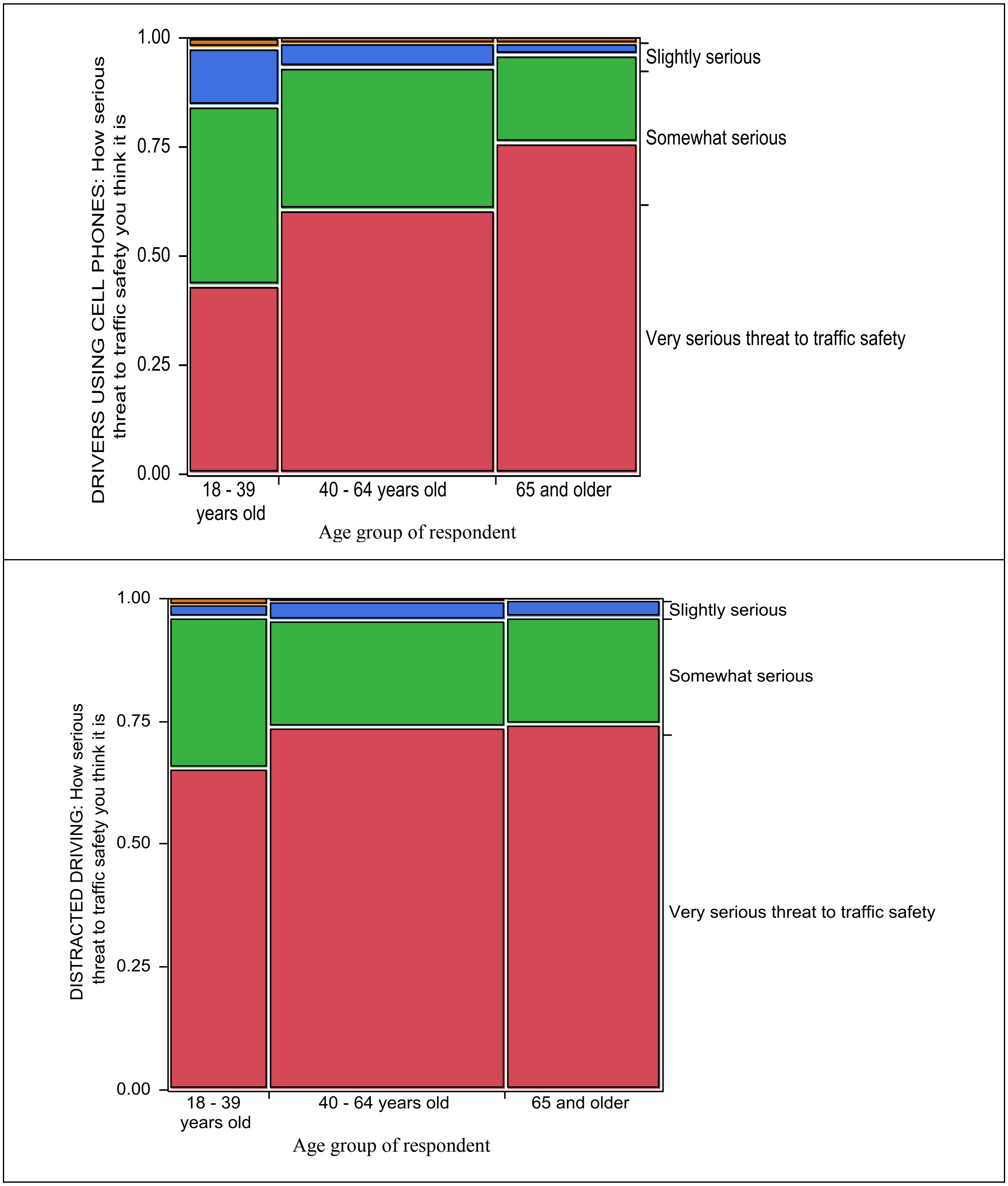


Figure 3-4: Opinions on the severity of driver using cell phone and distracted driving to traffic safety by age groups

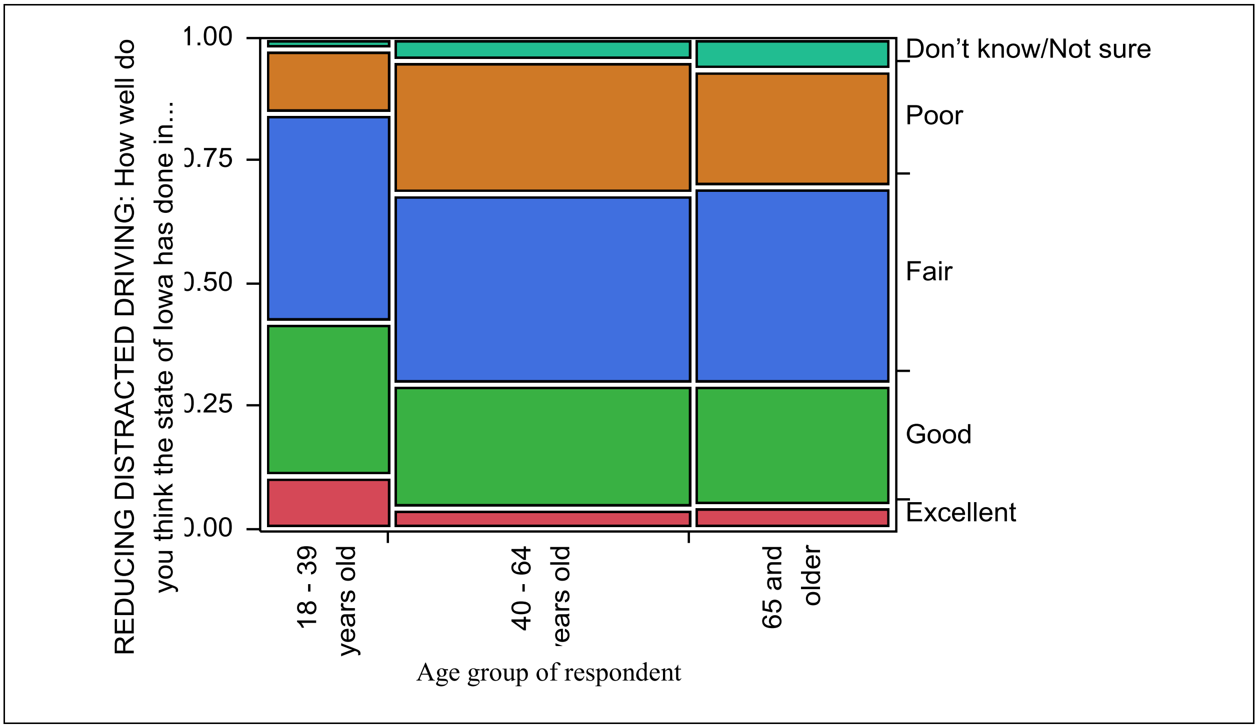


Figure 3-5: Opinions on how well the state of Iowa has done in reducing distracted driving by age group

According to Figure 3-4, lower percentage of younger participants (18-39 years old) reported distracted driving and drivers using cell phones as very serious threats to traffic safety than the other age groups.

Regarding the personal acceptance for talking on handheld, hands-free phone, and sending text messages or emails while driving, the results represented explicitly distinct different opinions among younger and older participants. Comparably, younger participants did not take distracted driving as a serious threat as older participants, and they potentially indicated themselves as risk-takers.

Figure 3-6 illustrates the relationship between age of respondents and their acceptable level of talking on hands-free cell phone while driving and it shows that the acceptance level decreases as age increases.

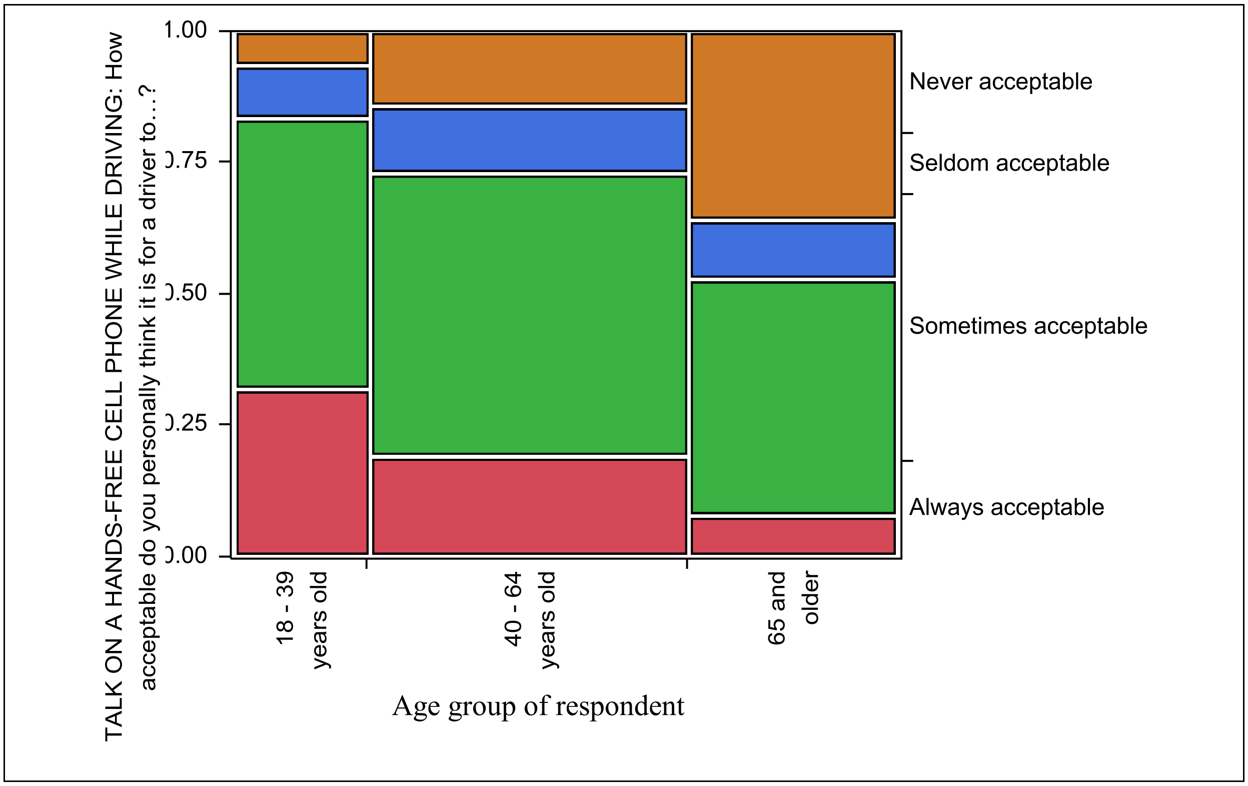


Figure 3-6: Acceptability of talk on a hands-free cell phone while driving by age groups

Apart from self-reported attitude towards distracted driving, the reported observations for other drivers by different age groups were illustrated in Figure 3-7. The distraction activity (read or send a text message or email while driving) observation rates decreased with an increase in age. The overall responses stated clearly that the younger participants have observed more distracting driving activities than older drivers.

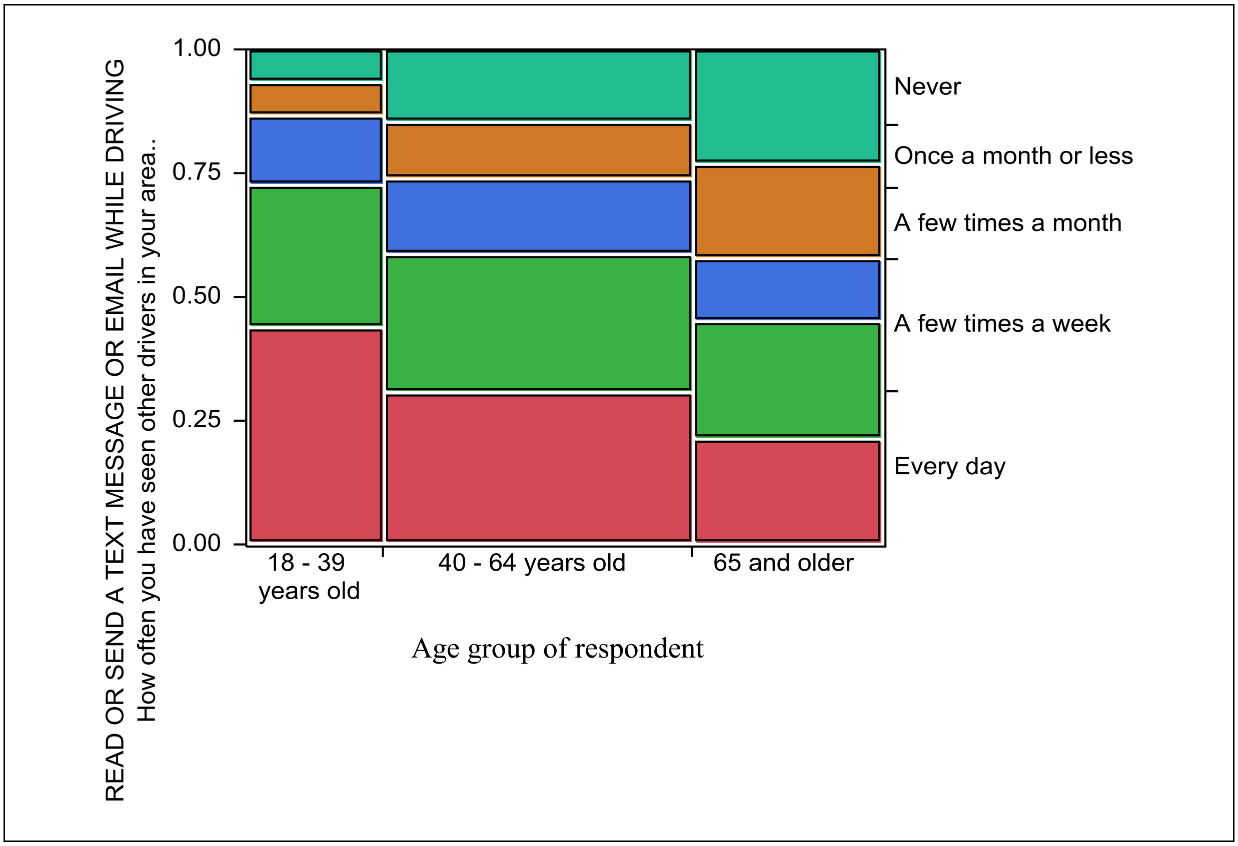


Figure 3-7: Observations on read or send text message or emailing while driving for other drivers by age groups

Other than observations, self-reported behaviors are bound to explore the differences in real attitudes between younger and older drivers in Iowa. Figure 3-8 showed the self-reported behavior of talking on any kind of cell phones while driving. Younger drivers still possessed higher rate than other age groups.

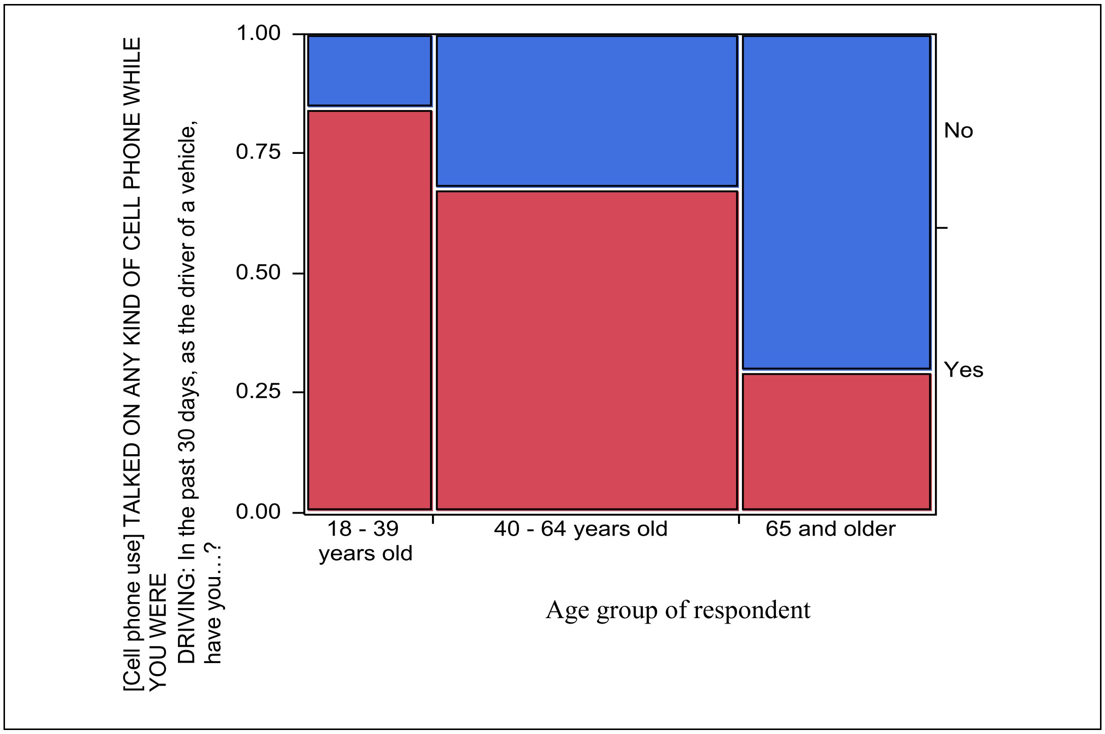


Figure 3-8: Self-reported behavior of talking on any kind of cell phone while driving by age groups

Through analyzing the age-oriented responses of distracted-related questions, it could be concluded that younger drivers should be deemed as a potential risk group for distracted driving, where improvement needs to be done. The overall responses obtained in the questionnaire provided clear evidence that younger drivers were more easily involved in distracted driving than older participants. In Chapter 4, age will be considered as an essential factor in the model construction.

3.3.2 Gender-oriented attitudes towards distracted driving

Similarly to the age-oriented analysis, gender was considered as another factor resulting in various attitudes and distracted driving behaviors. The following figures (Figure 3-9 to Figure 3-12) illustrate the overall attitudes stated among two different genders, and the results indicated that adult male drivers in Iowa were another underlying group that were more easily involved in distracted driving.

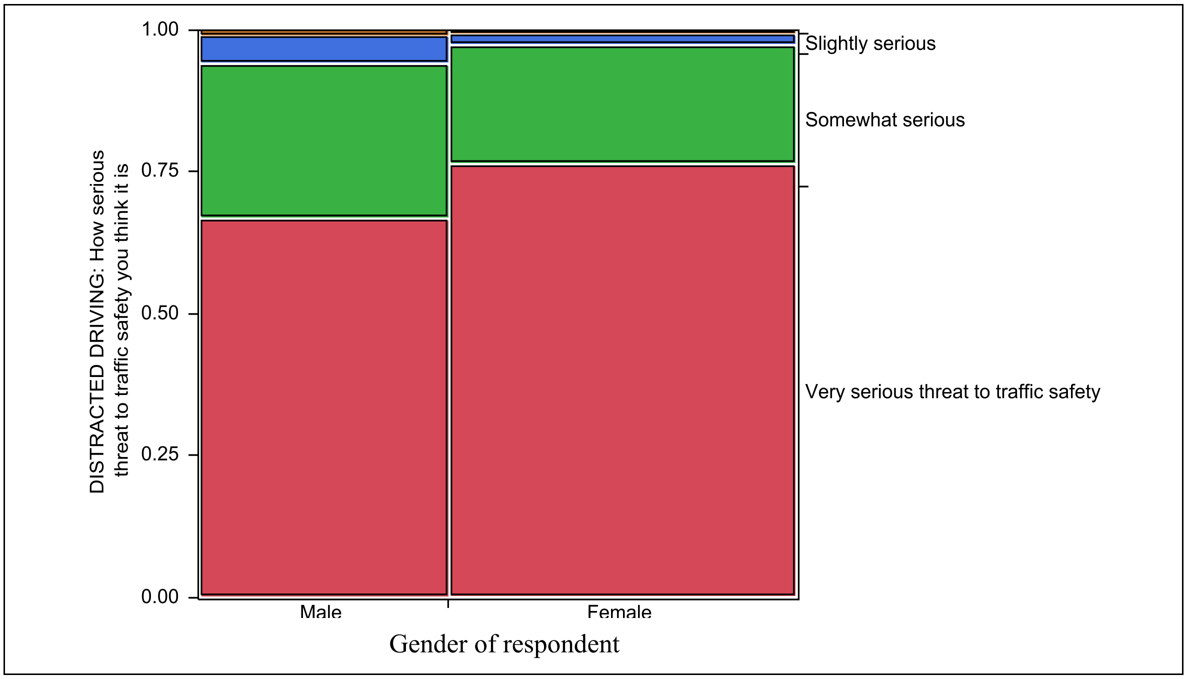


Figure 3-9: Opinions on how serious a threat to traffic safety of distracted driving by gender

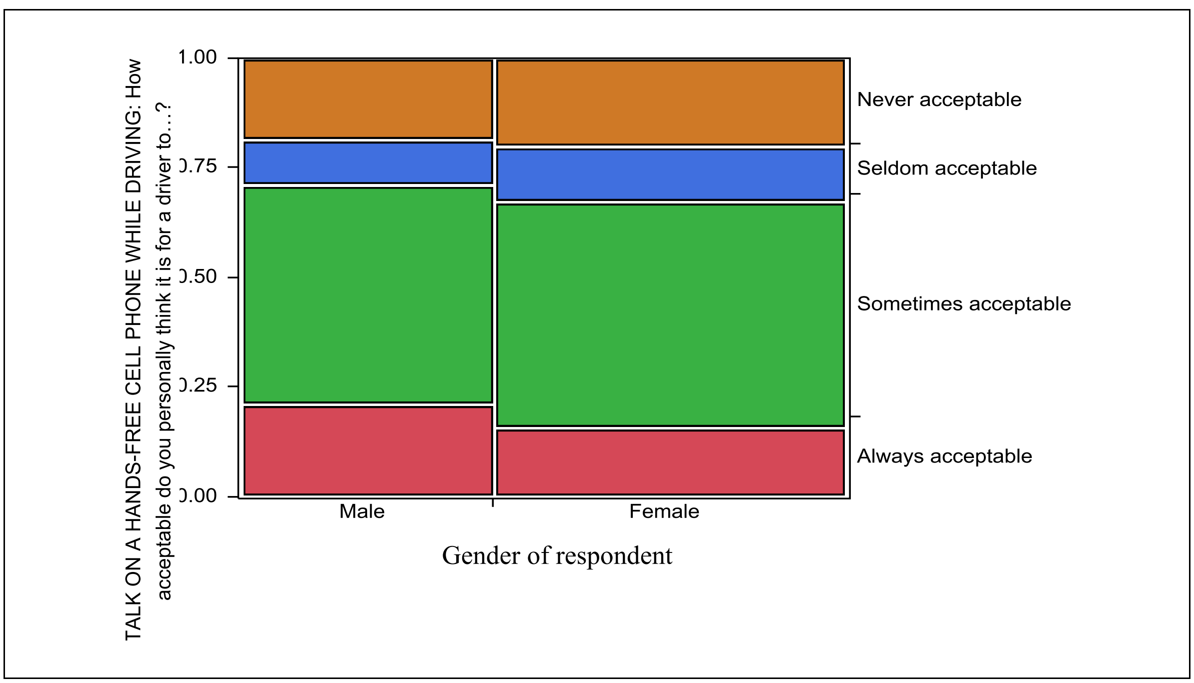


Figure 3-10: Acceptability of talk on a hands-free cell phone while driving by gender

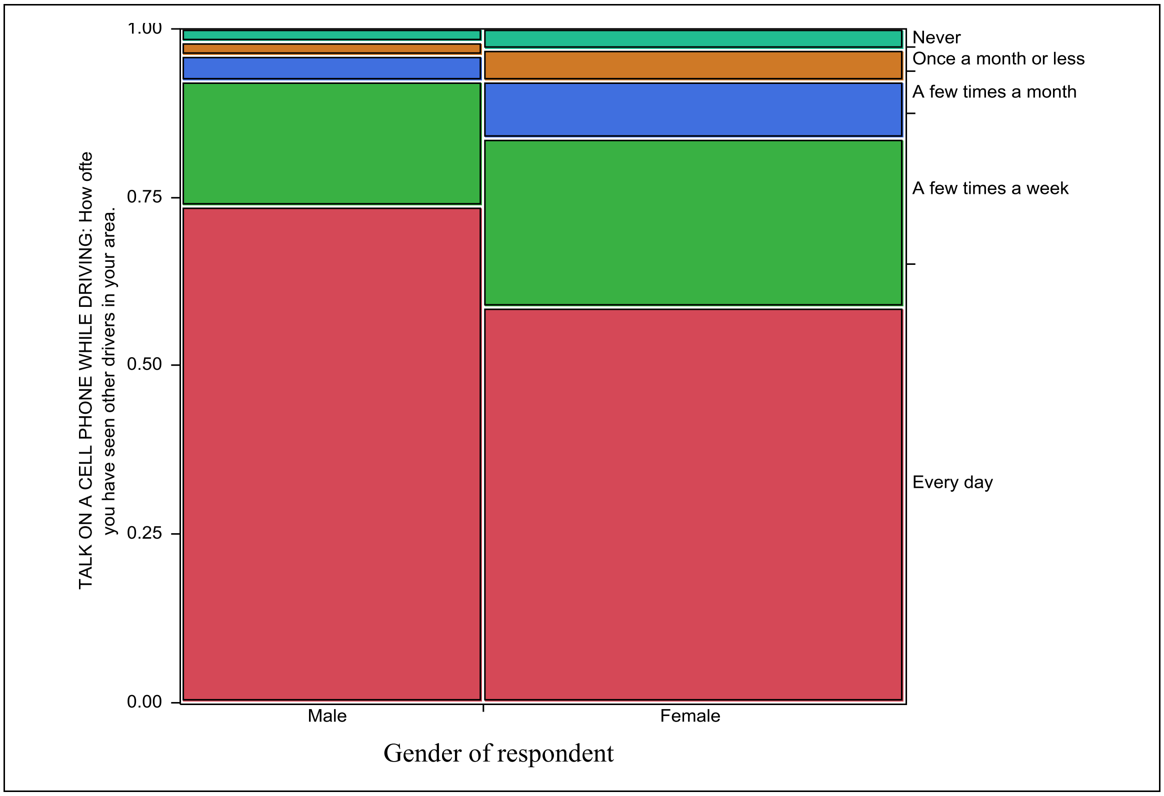


Figure 3-11: Observations on talk on a cell phone while driving for other drivers by gender

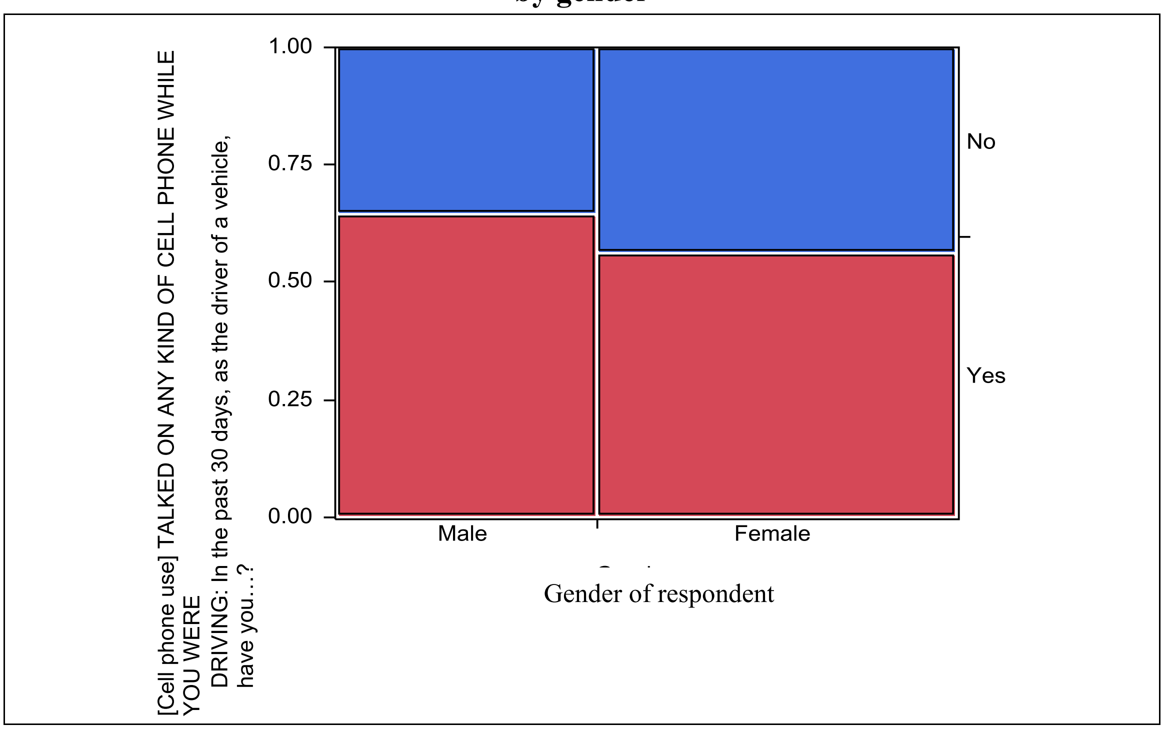
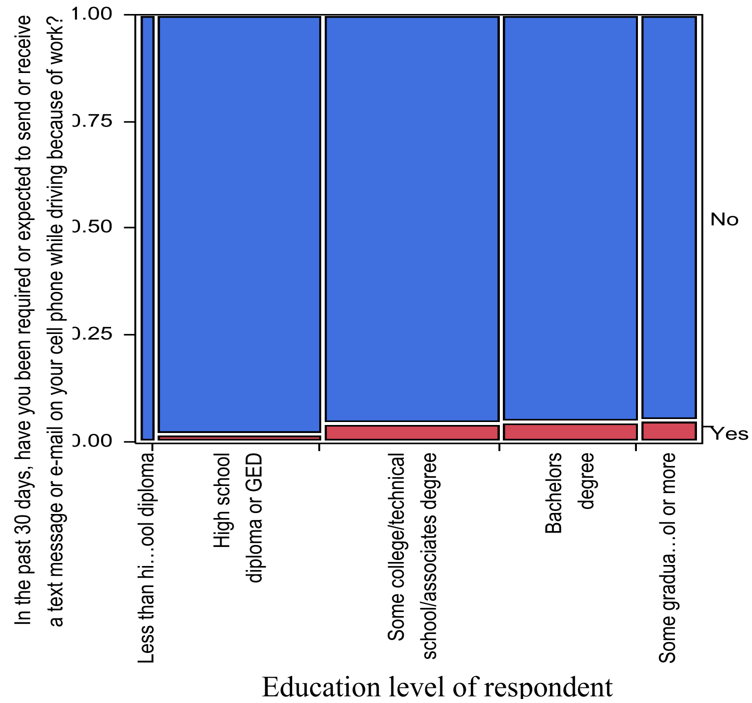


Figure 3-12: Self-reported behavior of talked on any kind of cell phone while driving by gender

3.3.3 Other factors that affect the responses

Other factors were also included in specific questions. Figure 3-13 represents the relationship between education level of participants and their responses on cell phone usage while driving that was required by work. The participants with higher education level had higher probability of being required to use cell phone while driving. Similarly, the respondents with higher household income reported higher chance of being required to use cell phone while driving because of work as well.



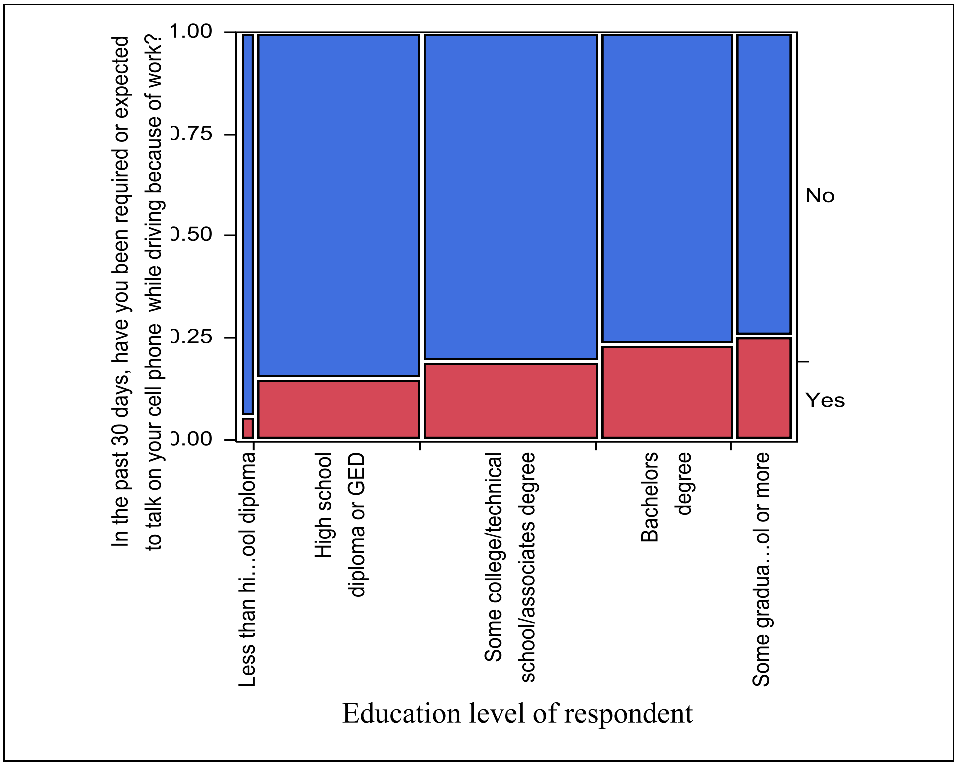
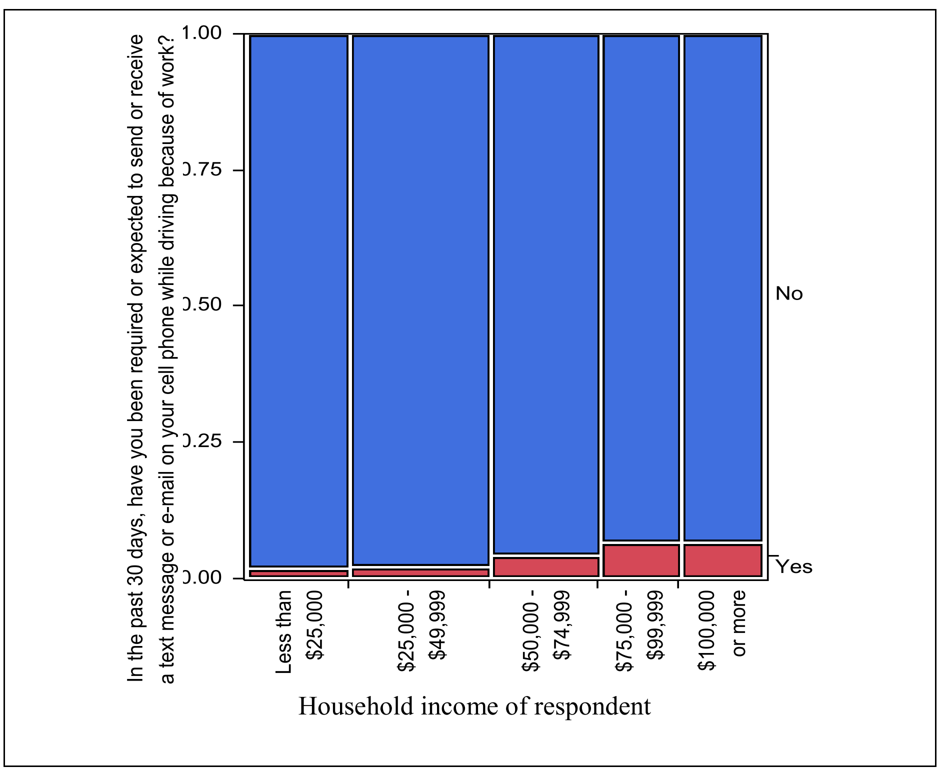


Figure 3-13: Self-reported behaviors of using cell phone use while driving that required by work for different household income levels



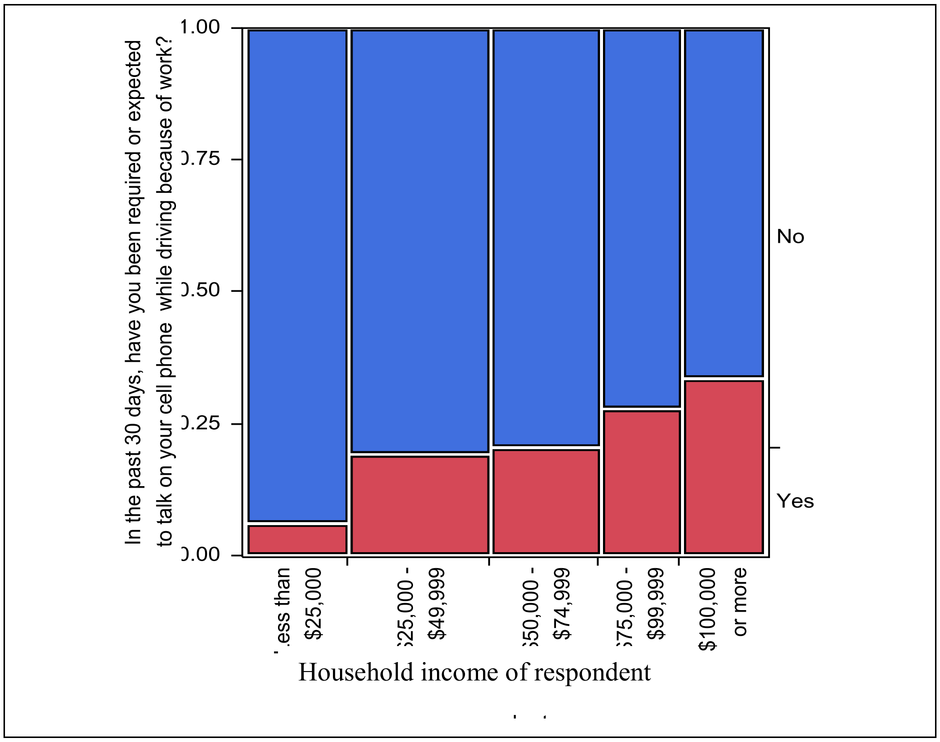


Figure 3-14: Self-reported behaviors of cell phone use while driving that required by work for different household income levels

3.4 Summary

The first part of this chapter briefly summarized the survey design and the survey responses gathered will respect to ten traffic safety related-goals. Overall, it was shown that adult Iowans are conscious about traffic safety and safe driving. However, safety concerns were raised for some specific areas, such as motorcycle operation, younger and older drivers.

The descriptive analysis of the survey showed that age, gender, education level, and household incomes affect the driving attitudes and behaviors in Iowa. Younger and males drivers were emphatically to be considered as latent distracted drivers in Iowa. This summary would facilitate to give the direction of the data analysis in next chapter.

In order to develop a comprehensive statistical model to explore the potential characteristics that may influence the driving behavior and attitudes, more information of participants will be used in developing the statistical model. The information would include such as socioeconomic status, demographics, basic knowledge on traffic safety, and current driving behavior and attitudes.

In next chapter, the development of statistical models will be discussed. The final results of the models will determine the contributing factors that form the current culture of distracted driving in Iowa.

CHAPTER 4. METHODOLOGY

4.1 Overview

This chapter presents the methodology used to investigate Iowa's present culture in distracted driving. In order to define the potential differences in attitudes, experiences, and behavior among adult Iowans with different socioeconomic and demographic characteristics, the Structural Equation Modeling (SEM) was selected as the most appropriate method for the analysis. This chapter presents an overview of the fundamentals of the modeling techniques as well as discusses previous transportation-related applications of this method.

4.2 Structural Equation Modeling (SEM)

SEM is a complex simulation model that has been widely used in social science. The modern SEM has developed over a century period and has greatly benefited by the application of advancing computer technology.

4.2.1 Brief history of SEM

According to Bollen (1989), SEM was founded on three primary analytical developments: (1) path analysis, (2) latent variable modeling, and (3) general covariance estimation methods. In 1934, a geneticist named Sewall Wright developed the basic path analysis that estimated the relationship among variables based on correlation matrix of observed variables. This method was later introduced to many different social disciplines such as sociology, economics, and psychology as well. Charles Spearman, a psychologist, developed the exploratory factor analysis which is considered as another important origin part for Structural Equation Modeling (SEM). In the discipline of economics, a simultaneous equation modeling was introduced by Haavelmo (1943) and Koopmans (1945). In the 1970s, the first generation of SEM was finally formed by interdisciplinary integration, and this great movement was generalized by Jöreskog (1970), Keesling (1972), and Wiley (1973). Another important development in SEM was the application of Maximum Likelihood Estimation (MLE) method for estimating the parameter coefficients and allowed testing of individual direct effects and error-term correlations (Matsueda, 2012; Kline, 2011; Golob, 2001). According to Matsueda (2012), the development in SEM progressed through four stages:

(1) early disciplinary specific developments of path analysis from genetics and later sociology, factor analysis from psychology, and simultaneous-equation models in economics;

(2) cross-disciplinary fertilization between economics, sociology, and psychology leading to an explosion of empirical applications of SEM;

(3) a period of developing methods for handling discrete, ordinal, and limited dependent variables; and

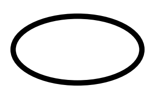
(4) a recent period of incorporating statistical advances into the SEM framework, including generalized linear models, mixed effects models, mixture regression models, Bayesian methods, graphical models, and methods for identifying causal effects.

4.2.2 Fundamental Theories in Structural Equation Modeling (SEM)

Structural equation modeling is a comprehensive statistical technique to examine a set of relationships between one or more independent variables and dependent variables, and these variables can be either continuous or discrete. Moreover, SEM is broadly used for assessing the quantitative relationships among underlying latent variables, which cannot be observed directly from the data. Two of the well-known analysis methods, path analysis and confirmatory factor analysis are simply special type of structural equation modeling (Tabachnick & Fidell, 1996). In other words, SEM is an extension of general linear modeling (GLM), such as analysis of variance (ANOVA) and multiple regression analysis (Lei & Wu, 2007).

4.2.2.1 Model Specification

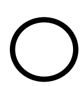
Generally, SEM includes two components, a measurement model and a structural model. The measurement model is constructed to analyze how various known variables (exogenous variables) measure latent variables, moreover, measurement model incorporate estimates of measurement errors of exogenous variables load on latent variables. The structural model examines the relationship between latent variables and it enables SEM to measure the underlying relationship or phenomenon which is distinguished from other methods. Another feature of SEM is the graphical representation through a path diagram, since this model allows for direct, indirect and associative relationships to be explicitly modeled (Washington, Karlaftis, & Mannering, 2011; Tabachnick & Fidell, 1996):

Latent variables: 

Observed variables: 

Hypothesized predictive relationship (regression): 

Association/correlation (covariance): 

Error/residual 

A sample graph of structural equation modeling is presented in Figure 4-1.

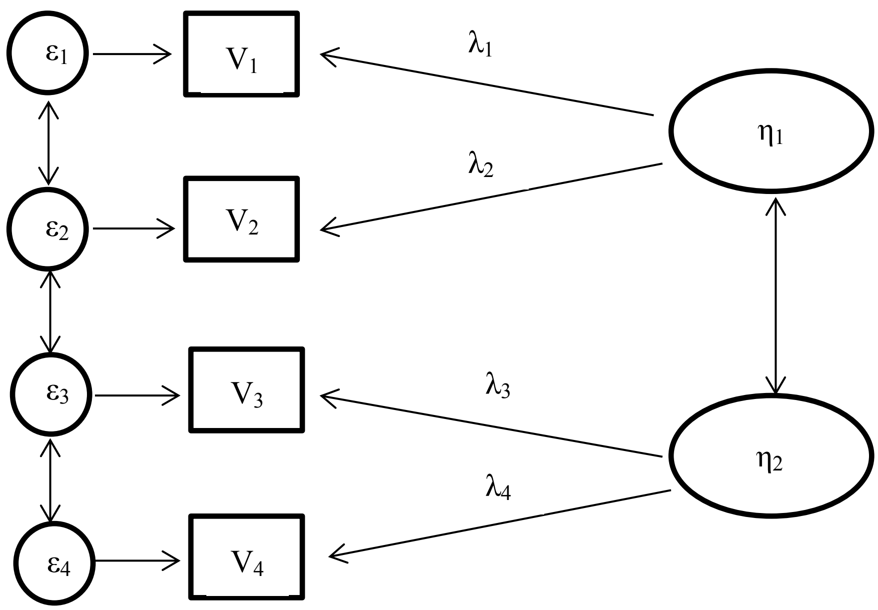


Figure 4-1: A example path diagram of SEM

For the underlying fundamental theory of SEM, one well-known method of model specification is the Bentler-Weeks method (Bentler & Weeks, 1980). The basic structure of SEM is that the hypothesized model has a set of underlying parameters that correspond to (1) the regression coefficients, and (2) the variances and covariance of the independent variables in the model (Bentler P. M., 2006). As known, the regression equation can be expressed as:

$$\boldsymbol{y = \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \varepsilon}$$

where y is the dependent variables (DVs) and x and ε (error term) are both independent variables (IVs).

Expressing the simple regression model in matrix algebra (Bentler-Weeks model) yields:

$$\boldsymbol{\eta = \beta\eta + \gamma\xi + \varepsilon}$$

where, if q is the number of DVs and r is the number of IVs, the $\boldsymbol{\eta}$ is a $q \times 1$ vector of DVs, $\boldsymbol{\beta}$ is a $q \times q$ matrix of regression coefficients among DVs, $\boldsymbol{\gamma}$ is a $q \times r$ matrix of regression coefficients among DVs and IVs, and $\boldsymbol{\xi}$ is a $r \times 1$ vector of IVs, $\boldsymbol{\varepsilon}$ is a vector of regression error.

It can be observed that $\boldsymbol{\eta}$ is on both sides of the equation, this is because DVs are endogenous. After identifying the basic structure of SEM, estimating the parameters is the next step.

4.2.2.2 Model Estimation

Parameter estimation in SEM is achieved by comparing the actual covariance matrix representing the relationships between variables and the estimated covariance matrix of the best fitting model. In order to reach the final solution, a few iterations are needed to minimize a certain discrepancy or fit the function between observed covariance matrix and model implied covariance matrix. A most common method used to estimate the parameter in SEM is Maximum Likelihood Estimation method (MLE). It is assumed that observed variables are multivariate normally distributed (Lei & Wu, 2007). Besides MLE, generalized least squares (GLS), asymptotically distribution-free (ADF), un-weighted least squares (ULS) and Browne's method are other methods that can be considered for estimating the parameters (Raykov & Marcoulides, 2006). These methods will be not discussed in detail in this thesis. For the details of these estimation methods please refer to Kline 2011, Raykov and Marcoulides 2006, Tabachnick and Fidell 1996.

The variance-covariance matrix can be expressed as:

$$\Sigma(\boldsymbol{\theta}) = \boldsymbol{G}(\mathbf{1} - \boldsymbol{\beta})^{-\mathbf{1}}\boldsymbol{\gamma}\boldsymbol{\phi}\boldsymbol{\gamma}'(\mathbf{1} - \boldsymbol{\beta})^{-\mathbf{1}'}\boldsymbol{G}'$$

In this expression, **G** is the selection matrix to select the observed variables from all the dependent variables in $\boldsymbol{\eta}$. The exogenous (IVs) factor covariance matrix is represented as $\boldsymbol{\phi}$=COV [ε, ε^T].

After estimating the unknown parameters using maximum likelihood estimation method, the overall fit of the model should be evaluated.

4.2.2.3 Model Evaluation (Goodness- of-Fit)

In a bid to assess the goodness-of-fit (GOF) of the overall model, several indicators should be examined that are briefly introduced next (Lei & Wu, 2007; Washington, Karlaftis, & Mannering, 2011; Raykov & Marcoulides, 2006; Kline, 2011).

The first important parameter used to measure the fit of a model is chi-square (χ^2). It is evaluated with the degrees of freedom equal to the difference between the total number of degrees of freedom and the number of parameters estimated. In a Chi-square test, the small p-value indicates a good fit of the model, but this is very common in the most studies. One drawback of using chi-square as a GOF measure is its sensitivity to sample size. As a rule of thumb, a quick way to adjust for sample size is to divide the chi-square by its degrees of freedom. If this value is less than or close to two, it indicates a very good fit of model. Values close to four are considered acceptable for a large sample size.

Two other common GOF measures are the "goodness of fit index (GFI)", which takes into account the sample size, and the "adjusted goodness of fit index (AGFI)", which additionally takes into account the number of parameters being estimated. The range for these two parameters is from zero to one; an estimated value close to 1.0 indicates a better fit.

Moreover, two of the widely used indices are the standardized root mean square residual (SRMR) and the root mean square error of approximation (RMSEA). For both of these two indices, a value close to zero (below or close to 0.05 or 0.06) is indicative that the model fits the data well.

Besides the indices introduced above, there are other indices that can be used to measure the overall fit of the models. These include the incremental fit indices (IFI) such as normal fit index (NFI), Tucker-Lewis Index (TLI), comparative fit index (CFI), and other; a higher IFI indicate large improvement in fit over the baseline model.

In summary, there are plenty of indices or parameters that can be used to measure the overall fit of SEM. Constructing the better fit model is always considered as one of the most important goals in model development. Also, it is a key factor for determining the accuracy of model selection.

4.3 Previous Studies Using Structural Equation Modeling

As discussed in previous sections, SEM has been mostly used in social sciences such as psychology, economics, and behavior studies. Within transportation engineering, SEM methods are getting more popular in the studies of assessing driving behavior or attitudes and how these factors would affect traffic safety. In this section, previous transportation-related studies will be summarized.

4.3.1 Case study I (Golob & Hensher, 1994)

In 1994, a study conducted in Australia aimed to examine the driving behavior of long distance truck drivers, and mainly focused on the effects of schedule compliance on drug use and speeding citations. The study used a total of 402 in-depth face to face interviews of long distance truck drivers throughout Australia. The data included many aspects of previous driving experience, driver's background, economic reward for each trip, and also other trip information. The SEM was developed and used to test the hypothesis established in this study. In order to estimate the parameters for mixed continuous and dichotomous variables (non-normal), a different method rather than maximum likelihood estimation was used in this study, the asymptotically distribution-free (ADF) weighted least squares (WLS).

The main finding of this study is that increasing speed was positively influenced by the propensity to take stay-awake pills which itself positively related to the propensity to self-impose schedules. In the other hand, financial rewards had significant impacts on self-imposed arrival time, pill taking on some or every trips, and number of speeding fines per year.

This study provided evidence of what the contribution factors leading poor performance of long distance truck drivers in Australia were. In addition, this study was an excellent example for analyzing non-normal types of data by using SEM.

4.3.2 Case study II (Silva, Morency, & Goulias, 2012)

This study used data from the 2003 large scale Origin-Destination travel survey (OD) conducted in the Greater Montreal Area, Canada to address the relationship between travel behavior and land use patterns. The final sample included 7,277 observations and the SEM was proposed to analyze the relationships among socioeconomic characteristics, land use patterns, relative residential and employment locations, car ownership and travel behavior.

The SEM results estimated showed a very good fit and proved that land use variables and travel behaviors were endogenous. Also, people with different socioeconomic characteristics tended to work and live in places in substantially different urban areas. The conclusions of this study provided strong evidence in support of using land use policies as tools to change travel behavior.

In this study, SEM was used for measuring direct effects between exogenous variables and endogenous variables, and helped with exploring the relationship among latent variables: socioeconomic characteristics, land patterns and travel behavior.

4.3.3 Case study III (Donovan, 1993)

Recognizing the broad use of SEM for determining the relationships between driving behavior and social psychology, the University of Colorado conducted a study about drinking-driving activities among young adults (aged 18 to 25).

The data used in this study involved 2,300 questionnaires survey responses. The latent variable of driving behavior was measured by drinking-driving frequency, drug-driving frequency, and risky driving behavior like speeding, passing violations and so on. Problem behavior was assessed by problem drinking, marijuana use, other illicit drug use and delinquent-type behaviors. The last latent variable of psychosocial was measured by psychosocial unconventionality, risky-taking and hostility/aggression activities.

The SEM results indicated that drinking-driving in young adulthood is related to other driving behaviors. Young adults who more frequently drove after drinking also tended to drive after using marijuana and other illicit drug, and tend to violate the traffic law as well. Moreover, drinking and driving was related to individual differences in psychosocial characteristics. Young adults showed higher level of personality and social unconventionality, enjoyed taking more risks and were somewhat more hostile and aggressive and had higher frequencies involved in drinking and driving.

This study helped examined the relationship between drinking-driving, drug-driving and risky driving for young adults. The correlation of psychosocial variables and drinking driving was also determined. Both relationships provided the evidence that drinking-driving is a lifestyle of problem behavior of young adulthood. Changing drinking driving behavior is not merely focusing on this single behavior, but should be giving more attention on the overall problem lifestyle and social psychological among young adults.

4.4 Summary

The major objective of this chapter was to establish a good understanding of SEM by exploring the history, basic theory, and past applications of structural equation modeling (SEM).

In the next chapter, the SEM method will applied to the data collected from the 2011 Iowa traffic safety culture public survey to determine the relationship between distracted driving attitudes, experiences and behaviors of Iowans with different socioeconomic and demographic characteristics.

CHAPTER 5. ESTIMATION RESULTS AND DISCUSSION

5.1 Overview

This chapter presents the results of the Structural Equation Model (SEM) that was developed for investigating the factors shaping the culture of distracted driving in Iowa. The descriptive statistics of the variables, the model construction, and the results yielded from structural equation modeling are discussed next.

5.2 Variable Descriptive Statistics

In the model construction, four latent variables were established, which are distractibility (DB), self-reported distracted driving behavior (SDDB), personal acceptability for distracted driving (PADD), and prediction of possible accident (PPA) caused by distraction. The variables used in constructing the measurement model and its descriptive statistics are presented in Table 5-1 and are categorized into the four latent variables considered in the analysis. In addition, the summary statistics of socioeconomic and demographic-related variables are presented in Table 5-2. The correlation matrix showing the correlation among all the variables used in the analysis is presented in Table 5-3. The highlighted cells indicate moderate correlation among the two corresponding variables.

Table 5-1: Summary statistics of participants' responses to the distracted driving-related questions (weighted)

Variables Mnemonic	Variable Description	Response Frequency	Min/Max	Cases (missing)
DB	**Distractibility of Responders (latent variable)**			
Q24a	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: to have the radio on or music playing [1: not at all, 2:somewhat, 3: very]	1:78.7% 2:20.1% 3:1.2%	1/3	1078 (10)

Table 5-1 (continued)

Variables Mnemonic	Variable Description	Response Frequency	Min/Max	Cases (missing)
Q24b	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To have passengers in your car having conversations or interacting [1: not at all, 2:somewhat, 3: very]	1:55.2% 2:42.7% 3:2.1%	1/3	1082 (6)
Q24c	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To have children sitting in the backseat [1: not at all, 2:somewhat, 3: very]	1:43.4% 2:48.6% 3:7.9%	1/3	1039 (49)
Q24d	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To drive through an area with a lot of commercial signage such as billboards [1: not at all, 2:somewhat, 3: very]	1:43.3% 2:44.1% 3:12.7%	1/3	1074 (14)
Q24e	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To use a GPS device while driving [1: not at all, 2:somewhat, 3: very]	1:39.3% 2:49.9% 3:10.8%	1/3	890 (198)
Q24f	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To make or receive cell phone calls [1: not at all, 2:somewhat, 3: very]	1:11.8% 2:52.7% 3:35.5%	1/3	1041 (47)
Q24g	Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to: To send or read text messages or e-mails [1: not at all, 2:somewhat, 3: very]	1:3.7% 2:11.9% 3:84.3%	1/3	994 (94)
SDDB	**Self-Reported Distracted Driving Behavior (latent variable)**			
Q21p	In the past 30 days, as the driver of a vehicle, have you: Talked on any kind of cell phone while you were driving [1:no, 2:yes]	1: 33.2% 2: 66.8%	1/2	1042 (46)
Q21q	In the past 30 days, as the driver of a vehicle, have you: Read or sent a text message or email while you were driving [1:no, 2:yes]	1: 80.9% 2: 19.1%	1/2	1042 (46)
Q25	In the past 30 days, have you been required or expected to talk on your cell phone while driving because of work? [1:no, 2:yes]	1: 77.5% 2: 22.5%	1/2	1083 (5)
Q26	In the past 30 days, have you been required or expected to send or receive a text message or e-mail on your cell phone while driving because of work? [1:no, 2:yes]	1: 95.0% 2: 5.0%	1/2	1083 (5)

Table 5-1 (continued)

Variables Mnemonic	Variable Description	Response Frequency	Min/Max	Cases (missing)
PADD	**Personal Acceptability for Distracted Driving (latent variable)**			
Q19d	How acceptable do you personally think it is for a driver to: send text messages or emails while driving [1:never, 2: seldom, 3: sometimes, 4:always]	1:88.4% 2:5.7% 3:4.6% 4:1.4%	1/4	1087 (1)
Q19h	How acceptable do you personally think it is for a driver to: talk on a handheld cell phone while driving [1:never, 2: seldom, 3: sometimes, 4:always]	1:45.6% 2:15.4% 3:35.8% 4:3.2%	1/4	1084 (4)
Q19i	How acceptable do you personally think it is for a driver to: talk on a hands-free cell phone while driving [1: never, 2: seldom, 3: sometimes, 4: always]	1:17.5% 2:10.5% 3:52.2% 4: 19.9%	1/4	1077 (11)
PPA	**Prediction of Possible Accidents caused by Distraction (latent variable)**			
Q30d	Whether you strongly agree, agree, disagree, or strongly disagree with each of the following statements: driving while talking on a cell phone increases the chance you might have an accident. [1: strongly disagree, 2:disagree, 3:agree, 4:strongly agree]	1:1.1% 2:8.5% 3:71.6% 4:18.8%	1/4	1081 (7)
Q30e	Whether you strongly agree, agree, disagree, or strongly disagree with each of the following statements: driving while eating or drinking increases the chance you might have an accident. [1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree]	1:0.2% 2:11.4% 3:77.5% 4:10.9%	1/4	1084 (4)

Table 5-2: Summary statistics of socioeconomic and demographic variables (weighted)

Variable Mnemonic	Variable Description	Response Frequency (Std.Dev.)	Min/Max	Cases (missing)
GENDER	The gender of the participants [1:male, 2:female]	1:48.2% 2:51.8%	1/2	1088 (0)
AGE	Current age of the participants [range 18-96]	N/A	18/95	1080 (8)
EDU (EDUCATION)	The highest level of education that the participants have completed [1: some high school, 2: high school graduate, 3: some college or technical school, 4: college graduate with BA/BS, etc., 5: graduated degree completed, MA, MS, MFA PhD,etc.]	1:11.5% 2:33.5% 3:31.7% 4:16.7% 5:6.5%	1/5	1086 (2)
INCOME	Annual household income from all sources [1: less than $25K, 2:$25K to less than $50K, 3: $50K to less than $75K, 4:$75K to less than $100K, 5:$100K or more]	1:20.4% 2:26.9% 3:22.8% 4:15.6% 5:14.3%	1/5	967 (121)

Table 5-3: Correlation matrix for measured variables

	Q24a	Q24b	Q24c	Q24d	Q24e	Q24f	Q24g	Q21p	Q21q	Q25
Q24a	1.0000	0.2963	0.1881	0.1911	0.1633	0.2114	0.0759	0.0618	0.0232	0.0474
Q24b	0.2963	1.0000	0.3516	0.2678	0.1890	0.2312	0.1615	0.0852	0.0243	0.0221
Q24c	0.1881	0.3516	1.0000	0.1805	0.1495	0.1024	0.1387	-0.0706	-0.0703	-0.0825
Q24d	0.1911	0.2678	0.1805	1.0000	0.2144	0.1581	0.1160	0.0423	0.0080	-0.0203
Q24e	0.1633	0.1890	0.1495	0.2144	1.0000	0.1641	0.1717	0.0335	0.0182	0.0040
Q24f	0.2114	0.2312	0.1024	0.1581	0.1641	1.0000	0.3289	0.4086	0.1497	0.2004
Q24g	0.0759	0.1615	0.1387	0.1160	0.1717	0.3289	1.0000	0.0528	0.2021	0.0437
Q21p	0.0618	0.0852	-0.0706	0.0423	0.0335	0.4086	0.0528	1.0000	0.2941	0.3350
Q21q	0.0232	0.0243	-0.0703	0.0080	0.0182	0.1497	0.2021	0.2941	1.0000	0.2355
Q25	0.0474	0.0221	-0.0825	-0.0203	0.0040	0.2004	0.0437	0.3350	0.2355	1.0000
Q26	-0.0223	0.0239	-0.0426	0.0216	0.0206	0.0795	0.1132	0.1337	0.3542	0.3756
Q19d	0.0169	-0.0154	0.0492	-0.0652	-0.0048	-0.1876	-0.2161	-0.1461	-0.3146	-0.1212
Q19h	-0.1179	-0.1065	0.0246	-0.0722	-0.0847	-0.4456	-0.1397	-0.4598	-0.2666	-0.2154
Q19i	-0.1482	-0.0959	0.0568	-0.0677	-0.0864	-0.3357	-0.0639	-0.3895	-0.1902	-0.1843
Q30d	0.0701	0.0709	0.0557	0.0913	0.0904	0.3790	0.1213	0.2841	0.1407	0.1316
Q30e	0.1239	0.1045	0.0659	0.1324	0.1002	0.2350	0.0334	0.1656	0.0632	0.0692
GENDER	0.0037	0.0437	0.0696	-0.0305	0.0053	0.0673	0.0653	0.0846	0.1033	0.2270
AGE	0.0630	0.0595	-0.0698	0.0192	0.0157	0.2556	0.0921	0.4582	0.3849	0.2136
EDUCATION	-0.0659	-0.0453	0.0591	-0.0310	0.0030	-0.0687	0.0471	-0.1805	-0.0406	-0.1057
INCOME	-0.0766	-0.0966	-0.0154	-0.0492	-0.0198	-0.1718	-0.0054	-0.3231	-0.1317	-0.2081

Table 5-3 (continued)

	Q26	Q19d	Q19h	Q19i	Q30d	Q30e	GENDER	AGE	EDUCATION	INCOME
Q24a	-0.0223	0.0169	-0.1179	-0.1482	0.0701	0.1239	0.0037	0.0630	-0.0659	-0.0766
Q24b	0.0239	-0.0154	-0.1065	-0.0959	0.0709	0.1045	0.0437	0.0595	-0.0453	-0.0966
Q24c	-0.0426	0.0492	0.0246	0.0568	0.0557	0.0659	0.0696	-0.0698	0.0591	-0.0154
Q24d	0.0216	-0.0652	-0.0722	-0.0677	0.0913	0.1324	-0.0305	0.0192	-0.0310	-0.0492
Q24e	0.0206	-0.0048	-0.0847	-0.0864	0.0904	0.1002	0.0053	0.0157	0.0030	-0.0198
Q24f	0.0795	-0.1876	-0.4456	-0.3357	0.3790	0.2350	0.0673	0.2556	-0.0687	-0.1718
Q24g	0.1132	-0.2161	-0.1397	-0.0639	0.1213	0.0334	0.0653	0.0921	0.0471	-0.0054
Q21p	0.1337	-0.1461	-0.4598	-0.3895	0.2841	0.1656	0.0846	0.4582	-0.1805	-0.3231
Q21q	0.3542	-0.3146	-0.2666	-0.1902	0.1407	0.0632	0.1033	0.3849	-0.0406	-0.1317
Q25	0.3756	-0.1212	-0.2154	-0.1843	0.1316	0.0692	0.2270	0.2136	-0.1057	-0.2081
Q26	1.0000	-0.1842	-0.1340	-0.0992	0.0562	0.0268	0.0519	0.1841	-0.0721	-0.0934
Q19d	-0.1842	1.0000	0.1888	0.1668	-0.0709	-0.0142	-0.0694	-0.1838	-0.0346	-0.0106
Q19h	-0.1340	0.1888	1.0000	0.4954	-0.2948	-0.1868	-0.0262	-0.3190	0.1369	0.1999
Q19i	-0.0992	0.1668	0.4954	1.0000	-0.2013	-0.1481	-0.0555	-0.3384	0.1297	0.2142
Q30d	0.0562	-0.0709	-0.2948	-0.2013	1.0000	0.3878	0.0040	0.1096	-0.0283	-0.0673
Q30e	0.0268	-0.0142	-0.1868	-0.1481	0.3878	1.0000	-0.0574	0.1237	-0.0488	-0.0309
GENDER	0.0519	-0.0694	-0.0262	-0.0555	0.0040	-0.0574	1.0000	0.1088	-0.0236	-0.1697
AGE	0.1841	-0.1838	-0.3190	-0.3384	0.1096	0.1237	0.1088	1.0000	-0.1507	-0.2072
EDUCATION	-0.0721	-0.0346	0.1369	0.1297	-0.0283	-0.0488	-0.0236	-0.1507	1.0000	0.3884
INCOME	-0.0934	-0.0106	0.1999	0.2142	-0.0673	-0.0309	-0.1697	-0.2072	0.3884	1.0000

5.3 Handling Missing Values

A total of 385 observations were missing from the dataset. According to the descriptive statistic, three variables had more than 5% of observations missing, which are Q24e (198 missing of 1,088), Q24g (94 missing of 1,088) and income (121 missing of 1,088). In a bid to examine whether the missing values would bias the results, the Box's M test was used to test the equality of covariance matrices between the two groups of datasets (with and without the missing data). The two groups of data were established by coding a dummy variable with value of 0 and 1: the cases without missing values on Q24e, Q24g and income were coded by 1; the cases with missing values on any of these three questions were coded by 0. The Box's M test examined if these two groups of data had same variance-covariance matrix.

H_0: Two groups of data had same variance-covariance matrix, $\Sigma_1 = \Sigma_2$;

H_1: Two groups of data had different variance-covariance matrix, $\Sigma_1 \neq \Sigma_2$.

The results of this test are presented in Table 5-4.

Table 5-4: Box's M test results

Box's M		395.429
F	Approx.	2.509
	df_1	153
	df_2	525051.666
	Sig.(p-value)	.000

The test concluded that the null hypothesis of equal population covariance-matrices ($p<0.05$) should be rejected. However, note that Box's M Test is very sensitive to violations of normality of the variables. Non-normal distribution of the variables can easily lead to a rejection of the null hypothesis by Box's M test. As such, this result cannot provide a definitive conclusion that the missing values would bias the model results in the analysis that will follow.

Imputation is considered as another effective strategy to deal with missing values. However, imputation could add bias to the estimation results.

Due to a lack of other evidence, the cases with missing values were deleted from the dataset. This will be discussed in Chapter 6 as a limitation of this study.

5.4 Model Construction and Results

In this section, the construction of the model will be illustrated via a hypothetical path diagram. The major hypotheses will be stated prior to the analysis, and the results will be discussed based on these hypotheses.

5.4.1 Model 1

A total of 16 distracted driving-related questions were used for constructing the model. For the detailed description of the questions please refer to Table 5-1. Five major hypotheses were made among the four latent variables as discussed next. The relationships between individual socioeconomic and demographic characteristics and their distracted driving-related attitudes, behaviors and experiences were also determined in this study.

The five major hypotheses among the latent variables are:

Hypothesis η_1: higher personal distractibility would decrease the chance of people engaging in distracting activities while driving (DB→SDDB).

Hypothesis η_2: higher personal distractibility leads to lower acceptability of driving with distraction (DB→PADD)

Hypothesis η_3: higher personal distractibility leads to higher agreement on possible accidents caused by distracted driving (DB→PPA)

Hypothesis η_4: lower indicated self-distraction while driving behavior leads to lower acceptability of distracted driving (SDDB→PADD).

Hypothesis η_5: lower acceptability of distracted driving leads to higher agreement on possible accidents caused by distracted driving (PADD→PPA).

Figure 5-1 illustrates the hypothetical path diagram for the analysis based on the above hypotheses. The estimation results would provide either practical supports or rejections on the hypotheses. Two types of relationships are indicated by arrows with different colors and directions. The blue arrows are pointed from latent variables to measured responses of distracted driving-related questions. The measured variables (responses to the questions) were considered as indicator variables for latent variables. The five arrows in red indicate relationships between the four endogenous (latent) variables that need to be examined.

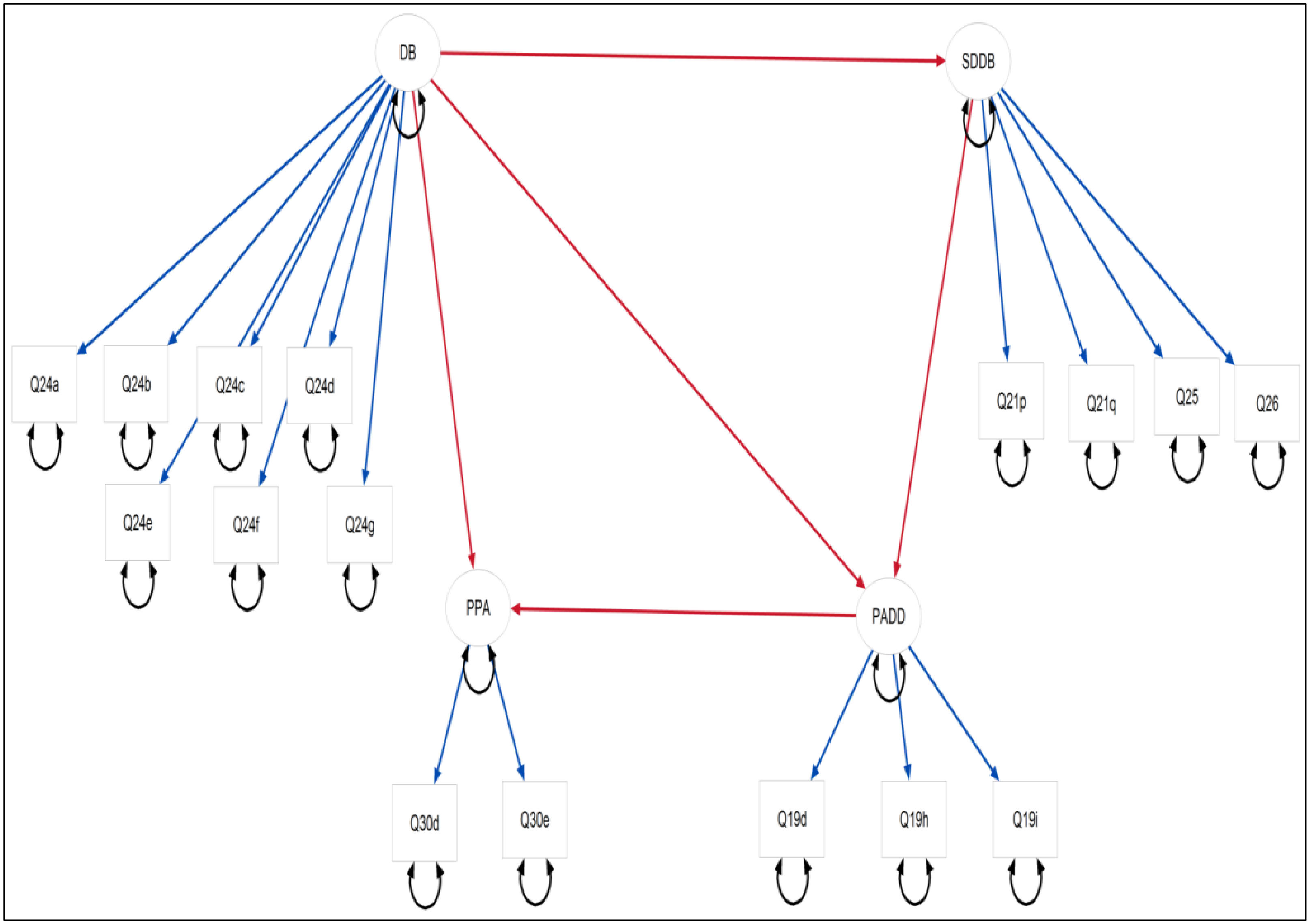


Figure 5-1: Hypothetical path diagram for model 1

The current section presents the estimated coefficients for hypothetical paths. Table 5-5 presents the standardized estimated coefficients for blue and red hypothetical path along with t-statistic, standard error and estimated p-value. Furthermore, the overall information of the model's goodness of fit is presented in Table 5-6. The discussions of the results is provided after each table.

Table 5-5: Estimation model 1 results

Hypothetic Path	Path Coefficient	Standard Error	t-statistic	*p*-value
Distractibility of Responders (DB)				
Q24a←DB	0.289	0.038	7.507	<0.0001*
Q24b←DB	0.355	0.037	9.533	<0.0001*
Q24c←DB	0.158	0.040	3.908	<0.0001*
Q24d←DB	0.281	0.038	7.282	<0.0001*
Q24e←DB	0.240	0.039	6.104	<0.0001*
Q24f←DB	0.802	0.030	26.506	<0.0001*
Q24g←DB	0.400	0.036	11.055	<0.0001*
Self-Reported Distracted Driving Behavior (SDDB)				
Q21p←SDDB	0.702	0.032	21.769	<0.0001*
Q21q←SDDB	0.473	0.036	13.201	<0.0001*
Q25←SDDB	0.451	0.036	12.387	<0.0001*
Q26←SDDB	0.321	0.039	8.188	<0.0001*
Personal Acceptability for Distracted Driving (PADD)				
Q19d←PADD	0.296	0.038	7.816	<0.0001*
Q19h←PADD	0.786	0.027	29.411	<0.0001*
Q19i←PADD	0.631	0.029	21.919	<0.0001*
Prediction of Possible Accidents caused by Distraction (PPA)				
Q30d←PPA	0.743	0.048	15.353	<0.0001*
Q30e←PPA	0.507	0.041	12.380	<0.0001*
Coefficients Among Endogenous (latent) Variables				
PADD←DB	-0.339	0.062	-5.485	<0.0001*
PADD←SDDB	0.565	0.062	9.179	<0.0001*
PPA←DB	0.434	0.082	5.308	<0.0001*
PPA←PADD	-0.208	0.081	-2.567	<0.01**
SDDB←DB	-0.562	0.046	-12.177	<0.0001*

** Variables are statistically significant at a 99.99% confidence level (α=0.0001)*

*** Variables are statistically significant at a 99% confidence level (α=0.01)*

The indicator variables for distractibility (DB), self-reported distracted driving behavior (SDDB), personal acceptability of distracted driving (PADD) and prediction of possible accidents caused by distraction (PPA) all have positive path coefficient signs and are statistically significant at a 99.99% confidence level ($\alpha = 0.0001$) except the path between PADD and PPA which is significant at a 99% confidence level ($\alpha = 0.01$). The path coefficients presented the relationship between exogenous variables as well as the loading that contributed to construct the latent variables by measured variables. A positive path coefficient shows that an increase in the measured variable would increase the latent variable, while a negative path coefficient shows that an increase in the measured variable would decrease the latent variable.

1) Distractibility (DB)

A total of seven questions were used in constructing the latent variable *distractibility* (DB). The consistently positive path signs indicated that the latent variable DB was constructed following the response sequence of measured variables (from not at all distracting to very distracting). For instance, the positive relationship between DB and question 24a indicated that people with higher distractibility would feel that having the radio on or music playing while driving is very distracting. Note that the stated responded on question 24c, asked about the driving experience with children sitting in the backseat, might not be truly capturing participants' experience as perhaps not all the participants who responded to this questions had children.

2) Self-reported distracted driving behavior (SDDB)

Four self-reported distracted driving behavior questions were used in constructing latent variable SDDB. In the same manner, the latent variable

SDDB has the same structure as the four measured variables used in constructing SDDB. For example, the positive sign between question 21p and SDDB shows that participants had higher chance to engage in distracted driving if they stated that they had talked on any kind of cell phone while driving in the past 30 days.

3) Personal acceptability of distracted driving (PADD)

   PADD was constructed by three measured indicators. PADD is ordered with responses from never accept to always accept for personal distracted driving. The positive relationship between PADD and other latent variables indicates that the driver would tend to always accept distracted driving.

4) Prediction of possible accidents caused by distraction (PPA)

   Prediction of possible accidents (PPA) led by distraction was constructed by two observed indicators. The ordered response was from strongly disagreeing to strongly agreeing, which also form the underlying construction of PPA. The positive relationship between PPA and other variables indicates that drivers tend to strongly agree that distracted driving would increase the chance of having an accident.

The estimated path coefficients showed that personal distractibility (DB) was negatively related to self-reported distracted driving behavior (SDDB), which indicates that the first hypothesis (η_1) is true: the driver with higher distractibility is not likely to accept distracted behavior while driving. In addition, the hypothesis η_2 has been proven true with negative path coefficient sign: higher personal distractibility (DB) leads to lower acceptability of distracted driving (PADD). In the same manner, a driver with higher personal distractibility (DB) is more likely to agree that distracted driving would more easily lead to accidents (PPA), so hypothesis η_3 turns out to be true in this study. Last two hypotheses (η_4 and η_5) examined the relationship between personal acceptability of distracted driving (PADD) and self-distracted driving behavior (SDDB) and predicted possible accidents for distracted driving (PPA). The path coefficient between PADD and SDDB is positive which shows that the assumptions made prior to the analysis were tested to be true. A driver who has lower acceptability of distracted driving would not drive with distractions. The negative path between PADD and PPA presented that with lower acceptability of distracted driving, it would increase the agreement on predicted possible accidents caused by distracted driving. All the hypotheses were tested to be true in this study. If present all the effects indicated in the path diagram by equations, it can be expressed as:

$$DB = -0.562(SDDB) + 0.434(PPA) - 0.339(PADD) + 0.289(\mathrm{Q24a}) + 0.355(\mathrm{Q24b}) + 0.158(\mathrm{Q24c}) + 0.281(\mathrm{Q24d}) + 0.240(\mathrm{Q24e}) + 0.802(\mathrm{Q24f}) + 0.400(\mathrm{Q24g}) + \mathrm{errors}$$

$$SDDB = -0.562(DB) + 0.565(PADD) + 0.702(\mathrm{Q21p}) + 0.473(\mathrm{Q21q}) + 0.451(\mathrm{Q25}) + 0.322(\mathrm{Q26}) + \mathrm{errors}$$

$$PPA = 0.434(DB) - 0.208(PADD) + 0.743(\mathrm{Q30d}) + 0.507(\mathrm{Q30e}) + \mathrm{errors}$$

$$PADD = -0.339(DB) - 0.208(PPA) + 0.565(\mathrm{SDDB}) + 0.296(\mathrm{Q19d}) + 0.786(\mathrm{Q19h}) + 0.631(\mathrm{Q19i}) + \mathrm{errors}$$

It can be observed that some paths had lower coefficients than others (such as DB→Q24c and DB →Q24e), which indicated that these measured variables had lower contribution to constructing the latent variables. It should be pointed out that the convergence (higher correlation) between some indicator variables affected the factor loadings. Since most of the latent variables were constructed by cell phone-related variables, the higher correlation between these variables led to higher path coefficients in the estimation results.

The overall information used to access the goodness of fit for the model is shown in Table 5-6. The GOF measures were defined in Chapter 4.

Table 5-6: Overall fit summary-model 1

Number of observations	783
Chi-Square	593.426
Degrees of Freedom (DOF)	95
Chi-Square/DOF	6.246
P > Chi-Square	<0.0001
Standardized RMSR (SRMSR)	0.0725
Adjusted GFI (AGFI)	0.858
Parsimonious GFI	0.713
Root Mean Square Error of Approximation (RMSEA) Estimate	0.081
Bentler Comparative Fit Index	0.748

In general, the model fit is good with such fairly large sample size and various non-significant paths. By adjusting the sample size, the value obtained by calculating the chi-square divided by the degrees of freedom was 6.25, which is higher than 2, but fairly close. In addition, the standardized RMSR (SRMSR) is 0.0725, which is close to 0.06. Moreover, the adjusted GFI (AGFI) is 0.8583 and considered close to 1.0 which indicated a good fit.

Based on the criteria used to assess the goodness of fit, it can be summarized that the model in this study fit quite close to the dataset and predicted the hypothesis very well. The results obtained in this study can sufficiently represent the current culture of distracted driving in Iowa.

5.4.2 Model 2

A second model was developed to examine the relationship among personal characteristics (gender, age, education and income) and latent variables (DB, SDDB, PADD, and PPA). Figure 5-2 shows the relationships that were examined in the second model. All the red and blue paths remained the same and another 16 paths (shown in black) from socioeconomic and demographic variables to the four latent variables were added. The estimation results are presented in Table 5-7, followed by a discussion of each significant path.

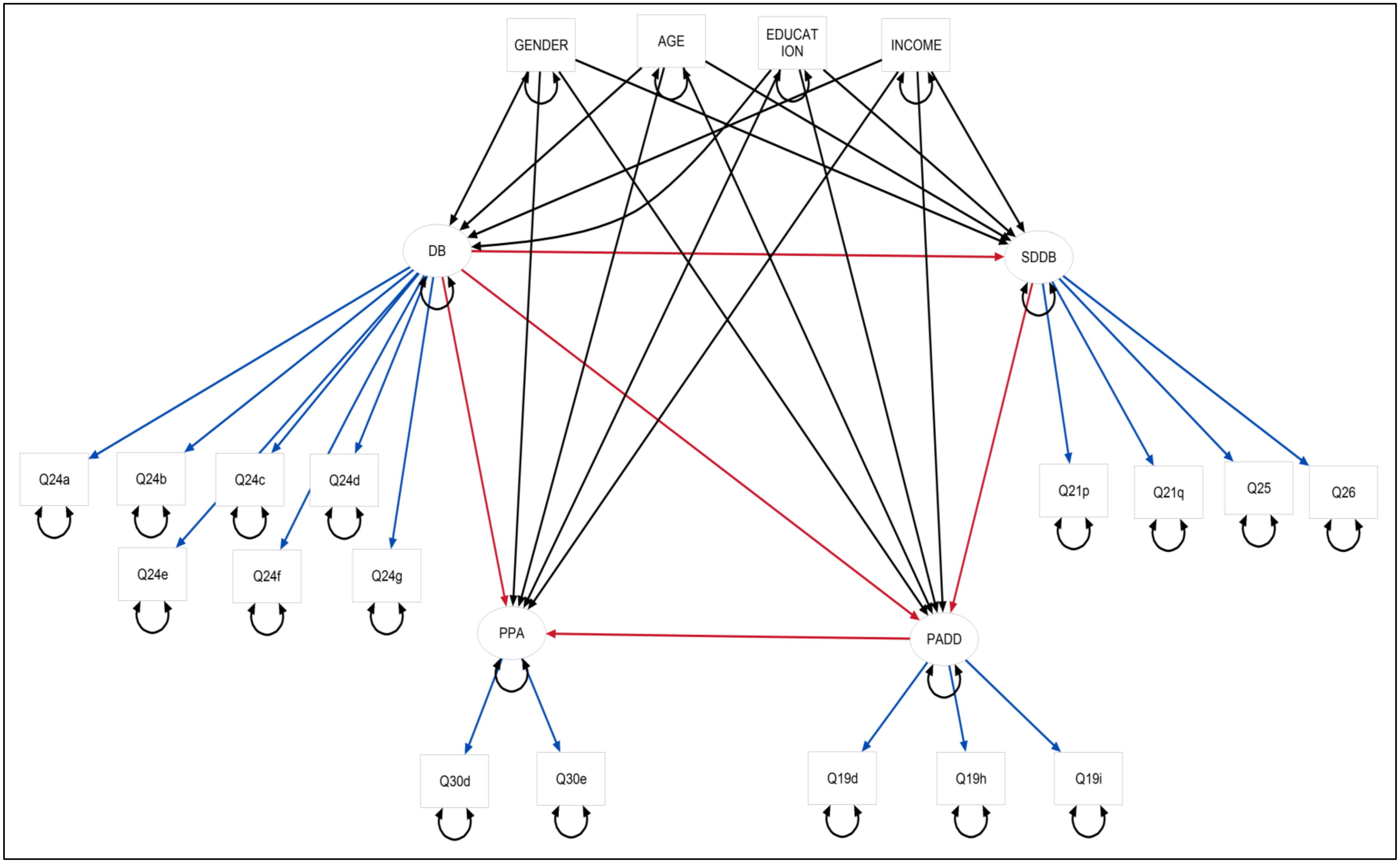


Figure 5-2: Hypothetical path diagram for model 2

Table 5-7: Path coefficients for socioeconomic and demographic variables

Hypothetic Path	Path Coefficient	Standard error	t-statistics	*p*-value
DB←GENDER	0.019	0.043	0.437	0.331
PADD←GENDER	0.0835	0.040	2.075	<0.025***
PPA←GENDER	-0.019	0.048	-0.425	0.335
SDDB←GENDER	-0.100	0.043	-2.513	<0.01**
DB←AGE	0.298	0.042	7.134	<0.0001*
PADD←AGE	-0.000	0.060	-0.007	0.497
PPA←AGE	-0.055	0.051	-1.070	0.142
SDDB←AGE	-0.408	0.042	-9.788	<0.0001*
DB←EDUCATION	-0.008	0.046	-0.187	0.426
PADD←EDUCATION	0.032	0.042	0.771	0.220
PPA←EDUCATION	0.019	0.048	0.405	0.343
SDDB←EDUCATION	0.051	0.043	1.207	0.114
DB←INCOME	-0.127	0.046	-2.730	<0.01**
PADD←INCOME	-0.066	0.048	-1.375	0.085
PPA←INCOME	0.083	0.049	1.701	0.045
SDDB←INCOME	0.211	0.044	4.847	<0.0001*

** Variables are statistically significant at a 99.99% confidence level (α=0.0001)*

*** Variables are statistically significant at a 99% confidence level (α=0.01)*

**** Variables are statistically significant at a 97.5% confidence level (α=0.025)*

The impacts of socioeconomic and demographic variables were not consistently significant in the model. According to the results shown in Table 5-7, three paths were statistically significant at a 99.99% confidence level (α = 0.0001); one paths was statistically significant at a 99% confidence level (α = 0.001); one path was statistically significant at a 97.5% confidence level (α = 0.025). The remaining ten hypothetical paths were not considered statistically significant in the study.

- **Gender (1: male, 2: female)**

  Two gender-related paths were significant. Female drivers seem to be more likely to accept distracted driving, and less likely to be driving under distraction. These results suggest that male drivers are more likely to be involved in distracted driving compared to female drivers.

- **Age (18-95 years old)**

  It was found that with an increase in age, drivers would more easily feel distracted while driving; in other words, older drivers have higher distractibility than younger drivers. In addition, the negative path coefficient between age and self-reported distracted driving behavior confirmed that young drivers are more likely to be involved in distracted driving. It can be concluded that younger drivers should be recognized as potential safety concern both in terms of attitudes and behavior.

- **Household Income (less than $25K –$100K and more)**

  Income was examined as an important structural factor of two latent variables. The results suggested that drivers of higher income have lower distractibility and are more likely to drive frequently with distractions compared to lower income drivers. The latter can be the reason why they have lower distractibility, as they are used to drive with distractions, they might no longer consider those activities distracting. This analysis shows that another socioeconomic group besides male and younger drivers is in higher risk of distracted driving.

- **Education (some high school - graduated degree completed)**

  In this study, the education level was not found to significantly contribute to any of the latent variables. This result seems to suggest that the personal education level does not directly affect the overall attitude and experience of distracted driving in Iowa. However, since education and income are typically correlated, the education level may have some indirect effects on distracted driving-related experience, attitudes and behavior.

It can be concluded that the socioeconomic and demographic status affect drivers' experiences, attitudes and behaviors of distracted driving. Similar to previous studies (Goodwin et al., 2012; Donovan, 1993; Hosking et al., 2009), younger drivers do not take distracted driving as serious as older drivers. Furthermore, this study provided evidence that male drivers and the drivers of higher household income could be considered more prone to distracted driving. Due to the correlation between education level and income, higher educated drivers could be engaged in distracted driving more frequently as well.

The overall model fit measures are presented in Table 5-8.

Table 5-8: Overall fit summary-model 2

Number of observations	703
Chi-Square	650.208
Degrees of Freedom	143
Chi-Square/DOF	4.547
P > Chi-Square	<0.0001
Standardized RMSR (SRMSR)	0.064
Adjusted GFI (AGFI)	0.860
Parsimonious GFI	0.681
Root Mean Square Error of Approximation (RMSEA) Estimate	0.071
Bentler Comparative Fit Index	0.776

Compared to the first model, the overall fit of this model is better. The chi-square value is larger, and the chi-square value over the degrees of freedom, decreased from 6.25 to 4.55. As stated in Chapter 4, with large sample size, a value close to four indicates an overall good fit of the model. Comparing to model 1, all the goodness of fit measurements indicate an overall better fit of this model.

5.4.3 Modified Model

Besides testing the hypotheses, another goal of this thesis is to identify the best model that can represent the culture of distracted driving in Iowa. To achieve this, model 2 was modified to include paths that are statistically significant at least at a 99% of confidence level. The resulting model is in Figure 5-3. Since variable EDUCATION was not eligible to be included in any paths, it was only connected to variable INCOME with a double pointed arrow showing that the correlation between education and income is considered in the model. Based on the modification indices provided in the model output, a newly added path (shown in green) was pointed from gender to Q25. This suggests that a strong relationship may exist between these two variables and in specific, that male drivers are more likely to use their cell phone while driving because of work. The path coefficients of the model are presented in Table 5-9 and the overall model fit summary is presented in Table 5-10.

Table 5-9: Estimation results of modified model

Hypothetic Path	Path Coefficient	Standard Error	t-statistic	*p*-value
Distractibility of Responders (DB)				
Q24a←DB	0.289	0.040	7.173	<0.0001*
Q24b←DB	0.362	0.039	9.362	<0.0001*
Q24c←DB	0.159	0.042	3.766	<0.0001*
Q24d←DB	0.285	0.040	7.074	<0.0001*
Q24e←DB	0.263	0.041	6.472	<0.0001*
Q24f←DB	0.811	0.030	26.908	<0.0001*
Q24g←DB	0.422	0.037	11.353	<0.0001*
Self-Reported Distracted Driving Behavior (SDDB)				
Q21p←SDDB	0.714	0.029	21.987	<0.0001*
Q21q←SDDB	0.499	0.034	14.378	<0.0001*
Q25←SDDB	0.408	0.037	11.106	<0.0001*
Q26←SDDB	0.299	0.040	7.487	<0.0001*
Personal Acceptability for Distracted Driving (PADD)				
Q19d←PADD	0.311	0.039	7.898	<0.0001*
Q19h←PADD	0.782	0.027	28.857	<0.0001*
Q19i←PADD	0.646	0.029	21.987	<0.0001*
Prediction of Possible Accidents caused by Distraction (PPA)				
Q30d←PPA	0.746	0.051	14.586	<0.0001*
Q30e←PPA	0.507	0.043	11.7317	<0.0001*

Table 5-9 (continued)

Coefficients Among Endogenous (latent) Variables				
PADD←DB	-0.348	0.063	-5.542	<0.0001*
PADD←SDDB	0.542	0.059	9.169	<0.0001*
PPA←DB	0.426	0.086	4.940	<0.0001*
PPA←PADD	-0.209	0.086	-2.441	<0.01**
SDDB←DB	-0.419	0.049	-8.606	<0.0001*
Path Coefficients for Socioeconomic and Demographic Variables				
DB←AGE	0.299	0.041	7.254	<0.0001*
DB←INCOME	-0.116	0.042	-2.737	<0.01**
SDDB←AGE	-0.419	0.048	-8.606	<0.0001*
SDDB←INCOME	0.227	0.038	5.875	<0.0001*
Q25←GENDER	-0.178	0.034	-5.215	<0.0001*

** Variables are statistically significant at a 99.99% confidence level (α=0.0001)*

*** Variables are statistically significant at a 99% confidence level (α=0.01)*

Table 5-10: Overall fit summary for modified model

Number of observations	703
Chi-Square	643.948
Degree of Freedom	154
Chi-Square/DOF	4.181
P > Chi-Square	<0.0001
Standardized RMSR (SRMSR)	0.063
Adjusted GFI (AGFI)	0.870
Parsimonious GFI	0.733
Root Mean Square Error of Approximation (RMSEA) Estimate	0.067
Bentler Comparative Fit Index	0.784

Compared to Model 1 and Model 2, the modified model includes all the critical paths that are statistically significant and displays a better fit. However, it should be pointed out that, a large number of observations, the violation of normality of the variables as well as the missing observations in the data set could affect the overall fit of the model. Based on the available data and information, the modified model results provided the best overall fit. The software outputs are provided in Appendix C.

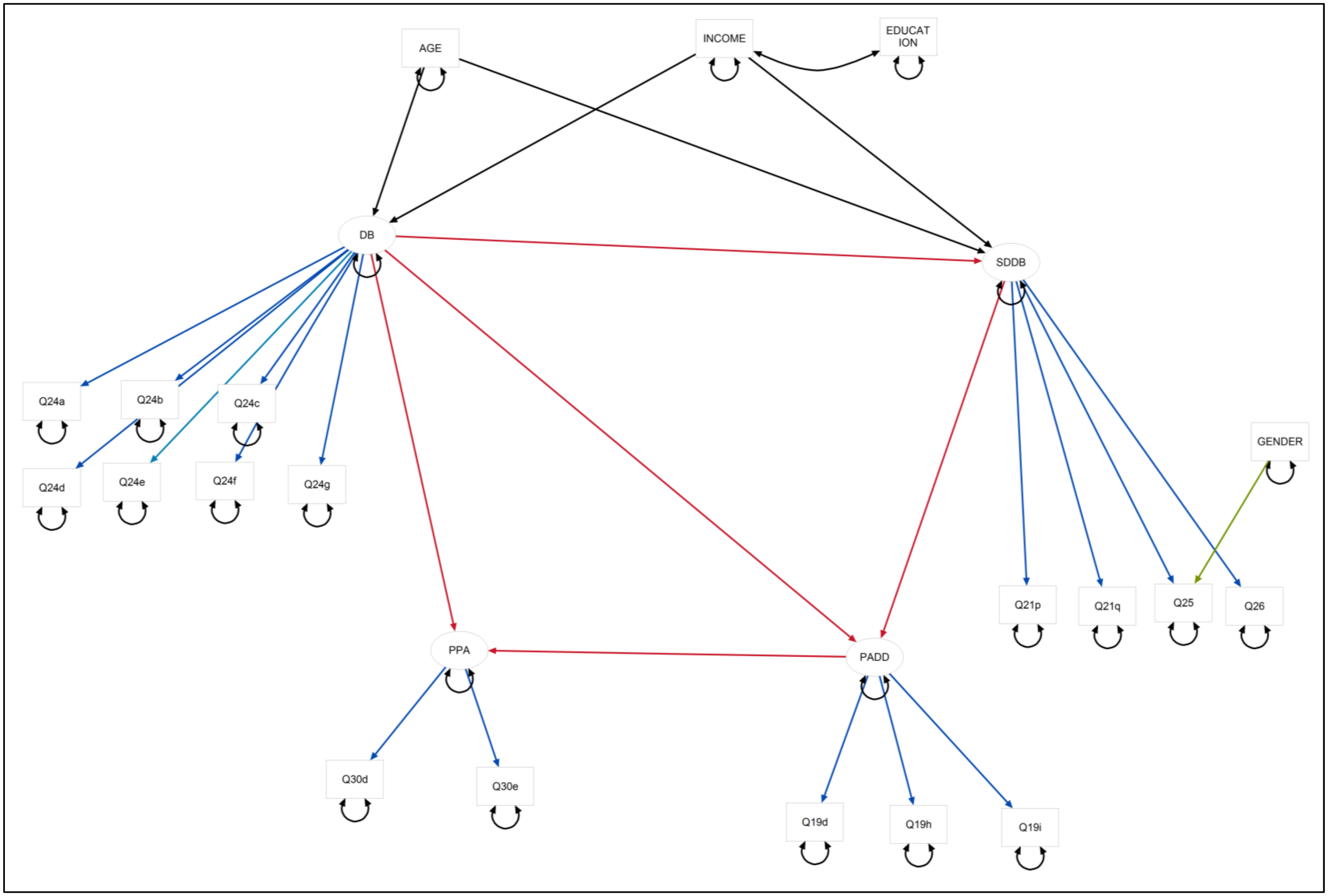


Figure 5-3: Hypothetical path diagram for modified model

5.5 Summary

This chapter identified the relationship among endogenous variables as well as the socioeconomic and demographic factors that mostly affect drivers' attitudes and experiences on distracted driving. It was found that the culture of distracted driving in Iowa was essentially shaped by drivers' behaviors, attitudes and experiences, the driver's attitudes and experiences were highly correlated, and some of the demographic characteristics contributed to the differences in distracted driving attitudes and experiences. For example, male, younger and drivers of higher income group were more likely to be involved in distracted driving.

The next chapter offers some concluding remarks as well as the limitations of the study, followed by recommendations for future research.

CHAPTER 6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Overview

The objectives of this thesis were to explore to the current culture of distracted driving and to develop a statistical model to investigate the Iowans' attitudes, behaviors and experiences toward distracted driving. This chapter summarizes the findings of this thesis followed by the limitations of the study and recommendations for future research.

6.2 Conclusions

Four latent variables were constructed using measured variables (survey questions), which included a wide range of distracting activities while driving. This study identified the relationship among endogenous variables as well as the socioeconomic and demographic factors that mostly affect drivers' attitudes and experiences on distracted driving. It was found that the culture of distracted driving in Iowa was essentially shaped by drivers' attitudes, experiences and behaviors, which were highly correlated. Drivers who engage frequently in distracted driving are less likely to view distracted driving as a serious safety concern compared to other drivers.

Moreover, those drivers would more easily accept distracted driving behaviors and predict fewer crashes to be caused due to drivers' distraction. Since cell phone-related questions contributed significantly to the constructing of the four latent variables, the results of this study can be viewed as the shared attitudes and behaviors regarding cell phone use while driving among adult Iowan drivers. Compared to texting or emailing while driving, the participants' responses related to talking on a cell phone while driving influenced their attitudes and experiences to a larger degree. In addition, the survey data revealed that talking on a cell phone was a more widespread and common form of distracted driving behavior among adult Iowan drivers. Furthermore, the public perceived using a hands-free cell phone as more acceptable than using a handheld cell phone. According to the previous studies (Abdel-Aty, 2003; Ishigami & Klein, 2009; Patten et al., 2004), there was no evidence to prove that using hands-free cell phone while driving was safer than using handheld cell phone. Hence, the drivers' attitudes associate with hands-free cell phone should be improved in Iowa.

The second model provided important evidence on the specific personal characteristics that affect distracted driving-related behaviors and attitudes and form the culture of distracted driving in Iowa. Higher income, younger and male drivers are more likely to be involved in distracted driving; these results were supported by previous studies and a national survey as well (Guarino, 2013; Hosking et al., 2009). In addition, male drivers indicated that they were more likely to use their cell phone while driving because of work. Also, drivers with higher education level from another group that is more likely to engage in distracted driving. Furthermore, age and household income were found to affect drivers' attitudes and behaviors regarding distracted driving at a large degree. In summary, this thesis determined the target populations that are in higher risk for distracted driving and these findings can be useful for developing intervention approaches to reduce distracted driving in Iowa. Past studies (Johnston, 2009; McNeely & Gifford, 2007; Wundersitz et al., 2010) have recommended strategies to transform the overall traffic safety culture. Safety campaigns, law enforcement, advanced in-vehicle technologies, education programs, and behavioral studies are all regarded as appropriate intervention approaches to reducing distracted driving (Cosgrove et al., 2011; Falk & Montgomery, 2007; Gostin & Jacobson, 2010; Governors Highway Safety Association, 2011; Ibrahim et al., 2011; National Highway Traffic Safety Administration, 2010; World Health Organization, 2011; World Road Association, 2012). These interventions can be designed to target specific population groups in a bid to deter them from distracted driving.

In specific, this study determined that younger drivers were more likely to invovled in distracted driving. Stricker law enforcement could be an effective strategy for reducing distracted driving among younger drivers, and ultimately, changing driver behavior. Additionally, launching traffic safety campaingns in schools and developing young driver education programs can all be potentially effective in reducing distracted driving by younger drivers. Moreover, drivers with higher income were identified with a higher frequesncy of distracted driving behaviors that can be associated with their work. Developing education programs within organizations and companies could help to reduce distracted driving because of work.

6.3 Study Limitations

It is important to point out that this study has three major limitations. The first relates to the data used for this study. The final model only included five distracted driving-related questions and four socioeconomic and demographics variables. In addition, more than 300 responses with missing values were deleted from the original dataset. As such, the information included in this study only addresses a limited range of distracted driving-related attitudes and behaviors. Deleting the missing data may result in loss of statistical power, and may also lead to bias in the results.

The second limitation relates to the use of self-reported data and the risk of under-reporting of real behaviors and attitudes. The respondents may wish to conceal or minimize the fact that they engage in such behaviors. The results may be prone to bias and might underestimate the existing phenomenon.

The last limitation of this study is the lack of comprehensive analysis among distracted driving and other risky driving behaviors (such as drunk driving, speeding, etc.). Drivers engaged in distracted driving, may adopt similar attitudes for other risk driving behaviors. A comprehensive study of these risky behaviors could offer a better understanding of the overall traffic safety culture in Iowa.

6.4 Recommendations for Future Research

While this study provided insights on the culture of distracted driving in Iowa, a few recommendations for future research are discussed next.

1. In order to obtain a more accurate estimation of the current culture of distracted driving in Iowa, future research should design a full-scale questionnaire that includes a comprehensive list of distracted driving-related questions with consistent responses, as well more questions about the participants' attributes, such as personal demographics and socioeconomic information. It would be desired to have a high response rate and collect a large numbers of responses, with as few missing values as possible.

2. It is recommended to conduct actual field observation on distracted driving behaviors. Combining the self-reported responses with field observations (giving participants unique personal ID or vehicle ID and install cameras in the vehicle to trace their driving behaviors) would provide convincing and more robust results on the existing culture of distracted driving. It would also test the authenticity of the responses.
3. Future research should examine the relationship among various risky driving behaviors and attitudes. This will be of particular interest for making inferences on the current overall traffic safety culture in Iowa and identify the target populations of safety concern.
4. It is also suggested to conduct similar studies in other states with similar or different laws related to restricting cell phone using while driving as well as similar of different socioeconomic and demographics. The results can be used to compare the culture of distracted driving in different states and develop comprehensive nation-wide intervention approaches to deter distracted driving.

BIBLIOGRAPHY

AAA Foundation for Traffic Safefty. (2013). *2012 Traffic Safety Culture Index.* Washington, DC: AAA Foundation for Traffic Safefty.

Abdel-Aty, M. (2003). Investigating the relationship between cellular phone use and traffic safety. *ITE*, 38-42.

Alm, H., & Nilsson, L. (1995). The effects of a mobile telephone task on driver behavior in a car following situation. *Accident Analysis and Prevention*, 27(5), 707-715.

Atchley, P., Hadlocka, C., & Lane, S. (2012). Stuck in the 70s: the role of social norms in distracted driving. *Accident Analysis and Prevention*, 48, 279-284.

Bayly, M., Young, K. L., & Regan, M. A. (2009). Sources of Distraction inside the Vehicle and Their Effects on Driving Performance. In K. Young, J. D. Lee, & M. A. Regan, *Driver Distraction: Theory, Effects, and Mitigation* (pp. 191-213). CRC Press.

Bentler, P. M. (2006). *EQS 6 Structural Equations Program Manual.* Encino: Multivariate software, Inc.

Bentler, P. M., & Weeks, D. G. (1980). Linear structural equations with latent variables. *Psychometrika*, 45(3), 289-308.

Bollen, k. A. (1989). *Structural Equations with Latent Variables.* New York: John Wiley & Sons.

Brusque, C., & Alauzet, A. (2008). Analysis of the individual factors affecting mobile phone use while driving in France: Socio-demographic characteristics, car and phone use in professional and private contexts. *Accident Analysis and Prevention*, 40(1), 35-44.

Bruyas, M.-P., Brusque, C., Debailleux, S., Duraz, M., & Aillerie, I. (2009). Does making a conversation asynchronous reduce the negative impact of phone call on driving? *Transportation Research Part F*, 12(1), 12-20.

Consiglio, W., Driscoll, P., Witte, M., & Berg, W. P. (2003). Effect of cellular telephone conversations and other potential interference on reaction time in a breaking response. *Accident Analysis and Prevention*, 35(4), 495-500.

Cosgrove, L., Chaudhary, N., & Reagan, I. (2011). *Four High-Visibility Enforcement Demonstration Waves in Connecticut and New York Reduce Hand-Held Phone Use.* Washington, DC: NHTSA.

Cox, S., & Flin, R. (1998). Safety culture:philosopher's stone or man of straw? *Work & Stress:An International Journal of Work*, 12(3), 189-201.

Donovan, J. E. (1993). Young adult drinking-driving: behavioral and psychosocial correlates. *Journal of Studies on Alcohol*, 54(5), 600-613.

Falk, B., & Montgomery, H. (2007). Developing traffic safety intercentions from conceptions of risks and accidents. *Transportation Research Part F*, 414-427.

Fofanova, J., & Vollrath, M. (2011). Distraction while driving: The case of older drivers. *Transportation Research Part F*, 14(6), 638-648.

Fujii, S., Kitamura, R., & Kishizawa, K. (1999). An analysis of individuals' joint activity engagement using a model system of activity-travel behavior and time use. *Transportation Research Record*, 1676, 11-19.

GHSA. (2011). *Distracted Driving, what research shows and what states can do.* Washington, DC: Governors Highway safety Association, GHSA. Retrieved from Distraction.GOV: http://www.distraction.gov/content/get-the-facts/facts-and-statistics.html

Golob, T. F. (2001). Review structural equation modeling for travel behavior research. *Transportation Research Part B*, 37, 1-25.

Golob, T. F., & Hensher, D. A. (1994). *Driver Behavior of Long Distance Truck Drivers: The Effects of Schedule Compliance on Drug Use and Speeding Citations.* Irvine: Institute of Transportation Studies, University of California.

Goodwin, A. H., D.Foss, R., Harrell, S. S., & O'Brien, N. P. (2012). *Distracted driving among newly licensed teen drivers.* Washington, DC: AAA Foundation for Traffic Safety.

Gostin, L. O., & Jacobson, P. D. (2010). Reducing distracted driving: regulation and education to avert traffic injuries and fatalities. *JAMA*, 1419-1420.

Governor's Traffic Safety Bureau (GTSB). (2010). *Iowa Distracted Driving Fact Sheet.* Governor's Traffic Safety Bureau (GTSB), Iowa Depatment of Public Safety.

Governor's Traffic Safety Bureau. (2010). *Iowa Distracted Driving Fact Sheet.* Governor's Traffic Safety Bureau (GTSB), Iowa Department of Public safety.

Guarino, J. (2013). *Survey Reveals Public Open to Ban on Hand-Held Cell Phone Use and Texting.* Washington D.C.: Bureau of Transportation Statistics (BTS).

Haavelmo, T. (1934). The statistical implications of a system of simultaneous equations. *Econometrica*, 11(1), 1-12.

Haigney, D., Taylor, R., & Westerman, S. (2000). Concurrent mobile (cellular) phone use and driving performance: task demand characteristics and compensatory processes. *Transportation Research Part F*, 3(3), 113-121.

Hancock, P., Lesch, M., & Simmons, L. (2003). The distraction effects of phone use during a crucial driving maneuver. *Accident Analysis and Prevention*, 35(4), 501-514.

Hanowski, R. J., Olson, R. L., Hickman, J. S., & Dingus, T. A. (2006). *The 100-Car Naturalistic Driving Study: A Descriptive Analysis of Light Vehicle-Heavy Vehicle Interactions from the Light Vehicle Driver's Perspective, Data Analysis Results.* Washington, DC: National Highway Traffic Safety Administration(NHTSA).

Horberry, T., Anderson, J., Michael A, R., Triggs, T. J., & Brown, J. (2006). Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accident Analysis and Prevention*, 38(1), 185-191.

Horrey, W. J., & Wickens, C. D. (2006). Examining the impact of cell phone conversations on driving using meta-analytic techniques. *Human Factors*, 48(1), 196-205.

Hosking, S. G., Young, K. L., & Regan, M. A. (2009). The effects of text messaging on young drivers. *Human Factors*, 51(4), 582-592.

Hosking, S. G., Young, K. L., & Regan, M. A. (2009). The Effects of Text Messaging on Young Drivers. *HUMAN FACTORS*, 582-592.

Ibrahim, J. K., Anderson, E. D., Burris, S. C., & Wagenaar, A. C. (2011). State laws restricting driver use of mobile communications devices, distracted-driving provisions, 1992-2010. *American Journal of Preventive Medicine*, 40(6), 659-665.

Ishigami, Y., & Klein, R. M. (2009). Is a hands-free phone safer than a handheld phone? *Journal of Safety Research*, 40(2), 157-164.

Johnston, I. (2009). Beyond ‘‘best practice” road safety thinking and systems management – A case for culture change research. *Safety Science*, 48(9), 1175-1181.

Jöreskog, K. (1970). A general method for analysis of covariance structures. *Biometrik*, 57(2), 239-251.

Just, M. A., Keller, T. A., & Cynkar, J. (2008). A decrease in brain activation associated with driving when listening to someone speak. *ELSEVIER, Brain research*, 1205, 70-80.

Kaber, D. B., Liang, Y., Zhang, Y., Rogers, M. L., & Gangakhedkar, S. (2012). Driver performance effects of simultaneous visual and cognitive distraction and adaptation behavior. *Transportation Research Part F*, 15(5), 491-501.

Kass, S. J., Cole, K. S., & Stanny, C. J. (2007). Effects of distraction and experience on situation awareness and simulated driving. *Transportation Research Part F*, 10(4), 321-329.

Keesling, J. W. (1972). *Maximum likelihood approaches to causal analysis.* Department of Education, University of Chicago.

Kline, R. B. (2011). *Principles and Practice of Structural Equation Modeling.* New York: Guilford Press.

Koopmans, T. (1945). Statistical estimation of simultaneous economic relations. *Journal of the American Statistical Association*, 40(232), 448-466.

Lei, P.-W., & Wu, Q. (2007). *Introduction to Structural Equation Modeling: Issues and Practical Considerations.* Madison: NCME.

Liang, Y., & Lee, J. D. (2010). Combining cognitive and visual distraction: less than the sum of its parts. *Accident Analysis and Prevention*, 881-890.

Lonero, L. P. (2007). *Finding the next cultural paradigm for road safety.* AAA Foundation for Traffis Safety.

Matsueda, R. L. (2012). Key adcances in the history of structural equation modeling. In R. H. Hoyle, *Handbook of structrual equation modeling.* New York: Guilford Press.

McEvoy, S. P., Stevenson, M. R., & Woodward, M. (2007). The contribution of passengers versus mobile phone use to motor vehicle crashes resulting in hospital attendance by the driver. *Accident Analysis and Prevention*, 39(6), 1170-1176.

McNeely, C. L., & Gifford, J. L. (2007). *Effecting a traffic safety culture: lessons from cultural change initiatives.* Washington, DC: AAA Foundation for Traffic Safety.

Mearns, K. J., & Flin, R. (1999). Assessing the state of organizational safety-culture or climate. *Current Psychology: Developmental,Learning,Personality,Social*, 18(1), 5-17.

Megan Bayly, K. L. (2008). Sources of distraction insidem the vehicle and their effects on driving performance. In J. D. Michael A . Regan, *In Driver Distraction:Theory, Effects, and Mitigation* (pp. 191-213). FL: CRC Press.

Moeckli, J., & Lee, J. D. (2007). *The making of driving cultures.* Washington DC.: AAA Foundation for Trffic Safety.

Neyens, D. M., & Boyle, L. N. (2008). The influence of driver distraction on the severity of injuries sustained by teenage drivers and their passengers. *Accident Analysis and Prevention*, 40(1),254-259.

NHTSA. (2009). *An Examination of Driver Distraction as Recorded in NHTSA Databases.* Washington, DC: NHTSA.

NHTSA. (2012). *2010 Motor Vehicle Crashes:Overview.* Washington, DC: NHTSA's National Center for Statistics and Analysis.

Patten, C. J., Kircher, A., Östlund, J., & Nilsson, L. (2004). Using mobile telephones: cognitive workload and attention resource allocation. *Accident Analysis and Prevention*, 36(3), 341-350.

Pidgeon, N. (1998). Safety culture: Key theoretical issues. *Work & Stress: An International Journal of Work, Health & Organisations*, 12(3), 202-216.

Pöysti, L., Rajalin, S., & Summala, H. (2005). Factors influencing the use of cellular (mobile) phone during driving and hazards while using it. *Accident Analysis and Prevention*, 37(1), 47-51.

Raykov, T., & Marcoulides, G. (2006). *A First Course in Structural Equation Modeling, Second Edition.* New Jersey: Lawrence Erlbaum Associates.

Rochlin, G. I., & Meier, A. v. (1994). Nuclear power operations: A cross-culture perspective. *Annual Review of Energy and the Environment*, 19, 154-186.

Rosenbloom, T. (2006). Driving performance while using cell phone: An observational study. *Journal of Safety Research*, 37(2), 207-212.

Silva, J. d., Morency, C., & Goulias, K. G. (2012). Using structural equations modeling to unravel the influence of land use patterns on travel behavior of workers in Montreal. *Transportation Research Part A*, 46(8), 1252-1264.

Strayer, D. L., & Drew, F. A. (2004). Profiles in driver distraction: effects of cell phone conversations on younger and older drivers. *Human Factors*, 46(4), 640–649.

Tabachnick, B., & Fidell, L. (1996). *Using Multivariate Statistics.* New York: HarperCollins College Publishers.

Thompson, K. R., Johnson, A. M., Emerson, J. L., Dawson, J. D., Boer, E. R., & Rizzo, M. (2012). Distracted driving in elderly and middle-aged drivers. *Accident Analysis and Prevention*, 45, 711-717.

Tison, J., Chaudhary, N., & Cosgrove, L. (2011). *National Phone Survey on Distracted Driving Attitudes and Behaviors.* Washington D.C.: National Highway Transportation Safety Administration.

Tornros, J., & Bolling, A. (2006). Mobile phone use - effects of conversation on mental workload and driving speed in rural and urban environments. *Transportation Reseach Part F*, 9(4), 298-306.

Tractinsky, N., Ram, E. S., & Shinar, D. (2013). To call or not to call - that is the question (while driving). *Accident Analysis and Prevention*, In Press.

Treffner, P. J., & Barrett, R. (2004). Hands-free mobile phone speech while driving degrades coordination and control. *Transportation Research Part F*, 7, 229-246.

Troglauer, T., Hels, T., & Christens, P. F. (2006). Extent and variations in mobile phone use among drivers of heavy vehicles in Denmark. *Accident Analysis and Prevention*, 38(1), 105-111.

Vermette, E. (2010). *Curbing distracted driving 2010 survey of state safety programs.* Washington, DC: GHSA.

Ward, N. J., linkenbach, J., Keller, S. N., & Otto, J. (2010). *White Paper on Traffic safety Culture.* Bozeman: Western Transportation Institute.

Washington, S. P., Karlaftis, M. G., & Mannering, F. (2011). *Statistical and Econometric Methods for Transportation Data Analysis, Second Edition.* Boca Raton: CRC.

Wiegmann, D. A., Zhang, H., Thadenl, T. v., Sharma, G., & Mitchell, A. (2002). *A Synthesis of Safety Culture and Safety Climate Research.* Urbana: Federal Aviation Administration,Atlantic City International Airport, NJ.

Wilson, F. A., & Stimpson, J. P. (2010). Trends in fatalities from distracted driving in the United States, 1999 to 2008. *American Journal of Public Health*, 100(11), 2213-2219.

World Health Organizartion. (2011). *Mobile phone use: a growing problem of driver distraction.* Geneva, Switzerland: World Health Organizartion.

World Road Association (PLARC). (2012). *Best practices for road safety campaigns.* La Defense cedex: World Road Association (PLARC).

Wundersitz, L. N., Hutchinson, T., & Woolley, J. (2010). *Best practice in road safety mass media campaigns: A literature review.* Adelaide: The University of Adelaide.

Zhang, H., Wiegmann, D. A., Thaden, T. L., Sharma, G., & Mitchell, A. A. (2002). *Safety culture: a concept in chaos?* Santa Monica: University of Illinois at Urbana-Champaign.

APPENDIX A: DISTRACTED DRIVING-RELATED SURVEY

QUESTIONS AND RESPONSES

Questions	Responses
Q10. How well do you think the state of Iowa has done in the following areas: f. Reducing distracted driving	1. Excellent: 6.1% 2. Good: 28.0% 3. Fair: 42.4% 4. Poor: 20.2% 5. Don't know/not sure: 3.2%
Q14. Is it legal or illegal for driver under 18 to use a cell phone for any purpose while driving in Iowa?	1. Legal:13.3% 2. Illegal: 86.7%
Q15. For adults, is it legal or illegal to read, write, or send a text message while driving in Iowa?	1.Legal: 11.2% 2.Illegal: 88.8%
Q18. How serious a threat to traffic safety you think it is? e. Distracted Driving i. Drivers using cell phones	e. 1. Very serious: 71.8% 2. Somewhat serious: 24% 3. Slightly serious: 3.1% 4. Not at all serious: 1.1% i. 1. Very serious: 57.6% 2. Somewhat serious: 32.0% 3. Slightly serious: 8.3% 4. Not at all serious: 2.1%
Q19. How acceptable to you personally think it is for a driver to…? d. Send text messages or emails while driving h. Talk on a hand-held cell phone while driving i. Talk on a hand-free cell phone while driving	d. Always acceptable: 1.4% Sometimes acceptable: 4.6% Seldom acceptable: 5.7% Never acceptable:88.4% h. Always acceptable: 3.2% Sometimes acceptable: 35.8% Seldom acceptable: 15.4% Never acceptable:45.6% i. Always acceptable: 19.9% Sometimes acceptable: 52.2% Seldom acceptable: 10.5% Never acceptable:17.5%
Q20. Please tell me how often you have seen other drivers in your area do the following…	a. Every day: 71.7%

a. Talk on a cell phone while driving i. Read or send a text message or email while driving	A few times a week: 18.4% A few times a month: 4.4% Once a month or less: 3.3% Never: 2.2% i. Every day: 35.0% A few times a week: 29.5% A few times a month: 13.4% Once a month or less: 9.8% Never: 12.2%
Q21. In the past 30 days, as the driver of a vehicle, have you…? Cell phone use p. Talked on any kind of cell phone while you were driving q. Read or sent a text message or email while you were driving	p. Yes: 66.8%, No: 33.2% q. Yes: 19.1%, No: 80.9%
Q24. Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to… a. To have the radio on or music playing b. To have passengers in your car having conversations or interacting c. To have children sitting in the backseat d. To drive through an area with a lot of commercial signage such as billboards e. To use a GPS device while driving f. To make or receive cell phone calls g. To receive text messages or emails	a. Very distracting: 1.2% Somewhat distracting: 20.1% Not at all distracting: 78.7% b. Very distracting: 2.1% Somewhat distracting: 42.7% Not at all distracting: 55.2% c. Very distracting: 7.9% Somewhat distracting: 48.6% Not at all distracting: 43.4% d. Very distracting: 12.7% Somewhat distracting: 44.1% Not at all distracting: 43.3% e. Very distracting: 10.8% Somewhat distracting: 49.9% Not at all distracting: 39.3% f. Very distracting: 35.5% Somewhat distracting: 52.7% Not at all distracting: 11.8% g. Very distracting: 84.3% Somewhat distracting: 11.9% Not at all distracting: 3.7%

Q25. In the past 30 days, have you been required or expected to talk on your cell phone while driving because of work?	Yes: 22.5% No: 77.5%
Q26. In the past 30 years, have you been required or expected to send or receive a text message or e-mail on your cell phone while driving because of work?	Yes: 5.0% No: 95.0%
Q30. Please tells me whether you strongly agree, disagree, or strongly disagree with each of the following statements. d. Driving while talking on a cell phone increase the chance you might have an accident e. Driving while eating or drinking increases the chance you might have an accident j. The chance of being caught is small for sending or receiving a text message while driving	d. Strongly agree: 18.8% Agree: 71.6% Disagree: 8.5% Strongly disagree: 1.1% e. Strongly agree: 10.9% Agree: 77.5% Disagree: 11.4% Strongly disagree: 0.2% j. Strongly agree: 10.4% Agree: 63.6% Disagree: 22.8% Strongly disagree: 3.2%
Q36. During the past 2 years, how many accidents have you been in while you were driving?	0: 86.4% 1:10.6% 2:2.4% 3:0.3% 4:0.0% 5:0.2%
Q37. In how many of these accidents did distracted driving play a role?	0:71.5% 1:19.9% 2:5.3% 3:2.0% 5:1.4%

APPENDIX B: COMPLETE SURVEY QUESTIONNAIRE

HELLO, my name is ____(name)____. I am calling from the University of Northern Iowa. We are gathering information about traffic safety in Iowa. This project is conducted by the Iowa Department of Transportation. Your telephone number has been chosen randomly, and I would like to ask some questions about driving practices and traffic safety.

Is this **__(phone number)__** ?

> **If "no,"**
> Thank you very much, but I seem to have dialed the wrong number. It's possible that your number may be called at a later time. **STOP**

Is this a private residence in Iowa?

> **If "no,"**
> Thank you very much, but we are only interviewing private residences in **Iowa. STOP**

Is this a cellular telephone?

[Read only if necessary: "By cellular (or cell) telephone we mean a telephone that is mobile and usable outside of your neighborhood."

> **If "yes,"**
> Thank you very much, but at this time we are only interviewing people on landline telephones in private residences. **STOP**

I need to randomly select one adult who lives in your household to be interviewed. How many members of your household, including yourself, are 18 years of age or older?

> __ Number of adults
>
> **If "1,"**
> Are you the adult?
>
> **If "yes,"**
> Then you are the person I need to speak with. Enter 1 man or 1 woman below (Ask gender if necessary). **Go to page 5.**
>
> **If "no,"**
> Is the adult a man or a woman? Enter 1 man or 1 woman below. May I speak with **[fill in (him/her) from previous question]**? **Go to "correct respondent" on the next page.**

How many of these adults are men and how many are women?

__ Number of men

__ Number of women

The person in your household that I need to speak with is ________________.

If "you," go to Consent
If other, ask to speak with him/her or schedule callback.

To the correct respondent:

HELLO, I am calling for the Iowa Department of Transportation from the University of Northern Iowa. My name is **____(name).** We are gathering information from the public about traffic safety in Iowa. Your telephone number has been chosen randomly, and I would like to ask some questions.

Consent

I will not ask for your last name, address, or other personal information that can identify you. You do not have to answer any question you do not want to, and you can stop the interview at any time. For most people the interview takes about 25 minutes, but it can vary from person to person. There are no direct benefits to you and any risks of participating are similar to those typically encountered in your day to day life. Your individual answers are grouped with those of others to maintain your confidentially. If you have any questions about the study, I will provide a telephone number for you to call to get more information.

1. Have you driven in the past year?

   1. Yes
   2. No

   7. Don’t know/Not sure
   9. Refused

2. During the last year, in a typical 7-day week, about how many miles did you drive?

   11. None
   12. Less than 20 miles
   13. 20-99 miles
   14. 100-199 miles
   15. 200-499 miles
   16. 500-999 miles
   17. 1000 miles or more

66. I do not drive anymore
77. Don't know/Not sure
99. Refused

3. Overall, do you think driving in Iowa feels safer, less safe, or about the same as it did 5 years ago?

1. Safer
2. About the same
3. Less safe

7. Don't know/Not sure
9. Refused

4. How safe do you feel when driving a licensed motor vehicle on…

a. rural gravel roads in Iowa?
b. city streets in Iowa?
c. highways and interstates in Iowa?

Would you say…

1. Very safe,
2. Somewhat safe, or
3. Not at all safe?

6. I have never driven on a [..…]in Iowa
7. Don't know/Not sure
9. Refused

5. Have you made a specific effort to improve or maintain your driving skills in the last 5 years, such as reading about safe driving, looking at the official Iowa driver's manual, or taking a refresher class?

1. Yes
2. No

6. Haven't driven in the last 5 years
7. Don't know/Not sure
9. Refused

6. Thinking about ways to improve driving skills and habits…

a. Do you think drivers renewing their license should be required to spend 10 to 15 minutes reviewing safe driving tips and updates on laws and road design?
b. Do you think drivers renewing their license should be required to pass a written test?
c. Do you think drivers renewing their license should be required to pass a driving test?
d. Should there be an insurance discount or other incentive for all licensed drivers to take a refresher class to improve their driving skills and knowledge?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

[If Q1=2, skip to Q8]

7. Would you take such a driving class, either online or in person, if you received an insurance discount or other incentive for doing so?

Would you say…

1. Definitely yes,
2. Probably yes,
3. Probably not, or
4. Definitely not?

7. Don't know/Not sure
9. Refused

8a. The Iowa Department of Transportation provides information about road conditions through the Iowa 511 traveler information system. Have you ever used DOT resources to learn about any of the following?

Road driving conditions
Construction zones
Road closures and detours
Weather, winds and temperatures

1. Yes
2. No

7. Don't know/Not sure
9. Refused

[If 8a=2, skip to Q9a]

8b. Did you use the Iowa 511 resources to make your trip faster or to make your trip safer?

1. Faster
2. Safer

3. Both (DO NOT READ)

7. Don't know/Not sure
9. Refused

9a. Which of the following do you think would be most effective in making driving in Iowa safer?

1. Engineering, such as road signs and road design
2. Education, such as driver's education, refresher classes, or public service messages
3. Enforcement, such as fines and penalties for speeding or sending text messages

7. Don't know/Not sure
9. Refused

9b. Which of the following do you think would be least effective in making driving in Iowa safer?

1. Engineering, such as road signs and road design
2. Education, such as driver's education, refresher classes, or public service messages
3. Enforcement, such as fines and penalties for speeding or sending text messages

7. Don't know/Not sure
9. Refused

10. How well do you think the state of Iowa has done in the following areas:

a. Reducing alcohol-related accidents
b. Increasing safety belt use
c. Improving motorcycle safety
d. Improving the condition and safety of roads
e. Enforcing the speed limit

f. Reducing distracted driving
g. Increasing commercial vehicle safety
h. Improving emergency medical services
i. Improving the safety of young drivers
j. Improving the safety of older drivers

Would you say…

1. Excellent,
2. Good,
3. Fair, or
4. Poor?

7. Don't know/Not sure
9. Refused

11. Thinking of response times and quality of care, how satisfied are you with the emergency medical services in your area?

Would you say…

1. Very satisfied,
2. Somewhat satisfied, or
3. Not very satisfied?

7. Don't know/Not sure
9. Refused

12. Do you support or oppose…

a. Having high-visibility law enforcement operations
b. Increasing the dollar amount of fines for speeding
c. Requiring OWI repeat offenders to use ignition interlock devices for extended periods of time
d. Requiring motorcycle riders to complete more extensive training
e. Reinstating a law that requires motorcyclists to wear a helmet
f. Having a graduated licensing system for motorcyclists that is based on engine size

1. Support
2. Oppose

7. Don't know/Not sure
9. Refused

13a. The next few questions are about Iowa's graduated driver licensing system, or GDL. In Iowa, drivers go through three levels of licensing: instruction permit with supervised driving, intermediate license with some restrictions, and the full license. In Iowa, teens can get an instruction permit at age 14. In some states, the age for a first license is older. Do you think 14 is ok, or what other age do you think it should be?

[ ] = age (if respondent says "ok" insert 14)

77. Don't know/Not sure
99. Refused

13b. Iowa requires teens to have an instruction permit for six months before they are allowed to drive without an adult in the car. Some states require teens to have an instruction permit for 12 months. Do you think Iowa should increase the permit length to 12 months?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

13c. Some states limit the number of young passengers that newly licensed teens can have. Do you think Iowa should limit newly licensed teen drivers to no more than one teen passenger?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

13d. Iowa currently allows newly licensed teens to drive until 12:30 am. Some states prohibit driving after 10 pm. Do you think Iowa should limit driving after 10 pm for newly licensed teen drivers?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

14. Is it legal or illegal for drivers under 18 to use a cell phone while driving in Iowa? [Interviewer note: electronic devices that are installed into the car are not considered cell phones for this question.]

1. Legal
2. Illegal

7. Don't know/Not sure
9. Refused

15. Is it legal or illegal to read, write, or send a text message while driving in Iowa?

1. Legal
2. Illegal

7. Don't know/Not sure
9. Refused

16. The use of automated enforcement techniques such as speed cameras and red-light cameras is increasing in Iowa.

a. Do you support or oppose using cameras to automatically ticket speeding drivers on major highways?
b. Do you support or oppose using cameras to automatically ticket speeding drivers on city streets?
c. Do you support or oppose using cameras to automatically ticket drivers who drive through red lights?

1. Support
2. Oppose

7. Don't know/Not sure
9. Refused

17. In your opinion, would drivers be more careful if they knew that speed and red light cameras were in place?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

18. I'm going to read a list of issues involving traffic safety. For each one, I'd like to know how serious a threat to traffic safety you think it is.

a. People driving after drinking too much alcohol
b. People running red lights

c. Excessive speeding
d. Aggressive driving
e. Distracted driving
f. Drowsy driving
g. Elderly drivers
h. Young drivers
i. Drivers using cell phones
j. People not wearing seatbelts

Would you say …
1. Very serious threat to traffic safety
2. Somewhat serious
3. Slightly serious
4. Not at all serious

7. Don't know/Not sure
9. Refused

19. How acceptable to you personally think it is for a driver to…?

a. Drive when they think they may have had too much to drink
b. Drive when they're so sleepy that they have trouble keeping their eyes open
c. Drive 10 mph over the speed limit on a city street
d. Send text messages or emails while driving
e. Drive through a light that just turned red, when they could have stopped easily
f. Drive without wearing their seatbelt
g. Drive 10 mph over the speed limit on a freeway
h. Talk on a hand-held cell phone while driving
i. Talk on a hands-free cell phone while driving
j. Drive through a stop sign if the way looks clear
k. Make a right turn at a red light without stopping
l. Drive 10 mph over the speed limit on a rural gravel road

Would you say…

1. Always acceptable,
2. Sometimes acceptable,
3. Seldom acceptable, or
4. Never acceptable?

7. Don't know/Not sure
9. Refused

20. Please tell me how often you have seen other drivers in your area do the following...

a. Talk on a cell phone while driving
b. Honk at other drivers
c. Speed through a yellow traffic light
d. Drive 10 miles per hour over the speed limit on a major highway
e. Drive 10 miles per hour over the speed limit on a city street
f. Drive through red lights on purpose
g. Drive while tired or sleepy
h. Tailgate other vehicles
i. Read or send a text message or email while driving
j. Become visibly angry at something another driver did
k. Drive while seeming to be impaired by drug or alcohol use
l. Drive through a stop sign
m. Turn right at a red light without stopping
n. Drive 10 mph over the speed limit on a rural gravel road

Would you say…

1. Every day,
2. A few times a week,
3. A few times a month,
4. Once a month or less, or
5. Never?

7. Don't know/Not sure
9. Refused

[If Q1=2, skip to Q22]

21. In the past 30 days, as the driver of a vehicle, have you…?

Seatbelt use
a. Allowed passengers to ride in the back seat of your car without wearing their seatbelts
b. Allowed passengers to ride in the front seat of your car without wearing their seatbelts
c. Driven without wearing your seatbelt
d. Asked passengers to wear a seatbelt

Speeding
e. Been asked by a passenger to slow down or drive more carefully while driving
f. Driven 10 mph over the speed limit on a highway or interstate
g. Driven 10 mph over the speed limit on a city street
h. Felt pressure from other drivers to drive faster
i. Driven 10 mph over the speed limit on a rural gravel road

Lights/stop signs
j. Driven through a light that has just turned red, when you could have stopped safely
k. Sped up to get through a yellow light before it changed

l. Turned right at a red light without stopping
m. Driven through a stop sign

Drinking
n. Driven when you thought your blood alcohol content was above the legal limit
o. Driven when you thought your blood alcohol content was a little below the legal limit

Cell phone use
p. Talked on any kind of cell phone while you were driving
q. Read or sent a text message or email while you were driving

Other
r. Driven with an expired license
s. Driven when you were so tired that you had a hard time keeping your eyes open
t. Tailgated another vehicle
u. Became extremely angry at something another driver did
v. Honked at other drivers
w. Tried to avoid driving on a certain road because you felt it was dangerous

1. Yes
2. No

7. Don’t know/Not sure
9. Refused

22. If you have driven 10 mph or more over the speed limit in the past 5 years, was it usually because you…

1. enjoyed the thrill of driving fast,
2. were running late,
3. were not paying attention to your speed, or
4. were keeping up with the flow of traffic

8. Didn’t drive 10 mph over in past 5 years

7. Don’t know/Not sure
9. Refused

23a. What do you think the speed limit is on rural gravel roads?

___ ___ Miles per hour
76 76 mph or higher
77 Don't know/Not sure
88 Depends on time of day
99 Refused

[IF Q23a <> 88, SKIP TO 24a]

23b. [INTERVIEWER: ENTER DAYTIME LIMIT BELOW]

___ ___ Daytime Limit
76 76 mph or higher
77 Don't know/Not sure
99 Refused

23c. [INTERVIEWER: ENTER NIGHTTIME LIMIT BELOW]
___ ___ Nighttime Limit
76 76 mph or higher
77 Don't know/Not sure
99 Refused

24. I'm going to read a list of things that might be distracting for some drivers. Please tell me whether you find it very distracting, somewhat distracting, or not at all distracting to…

a. To have the radio on or music playing.
b. To have passengers in your car having conversations or interacting.
c. To have children sitting in the backseat.
d. To drive through an area with a lot of commercial signage such as billboards.
e. To use a GPS device while driving.
f. To make or receive cell phone calls.
g. To receive text messages or e-mails.

Would you say it is…

1. Very distracting,
2. Somewhat distracting, or
3. Not at all distracting?

6. I have never been in that situation

7. Don't know/Not sure
9. Refused

25. In the past 30 days, have you been required or expected to talk on your cell phone while driving because of work?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

26. In the past 30 days, have you been required or expected to send or receive a text message or e-mail on your cell phone while driving because of work?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

27. When you ride a bicycle, do you usually wear a helmet?

1. Yes
2. No

6. I do not ride a bicycle

7. Don't know/Not sure
9. Refused

28. When you ride a motorcycle, do you usually wear a helmet?

1. Yes
2. No

6. I do not ride a motorcycle

7. Don't know/Not sure
9. Refused

29. About how many people do you think died last year from motor vehicle accidents in Iowa? Even if you don't know the exact number, please give me your best guess.

___________________ (Range 0-999,995)

999,996. 999,996 or more

999,997. Don't know/Not sure
999,999. Refused

30. Please tell me whether you strongly agree, agree, disagree, or strongly disagree with each of the following statements.

a. There isn't much chance of an accident if I am careful when speeding.
b. There isn't much chance of an accident if I am careful when driving after drinking alcohol.
c. Driving when you are tired increases the chance you might have an accident.
d. Driving while talking on a cell phone increases the chance you might have an accident.

e. Driving while eating or drinking increases the chance you might have an accident.
f. The chance of being caught is small for not wearing a seatbelt.
g. The chance of being caught is small for driving after drinking alcohol.
h. The chance of being caught is small for speeding.
i. The chance of being caught is small for running a red light.
j. The chance of being caught is small for sending or receiving a text message while driving.

Would you…

1. Agree strongly,
2. Agree somewhat,
3. Disagree somewhat, or
4. Disagree strongly?

7. Don't know/Not sure
9. Refused

31. Which one of the following most motivates you to drive safer? Is it …

1. Your own safety
2. Safety of others
3. Fear of getting caught driving recklessly, or
4. Setting a good example?

7. Don't know/Not sure
8. None of these
9. Refused

32. I have a few last questions about your background and we'll be finished. What types of vehicles do you drive? (Check all that apply.)

1. Car
2. Pickup truck or van
3. Motorcycle
4. Commercial vehicle
5. Other [Specify:]

8. No vehicles

7. Don't know/Not sure
9. Refused

33. Do you have a valid motor vehicle driver's license?

1. Yes
2. No, do not have a license
3. No, current license suspended

7. Don't know/Not sure
9. Refused

34. Has your license ever been suspended or revoked?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

35. How many traffic tickets, if any, have you gotten in the past 2 years for moving violations, including any that were reduced or dismissed?

_______ # 0-20

77. Don't know/Not sure
99. Refused

36. During the past 2 years, how many accidents have you been in while you were driving?

_______ # 0-20

77. Don't know/Not sure
99. Refused

If 36 = 0, skip to 38

37. Did distracted driving play a role in any of these accidents?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

38. Are you…

1. Male
2. Female

39. What is your current age?

______ [range 0-96]

96. 96 or older

97. Don't know/Not sure
99. Refused

40a. How many children under age 5 currently live in your household?

[ ] children under 5

77. Don't know/Not sure
99. Refused

40b. How many children ages 5 through 17 currently live in your household?

[ ] children

77. Don't know/Not sure
99. Refused

41. What is the highest level of education you have completed?

1. Never attended school or only attended kindergarten
2. Grades 1-8 (elementary)
3. Grades 9-11 (some high school)
4. Grade 12 or GED (high school graduate)
5. College 1 year to 3 years (some college or technical school)
6. College 4 years or more (college grad with BA/BS, etc.)
7. Graduate degree completed (MA, MS, MFA, MBA, MD, PhD, etc.)

7. Don't know/Not sure
9. Refused

42. Which of the following best describes where you live? Do you live…

1. On a farm or in an open rural area,
2. In a small town of less than 5,000 persons,
3. In a large town of 5,000 to less than 25,000 persons,
4. In a city of 25,000 to less than 50,000 persons, or
5. In a city of 50,000 or more persons?

7. Don't know/Not sure

9. Refused

43. Which of the following best describes where you work? Do you work…

1. On a farm or in an open rural area,
2. In a small town of less than 5,000 persons,
3. In a large town of 5,000 to less than 25,000 persons,
4. In a city of 25,000 to less than 50,000 persons,
5. In a city of 50,000 or more persons, or
6. Do you work on the road, such as in sales, delivery, utility, bus or truck driving, law enforcement, road worker, repair calls, and so forth?

8. Not currently working

7. Don't know/Not sure
9. Refused

44. What is your annual household income from all sources?

Is it…
1. Less than $25K
2. $25K to $49K
3. $50K to $74K
4. $75k - $99k
5. $100k or more

7. Don't know/Not sure
9. Refused

45. Are you of Hispanic, Latino, or Spanish origin?

1. Yes
2. No

7. Don't know/Not sure
9. Refused

46. Which of the following best describes your race? Would you say… [SELECT ONLY ONE]

1. White,
2. African American or Black,
3. Asian,
4. American Indian or Alaska Native,
5. Native Hawaiian or Other Pacific Islander, or

6. Other [Specify:_______________]

7. Don't know/Not sure
9. Refused

47. What county do you live in?

_____________ County

7. Don't know/Not sure
9. Refused

48. What is your ZIP Code?

[ ]
77777. Don't know/Not sure
99999. Refused

49. How many landline telephone numbers are used in your household to make or receive phone calls?

_ Residential telephone numbers [6 = 6 or more]
7 Don't know / Not sure
9 Refused

50. Thinking about all the phone calls that you receive on your landline and cell phone, what percent, between 0 and 100, are received on your cell phone?

_ _ _ Enter percent (1 to 100)
8 8 8 Zero
7 7 7 Don't know / Not sure
9 9 9 Refused

APPENDIX C: SOFTWARE MODEL OUTPUT

Model 1

Modeling Specification

Modeling Information

Data Set	WORK.FINAL_DATASET
N Records Read	1088
N Records Used	783
N Obs	783
Model Type	PATH
Analysis	Covariances

Fit

Fit Summary

Modeling Info	N Observations	783
Absolute Index	Chi-Square	593.4255
	Chi-Square DF	95
	Pr > Chi-Square	<.0001
	Standardized RMSR (SRMSR)	0.0725
Parsimony Index	Adjusted GFI (AGFI)	0.8583
	Parsimonious GFI	0.7133
	RMSEA Estimate	0.0819
	RMSEA Lower 90% Confidence Limit	0.0757
	RMSEA Upper 90% Confidence Limit	0.0883
	Probability of Close Fit	<.0001
Incremental Index	Bentler Comparative Fit Index	0.7475

Standardized Results

PATH List

Standardized Results for PATH List

Path

			Parameter	Estimate	Standard Error	t Value
PADD	<---	DB	_Parm01	-0.3389	0.06178	-5.4851
PADD	<---	SDDB	_Parm02	0.56485	0.06154	9.17909
PPA	<---	DB	_Parm03	0.43445	0.08184	5.30836
PPA	<---	PADD	_Parm04	-0.2079	0.08097	-2.5671
Q19d	<---	PADD	_Parm05	0.29566	0.03783	7.81582
Q19h	<---	PADD	_Parm06	0.78583	0.02672	29.4112
Q19i	<---	PADD	_Parm07	0.63119	0.0288	21.919
Q21p	<---	SDDB	_Parm08	0.70208	0.03225	21.7694
Q21q	<---	SDDB	_Parm09	0.4732	0.03584	13.2013
Q24a	<---	DB	_Parm10	0.28907	0.03851	7.50697
Q24b	<---	DB	_Parm11	0.35487	0.03722	9.53314
Q24c	<---	DB	_Parm12	0.15764	0.04034	3.90776
Q24d	<---	DB	_Parm13	0.28139	0.03864	7.28221
Q24e	<---	DB	_Parm14	0.23996	0.03931	6.10405
Q24f	<---	DB	_Parm15	0.8018	0.03025	26.5063
Q24g	<---	DB	_Parm16	0.40039	0.03622	11.0553
Q25	<---	SDDB	_Parm17	0.45084	0.03639	12.3875
Q26	<---	SDDB	_Parm18	0.32151	0.03926	8.18823
Q30d	<---	PPA	_Parm19	0.7428	0.04838	15.3531
Q30e	<---	PPA	_Parm20	0.50689	0.04094	12.3799
SDDB	<---	DB	_Parm21	-0.5616	0.04612	-12.177

Variance Parameters

Standardized Results for Variance Parameters

Variance Type	Variable	Parameter	Estimate	Standard Error	t Value
Exogenous	DB	_Add01	1	.	.
Error	Q19d	_Add02	0.91259	0.02237	40.7982
	Q19h	_Add03	0.38247	0.04199	9.10782
	Q19i	_Add04	0.60161	0.03635	16.5496
	Q21p	_Add05	0.50709	0.04529	11.1976
	Q21q	_Add06	0.77608	0.03392	22.8773
	Q24a	_Add07	0.91644	0.02226	41.1657
	Q24b	_Add08	0.87407	0.02642	33.0846
	Q24c	_Add09	0.97515	0.01272	76.6701
	Q24d	_Add10	0.92082	0.02175	42.3422
	Q24e	_Add11	0.94242	0.01887	49.9532
	Q24f	_Add12	0.35711	0.04851	7.36186
	Q24g	_Add13	0.83969	0.029	28.9534
	Q25	_Add14	0.79674	0.03282	24.2787
	Q26	_Add15	0.89663	0.02525	35.5134
	Q30d	_Add16	0.44824	0.07188	6.23634
	Q30e	_Add17	0.74307	0.04151	17.9016
	PADD	_Add18	0.35114	0.05211	6.73803
	PPA	_Add19	0.64957	0.05489	11.8343
	SDDB	_Add20	0.68463	0.0518	13.2175

Covariance Structure Analysis: Maximum Likelihood Estimation
Covariance Structure Analysis: Maximum Likelihood Estimation
Covariance Structure Analysis: Maximum Likelihood Estimation

Modification Indices

Covariance Structure Analysis: Maximum Likelihood Estimation

Covariance Structure Analysis: Maximum Likelihood Estimation

All parameters in the model are significant. No parameter can be dropped in the Wald tests.

Covariance Structure Analysis: Maximum Likelihood Estimation

No LM statistic in the default test set for the paths is nonsingular. Ranking is not displayed.

There is no parameter to free in the default LM tests for the covariances of exogenous variables. Ranking is not displayed.

No LM statistic in the default test set for the covariances of errors is nonsingular. Ranking is not displayed.

SAS Log

```
114         /*======== BEGIN JMP Generated Code ========*/
115         ;*';*";*/;quit;run;
116         ODS _ALL_ CLOSE;
117         OPTIONS DEV=ACTXIMG;
118         FILENAME JMPXML TEMP;
119         ODS XML(ID=JMPXML) FILE=JMPXML  ENCODING='utf-8'
STYLE=Statistical   NOGTITLE
119       ! NOGFOOTNOTE GPATH=&sasworklocation ;
NOTE: Writing XML(JMPXML) Body file: JMPXML
120         /*========  END  JMP Generated Code ========*/
121
122
123
124         proc datasets library=work nowarn nolist;
125            delete _sem:;
126         run;

127

NOTE: PROCEDURE DATASETS used (Total process time):
      real time           0.09 seconds
      cpu time            0.00 seconds


128         data work._sem_rc_; isCompleted = 0; run;

NOTE: The data set WORK._SEM_RC_ has 1 observations and 1 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds



129
130         ods html frame='Single_Group_SEM.html' (title='Single Group
SEM') body='body.html'
130       ! contents='contents.html'
path='C:\Users\liwanjun\AppData\Local\Temp\SAS Temporary
130       ! Files\_TD4568_INTRANS-ISU151_\Prc2'(url=none);
NOTE: Writing HTML Body file: body.html
NOTE: Writing HTML Contents file: contents.html
NOTE: Writing HTML Frame file: Single_Group_SEM.html
131
132         title1;
133         proc calis data=final_dataset method=ml
outest=work._semEstimates_
133       ! outModel=work._semModel_ outFit=work._semFit_ short modification
platcov pcoves
133       ! residual toteff outStat=work._semStat_;
134               fitindex on(only)=[ AGFI BentlerCFI ChiSq Df ProbChi nObs
ProbClFit PGFI RMSEA
134       ! LL_RMSEA UL_RMSEA SRMSR ];
135            path
136               PADD <- DB     ,
137               PADD <- SDDB   ,
138               PPA  <- DB     ,
139               PPA  <- PADD   ,
140               Q19d <- PADD   ,
141               Q19h <- PADD   ,
142               Q19i <- PADD   ,
143               Q21p <- SDDB   ,
144               Q21q <- SDDB   ,
145               Q24a <- DB     ,
146               Q24b <- DB     ,
147               Q24c <- DB     ,
148               Q24d <- DB     ,
149               Q24e <- DB     ,
150               Q24f <- DB     ,
151               Q24g <- DB     ,
152               Q25  <- SDDB   ,
```

```
                Q26  <- SDDB   ,
                Q30d <- PPA    ,
                Q30e <- PPA    ,
                SDDB <- DB
             ;
          run;

WARNING: 305 of 1088 observations in data set WORK.FINAL_DATASET omitted
due to missing values.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: The Moore-Penrose inverse is used in computing the covariance matrix
for parameter
      estimates.
WARNING: Standard errors and t values might not be accurate with the use of
the Moore-Penrose
         inverse.
NOTE: The stability coefficient is 0, which is less than one. The condition
for converged total
      and indirect effects is satisfied.
WARNING: Lagrange multiplier statistics and Wald statistics might not be
accurate with the use of
         the Moore-Penrose inverse in computing the covariance matrix for
parameter estimates.
NOTE: The data set WORK._SEMESTIMATES_ has 90 observations and 44
variables.
NOTE: The data set WORK._SEMMODEL_ has 62 observations and 6 variables.
NOTE: The data set WORK._SEMFIT_ has 39 observations and 5 variables.
NOTE: The data set WORK._SEMSTAT_ has 308 observations and 22 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           3.12 seconds
      cpu time            1.48 seconds


          proc score data=final_dataset score=work._semStat_
out=work._semScores_;
             var Q19d Q19h Q19i Q21p Q21q Q24a Q24b Q24c Q24d Q24e Q24f
Q24g Q25 Q26 Q30d Q30e;
          run;

NOTE: There were 1088 observations read from the data set
WORK.FINAL_DATASET.
NOTE: There were 308 observations read from the data set WORK._SEMSTAT_.
NOTE: The data set WORK._SEMSCORES_ has 1088 observations and 191
variables.
NOTE: PROCEDURE SCORE used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds


          ods html close;
          data work._sem_rc_; set work._sem_rc_;
             isCompleted = 1;
             calisRc = "&CALIS_RC";
            calisOpt = "&CALIS_OPT"; calisHess = "&CALIS_HESS"; calisSe =
"&CALIS_SE";
          run;

NOTE: There were 1 observations read from the data set WORK._SEM_RC_.
NOTE: The data set WORK._SEM_RC_ has 1 observations and 5 variables.
NOTE: DATA statement used (Total process time):
      real time           0.08 seconds
      cpu time            0.01 seconds


          ods xml(ID=JMPXML) close;
          ods output PATHListStd=work._semStdest_(type=est);
          proc calis data=work._semStat_ inest=work._semEstimates_
inmodel=work._semModel_
        ! genpath short;
          run;
```

```
NOTE: The input model is recognized as a PATH model in the INMODEL= or
INRAM= data set.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: The Moore-Penrose inverse is used in computing the covariance matrix
for parameter
      estimates.
WARNING: Standard errors and t values might not be accurate with the use of
the Moore-Penrose
         inverse.
NOTE: The data set WORK._SEMSTDEST_ has 41 observations and 8 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           0.15 seconds
      cpu time            0.04 seconds



           /*======== BEGIN JMP Generated Code ========*/
           ;*';*";*/;quit;run;
           ODS _ALL_ CLOSE;
           ODS LISTING;
           QUIT; RUN;
           /*========  END  JMP Generated Code ========*/


============================================================================
```

Model 2

Modeling Specification

Modeling Information

Data Set	WORK.FINAL_DATASET
N Records Read	1088
N Records Used	703
N Obs	703
Model Type	PATH
Analysis	Covariances

Fit

Fit Summary

Modeling Info	N Observations	703
Absolute Index	Chi-Square	650.2082
	Chi-Square DF	143
	Pr > Chi-Square	<.0001
	Standardized RMSR (SRMSR)	0.0636
Parsimony Index	Adjusted GFI (AGFI)	0.8599
	Parsimonious GFI	0.6808
	RMSEA Estimate	0.0711
	RMSEA Lower 90% Confidence Limit	0.0656
	RMSEA Upper 90% Confidence Limit	0.0767
	Probability of Close Fit	<.0001
Incremental Index	Bentler Comparative Fit Index	0.7762

PATH List

Standardized Results for PATH List

Path

			Parameter	Estimate	Standard Error	t Value
DB	<---	AGE	_Parm01	0.29825	0.04181	7.13412
DB	<---	EDUCATION	_Parm02	-0.0086	0.04622	-0.1871
DB	<---	GENDER	_Parm03	0.01889	0.04322	0.43691
DB	<---	INCOME	_Parm04	-0.1273	0.04661	-2.7304
PADD	<---	AGE	_Parm05	-0.0004	0.05978	-0.0072
PADD	<---	DB	_Parm06	-0.3288	0.06922	-4.7504
PADD	<---	EDUCATION	_Parm07	0.0322	0.04178	0.77068
PADD	<---	GENDER	_Parm08	0.0835	0.04024	2.07525
PADD	<---	INCOME	_Parm09	-0.066	0.04797	-1.3747
PADD	<---	SDDB	_Parm10	0.597	0.09953	5.99787
PPA	<---	AGE	_Parm11	-0.0547	0.05114	-1.0701
PPA	<---	DB	_Parm12	0.41055	0.08639	4.75217
PPA	<---	EDUCATION	_Parm13	0.01944	0.04802	0.40474
PPA	<---	GENDER	_Parm14	-0.019	0.04467	-0.4252
PPA	<---	INCOME	_Parm15	0.08336	0.04902	1.70062
PPA	<---	PADD	_Parm16	-0.2826	0.09268	-3.0493
Q19d	<---	PADD	_Parm17	0.31491	0.03928	8.01722
Q19h	<---	PADD	_Parm18	0.77671	0.02693	28.8387
Q19i	<---	PADD	_Parm19	0.64523	0.0293	22.0217
Q21p	<---	SDDB	_Parm20	0.70723	0.02962	23.8748
Q21q	<---	SDDB	_Parm21	0.4964	0.03463	14.3354
Q24a	<---	DB	_Parm22	0.29147	0.04025	7.24176
Q24b	<---	DB	_Parm23	0.36571	0.03865	9.46119
Q24c	<---	DB	_Parm24	0.16314	0.04221	3.86508
Q24d	<---	DB	_Parm25	0.28661	0.04034	7.10451
Q24e	<---	DB	_Parm26	0.26494	0.04074	6.50327
Q24f	<---	DB	_Parm27	0.80793	0.03015	26.7992
Q24g	<---	DB	_Parm28	0.42283	0.03723	11.3568
Q25	<---	SDDB	_Parm29	0.4399	0.03631	12.1148
Q26	<---	SDDB	_Parm30	0.29666	0.03984	7.4458
Q30d	<---	PPA	_Parm31	0.74851	0.05044	14.8398
Q30e	<---	PPA	_Parm32	0.50493	0.0427	11.8256
SDDB	<---	AGE	_Parm33	-0.4084	0.04172	-9.7887
SDDB	<---	DB	_Parm34	-0.4096	0.04894	-8.3697
SDDB	<---	EDUCATION	_Parm35	0.05141	0.0426	1.20666
SDDB	<---	GENDER	_Parm36	-0.1001	0.03984	-2.5128
SDDB	<---	INCOME	_Parm37	0.21104	0.04354	4.84745

Variance Parameters

Standardized Results for Variance Parameters

Variance Type	Variable	Parameter	Estimate	Standard Error	t Value
Exogenous	GENDER	_Add01	1	.	.
	AGE	_Add02	1	.	.
	EDUCATION	_Add03	1	.	.
	INCOME	_Add04	1	.	.
Error	Q19d	_Add05	0.90083	0.02474	36.414
	Q19h	_Add06	0.39672	0.04184	9.48215
	Q19i	_Add07	0.58368	0.03781	15.4373
	Q21p	_Add08	0.49982	0.0419	11.9289
	Q21q	_Add09	0.75359	0.03438	21.9204
	Q24a	_Add10	0.91505	0.02346	39.0013
	Q24b	_Add11	0.86626	0.02827	30.6398
	Q24c	_Add12	0.97339	0.01377	70.6814
	Q24d	_Add13	0.91786	0.02312	39.6928
	Q24e	_Add14	0.92981	0.02159	43.0733
	Q24f	_Add15	0.34726	0.04871	7.12855
	Q24g	_Add16	0.82122	0.03148	26.0831
	Q25	_Add17	0.80649	0.03195	25.2453
	Q26	_Add18	0.91199	0.02364	38.5801
	Q30d	_Add19	0.43973	0.07551	5.82361
	Q30e	_Add20	0.74505	0.04312	17.2789
	DB	_Add21	0.88137	0.02808	31.3893
	PADD	_Add22	0.33992	0.05472	6.21225
	PPA	_Add23	0.63737	0.05823	10.9448
	SDDB	_Add24	0.41679	0.05023	8.29808

Covariances

Standardized Results for Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
AGE	GENDER	_Add25	0.05743	0.03762	1.52667
EDUCATION	GENDER	_Add26	0.0108	0.03774	0.28605
EDUCATION	AGE	_Add27	-0.1093	0.03729	-2.93
INCOME	GENDER	_Add28	-0.1446	0.03695	-3.9123
INCOME	AGE	_Add29	-0.1359	0.03705	-3.6686
INCOME	EDUCATION	_Add30	0.37604	0.03241	11.6041

Modification Indices

Stepwise Multivariate Wald Test

Cumulative Statistics

Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
_Parm05	5.23e-5	1	0.9942	5.23e-5	0.9942
_Parm02	0.03506	2	0.9826	0.03501	0.8516
_Add26	0.11686	3	0.9897	0.0818	0.7749
_Parm13	0.26475	4	0.9920	0.14789	0.7006
_Parm14	0.42334	5	0.9947	0.15859	0.6905
_Parm03	0.5663	6	0.9969	0.14297	0.7053
_Parm07	1.16256	7	0.9918	0.59625	0.4400
_Parm11	2.33825	8	0.9688	1.17569	0.2782
_Parm09	3.84297	9	0.9214	1.50472	0.2199
_Add25	6.27454	10	0.7917	2.43156	0.1189
_Parm35	8.71175	11	0.6485	2.43721	0.1185

Covariance Structure Analysis: Maximum Likelihood Estimation

LM Statistics for Path Coefficients

Rank Order of the 10 Largest LM Stat for Path Relations

To	From	LM Stat	Pr > ChiSq	Parm Change
GENDER	Q25	137.501	<.0001*	-1.6094
GENDER	Q24g	5.77441	0.0163*	0.25268
EDUCATION	Q24a	4.17878	0.0409*	-0.2938
INCOME	Q24a	3.55158	0.0595	-0.9311
GENDER	Q24d	3.4065	0.0649	-0.0651
EDUCATION	Q24c	2.83137	0.0924	0.11412
Q25	GENDER	1.25218	0.2631	-0.009
GENDER	Q24c	1.12645	0.2885	0.03507
Q26	Q25	0.7559	0.3846	0.00214
GENDER	Q26	0.72046	0.3960	0.10361

There is no parameter to free in the default LM tests for the covariances of exogenous variables. Ranking is not displayed.

LM Statistics for Covariances of Errors

The Largest LM Stat for Error Variances and Covariances

Error of	Error of	LM Stat	Pr > ChiSq	Parm Change
Q30e	Q26	0.17171	0.6786	0.00555

SAS Log

```
114         /*======== BEGIN JMP Generated Code ========*/
115         ;*';*";*/;quit;run;
116         ODS _ALL_ CLOSE;
117         OPTIONS DEV=ACTXIMG;
118         FILENAME JMPXML TEMP;
119         ODS XML(ID=JMPXML) FILE=JMPXML  ENCODING='utf-8'
STYLE=Statistical   NOGTITLE NOGFOOTNOTE
119       ! GPATH=&sasworklocation ;
NOTE: Writing XML(JMPXML) Body file: JMPXML
120         /*========  END  JMP Generated Code ========*/
121
122
123
124         proc datasets library=work nowarn nolist;
125            delete _sem:;
126         run;

127

NOTE: PROCEDURE DATASETS used (Total process time):
      real time           0.03 seconds
      cpu time            0.00 seconds


128         data work._sem_rc_; isCompleted = 0; run;

NOTE: The data set WORK._SEM_RC_ has 1 observations and 1 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds



129
130         ods html frame='Single_Group_SEM.html' (title='Single Group
SEM') body='body.html'
130       ! contents='contents.html'
path='C:\Users\liwanjun\AppData\Local\Temp\SAS Temporary
130       ! Files\_TD5892_INTRANS-ISU151_\Prc2'(url=none);
NOTE: Writing HTML Body file: body.html
NOTE: Writing HTML Contents file: contents.html
NOTE: Writing HTML Frame file: Single_Group_SEM.html
131
132         title1;
133         proc calis data=final_dataset method=ml
outest=work._semEstimates_ outModel=work._semModel_
133       !  outFit=work._semFit_ short modification platcov pcoves residual
toteff
133       ! outStat=work._semStat_;
134               fitindex on(only)=[ AGFI BentlerCFI ChiSq Df ProbChi nObs
ProbClFit PGFI RMSEA
134       ! LL_RMSEA UL_RMSEA SRMSR ];
135            path
136               DB   <- AGE         ,
137               DB   <- EDUCATION   ,
138               DB   <- GENDER      ,
139               DB   <- INCOME      ,
140               PADD <- AGE         ,
141               PADD <- DB          ,
142               PADD <- EDUCATION   ,
143               PADD <- GENDER      ,
144               PADD <- INCOME      ,
145               PADD <- SDDB        ,
146               PPA  <- AGE         ,
147               PPA  <- DB          ,
148               PPA  <- EDUCATION   ,
149               PPA  <- GENDER      ,
150               PPA  <- INCOME      ,
151               PPA  <- PADD        ,
152               Q19d <- PADD        ,
```

```
              Q19h <- PADD        ,
              Q19i <- PADD        ,
              Q21p <- SDDB        ,
              Q21q <- SDDB        ,
              Q24a <- DB          ,
              Q24b <- DB          ,
              Q24c <- DB          ,
              Q24d <- DB          ,
              Q24e <- DB          ,
              Q24f <- DB          ,
              Q24g <- DB          ,
              Q25  <- SDDB        ,
              Q26  <- SDDB        ,
              Q30d <- PPA         ,
              Q30e <- PPA         ,
              SDDB <- AGE         ,
              SDDB <- DB          ,
              SDDB <- EDUCATION   ,
              SDDB <- GENDER      ,
              SDDB <- INCOME
          ;
        run;

WARNING: 385 of 1088 observations in data set WORK.FINAL_DATASET omitted
due to missing values.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: The stability coefficient is 0, which is less than one. The condition
for converged total and
      indirect effects is satisfied.
NOTE: The data set WORK._SEMESTIMATES_ has 142 observations and 70
variables.
NOTE: The data set WORK._SEMMODEL_ has 92 observations and 6 variables.
NOTE: The data set WORK._SEMFIT_ has 39 observations and 5 variables.
NOTE: The data set WORK._SEMSTAT_ has 336 observations and 26 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           5.12 seconds
      cpu time            3.77 seconds


        proc score data=final_dataset score=work._semStat_
out=work._semScores_;
           var AGE EDUCATION GENDER INCOME Q19d Q19h Q19i Q21p Q21q Q24a
Q24b Q24c Q24d Q24e Q24f
     ! Q24g Q25 Q26 Q30d Q30e;
        run;

NOTE: There were 1088 observations read from the data set
WORK.FINAL_DATASET.
NOTE: There were 336 observations read from the data set WORK._SEMSTAT_.
NOTE: The data set WORK._SEMSCORES_ has 1088 observations and 191
variables.
NOTE: PROCEDURE SCORE used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds


        ods html close;
        data work._sem_rc_; set work._sem_rc_;
           isCompleted = 1;
           calisRc = "&CALIS_RC";
          calisOpt = "&CALIS_OPT"; calisHess = "&CALIS_HESS"; calisSe =
"&CALIS_SE";
        run;

NOTE: There were 1 observations read from the data set WORK._SEM_RC_.
NOTE: The data set WORK._SEM_RC_ has 1 observations and 5 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds
```

```
184       ods xml(ID=JMPXML) close;
185       ods output PATHListStd=work._semStdest_(type=est);
186       proc calis data=work._semStat_ inest=work._semEstimates_
inmodel=work._semModel_ genpath
186     ! short;
187       run;

NOTE: The input model is recognized as a PATH model in the INMODEL= or
INRAM= data set.
NOTE: At least one of the initial estimates for the variance or covariance
of exogenous manifest
      variables is replaced with the observed value, or with the weighted
average of the observed
      values among groups.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: The data set WORK._SEMSTDEST_ has 67 observations and 8 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           0.32 seconds
      cpu time            0.06 seconds



188
189
190
191       /*======== BEGIN JMP Generated Code ========*/
192       ;*';*";*/;quit;run;
193       ODS _ALL_ CLOSE;
194       ODS LISTING;
195       QUIT; RUN;
196       /*========  END  JMP Generated Code ========*/
197

==========================================================================
```

Modified Model

Modeling Information

Data Set	WORK.FINAL_DATASET
N Records Read	1088
N Records Used	703
N Obs	703
Model Type	PATH
Analysis	Covariances

Fit

Fit Summary

Modeling Info	N Observations	703
Absolute Index	Chi-Square	643.9477
	Chi-Square DF	154
	Pr > Chi-Square	<.0001
	Standardized RMSR (SRMSR)	0.0633
Parsimony Index	Adjusted GFI (AGFI)	0.8699
	Parsimonious GFI	0.7332
	RMSEA Estimate	0.0673
	RMSEA Lower 90% Confidence Limit	0.0620
	RMSEA Upper 90% Confidence Limit	0.0727
	Probability of Close Fit	<.0001
Incremental Index	Bentler Comparative Fit Index	0.7838

PATH List

Standardized Results for PATH List

Path

			Parameter	Estimate	Standard Error	t Value
DB	<---	AGE	_Parm01	0.29901	0.04122	7.25402
DB	<---	INCOME	_Parm02	-0.1157	0.04227	-2.7371
PADD	<---	DB	_Parm03	-0.3482	0.06282	-5.5424
PADD	<---	SDDB	_Parm04	0.54247	0.05916	9.16903
PPA	<---	DB	_Parm05	0.42621	0.08628	4.93988
PPA	<---	PADD	_Parm06	-0.2093	0.08572	-2.4414
Q19d	<---	PADD	_Parm07	0.31118	0.0394	7.89798
Q19h	<---	PADD	_Parm08	0.78233	0.02711	28.857
Q19i	<---	PADD	_Parm09	0.64656	0.02941	21.9871
Q21p	<---	SDDB	_Parm10	0.71421	0.02856	25.0091
Q21q	<---	SDDB	_Parm11	0.49869	0.03468	14.3781
Q24a	<---	DB	_Parm12	0.28874	0.04025	7.17322
Q24b	<---	DB	_Parm13	0.3622	0.03869	9.36158
Q24c	<---	DB	_Parm14	0.15896	0.0422	3.76636
Q24d	<---	DB	_Parm15	0.28522	0.04032	7.07389
Q24e	<---	DB	_Parm16	0.26352	0.04072	6.47221
Q24f	<---	DB	_Parm17	0.8108	0.03013	26.9081
Q24g	<---	DB	_Parm18	0.42233	0.0372	11.353
Q25	<---	GENDER	_Parm19	-0.1779	0.03411	-5.2149
Q25	<---	SDDB	_Parm20	0.40778	0.03672	11.1065
Q26	<---	SDDB	_Parm21	0.29943	0.03999	7.48684
Q30d	<---	PPA	_Parm22	0.74611	0.05115	14.5856
Q30e	<---	PPA	_Parm23	0.50655	0.04318	11.7317
SDDB	<---	AGE	_Parm24	-0.4193	0.03976	-10.547
SDDB	<---	DB	_Parm25	-0.4191	0.04871	-8.6056
SDDB	<---	INCOME	_Parm26	0.2271	0.03865	5.87528

Variance Parameters

Standardized Results for Variance Parameters

Variance Type	Variable	Parameter	Estimate	Standard Error	t Value
Exogenous	GENDER	_Add01	1	.	.
	AGE	_Add02	1	.	.
	EDUCATION	_Add03	1	.	.
	INCOME	_Add04	1	.	.
Error	Q19d	_Add05	0.90317	0.02452	36.8328
	Q19h	_Add06	0.38797	0.04242	9.14621
	Q19i	_Add07	0.58197	0.03803	15.3046
	Q21p	_Add08	0.4899	0.04079	12.0096
	Q21q	_Add09	0.75131	0.03459	21.719
	Q24a	_Add10	0.91663	0.02325	39.4326
	Q24b	_Add11	0.86881	0.02803	30.9992
	Q24c	_Add12	0.97473	0.01342	72.6456
	Q24d	_Add13	0.91865	0.023	39.9414
	Q24e	_Add14	0.93056	0.02146	43.3639
	Q24f	_Add15	0.3426	0.04886	7.01155
	Q24g	_Add16	0.82164	0.03142	26.149
	Q25	_Add17	0.79175	0.03156	25.0836
	Q26	_Add18	0.91034	0.02395	38.0088
	Q30d	_Add19	0.44332	0.07633	5.80778
	Q30e	_Add20	0.7434	0.04374	16.9943
	DB	_Add21	0.8878	0.02716	32.6915
	PADD	_Add22	0.36291	0.04948	7.33404
	PPA	_Add23	0.65567	0.05682	11.5403
	SDDB	_Add24	0.43063	0.04808	8.95713

Covariances

Standardized Results for Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
EDUCATION	INCOME	_Parm27	0.37604	0.03241	11.6041
AGE	GENDER	_Add25	0.05743	0.03762	1.52667
EDUCATION	GENDER	_Add26	0.0108	0.03774	0.28605
EDUCATION	AGE	_Add27	-0.1093	0.03729	-2.93
INCOME	GENDER	_Add28	-0.1446	0.03695	-3.9123
INCOME	AGE	_Add29	-0.1359	0.03705	-3.6686

Modification Indices

Covariance Structure Analysis: Maximum Likelihood Estimation

Covariance Structure Analysis: Maximum Likelihood Estimation

Stepwise Multivariate Wald Test

Cumulative Statistics

Parm	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
_Add26	0.0818	1	0.7749	0.0818	0.7749
_Add25	2.51336	2	0.2846	2.43156	0.1189

Covariance Structure Analysis: Maximum Likelihood Estimation

LM Statistics for Path Coefficients

Rank Order of the 10 Largest LM Stat for Path Relations

To	From	LM Stat	Pr > ChiSq	Parm Change
GENDER	Q21p	65.3753	<.0001*	-3.7968
Q19d	EDUCATION	15.0898	0.0001*	-0.1269
Q24c	EDUCATION	11.3139	0.0008*	0.14667
Q30e	EDUCATION	4.82634	0.0280*	-0.0783
Q24d	GENDER	4.28206	0.0385*	-0.1345
GENDER	Q21q	4.1026	0.0428*	-0.14
Q30e	GENDER	2.51604	0.1127	-0.0582
EDUCATION	Q19h	2.13634	0.1438	0.05626
EDUCATION	Q24c	2.1235	0.1451	0.08761
EDUCATION	Q21p	1.92519	0.1653	0.11175

There is no parameter to free in the default LM tests for the covariances of exogenous variables. Ranking is not displayed.

No LM statistic in the default test set for the covariances of errors is nonsingular. Ranking is not displayed.

SAS Log

```
182        /*======== BEGIN JMP Generated Code ========*/
183        ;*';*";*/;quit;run;
184        ODS _ALL_ CLOSE;
185        OPTIONS DEV=ACTXIMG;
186        FILENAME JMPXML TEMP;
187        ODS XML(ID=JMPXML) FILE=JMPXML  ENCODING='utf-8'
STYLE=Statistical   NOGTITLE
187      ! NOGFOOTNOTE GPATH=&sasworklocation ;
NOTE: Writing XML(JMPXML) Body file: JMPXML
188        /*========  END  JMP Generated Code ========*/
189
190
191
192        proc datasets library=work nowarn nolist;
193           delete _sem:;
194        run;

NOTE: Deleting WORK._SEMESTIMATES_ (memtype=DATA).
NOTE: Deleting WORK._SEMFIT_ (memtype=DATA).
NOTE: Deleting WORK._SEMMODEL_ (memtype=DATA).
NOTE: Deleting WORK._SEMSCORES_ (memtype=DATA).
NOTE: Deleting WORK._SEMSTAT_ (memtype=DATA).
NOTE: Deleting WORK._SEMSTDEST_ (memtype=DATA).
NOTE: Deleting WORK._SEM_RC_ (memtype=DATA).
195

NOTE: PROCEDURE DATASETS used (Total process time):
      real time           0.04 seconds
      cpu time            0.03 seconds


196        data work._sem_rc_; isCompleted = 0; run;

NOTE: The data set WORK._SEM_RC_ has 1 observations and 1 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds


197
198        ods html frame='Single_Group_SEM.html' (title='Single Group
SEM') body='body.html'
198      ! contents='contents.html'
path='C:\Users\liwanjun\AppData\Local\Temp\SAS Temporary
198      ! Files\_TD4568_INTRANS-ISU151_\Prc2'(url=none);
NOTE: Writing HTML Body file: body.html
NOTE: Writing HTML Contents file: contents.html
NOTE: Writing HTML Frame file: Single_Group_SEM.html
199
200        title1;
201        proc calis data=final_dataset method=ml
outest=work._semEstimates_
201      ! outModel=work._semModel_ outFit=work._semFit_ short modification
platcov pcoves
201      ! residual toteff outStat=work._semStat_;
202              fitindex on(only)=[ AGFI BentlerCFI ChiSq Df ProbChi nObs
ProbClFit PGFI RMSEA
202      ! LL_RMSEA UL_RMSEA SRMSR ];
203           path
204              DB   <- AGE      ,
205              DB   <- INCOME   ,
206              PADD <- DB       ,
207              PADD <- SDDB     ,
208              PPA  <- DB       ,
209              PPA  <- PADD     ,
210              Q19d <- PADD     ,
211              Q19h <- PADD     ,
212              Q19i <- PADD     ,
213              Q21p <- SDDB     ,
```

```
             Q21q <- SDDB     ,
             Q24a <- DB       ,
             Q24b <- DB       ,
             Q24c <- DB       ,
             Q24d <- DB       ,
             Q24e <- DB       ,
             Q24f <- DB       ,
             Q24g <- DB       ,
             Q25  <- GENDER   ,
             Q25  <- SDDB     ,
             Q26  <- SDDB     ,
             Q30d <- PPA      ,
             Q30e <- PPA      ,
             SDDB <- AGE      ,
             SDDB <- DB       ,
             SDDB <- INCOME
          ;
          pcov
             EDUCATION INCOME
          ;
       run;

WARNING: 385 of 1088 observations in data set WORK.FINAL_DATASET omitted
due to missing values.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: The Moore-Penrose inverse is used in computing the covariance matrix
for parameter
      estimates.
WARNING: Standard errors and t values might not be accurate with the use of
the Moore-Penrose
         inverse.
NOTE: The stability coefficient is 0, which is less than one. The condition
for converged total
      and indirect effects is satisfied.
WARNING: Lagrange multiplier statistics and Wald statistics might not be
accurate with the use of
         the Moore-Penrose inverse in computing the covariance matrix for
parameter estimates.
NOTE: The data set WORK._SEMESTIMATES_ has 120 observations and 59
variables.
NOTE: The data set WORK._SEMMODEL_ has 81 observations and 6 variables.
NOTE: The data set WORK._SEMFIT_ has 39 observations and 5 variables.
NOTE: The data set WORK._SEMSTAT_ has 336 observations and 26 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           3.94 seconds
      cpu time            3.21 seconds


       proc score data=final_dataset score=work._semStat_
out=work._semScores_;
          var AGE EDUCATION GENDER INCOME Q19d Q19h Q19i Q21p Q21q Q24a
Q24b Q24c Q24d Q24e
     ! Q24f Q24g Q25 Q26 Q30d Q30e;
       run;

NOTE: There were 1088 observations read from the data set
WORK.FINAL_DATASET.
NOTE: There were 336 observations read from the data set WORK._SEMSTAT_.
NOTE: The data set WORK._SEMSCORES_ has 1088 observations and 191
variables.
NOTE: PROCEDURE SCORE used (Total process time):
      real time           0.08 seconds
      cpu time            0.00 seconds
```

```
       ods html close;
       data work._sem_rc_; set work._sem_rc_;
          isCompleted = 1;
          calisRc = "&CALIS_RC";
         calisOpt = "&CALIS_OPT"; calisHess = "&CALIS_HESS"; calisSe =
"&CALIS_SE";
       run;

NOTE: There were 1 observations read from the data set WORK._SEM_RC_.
NOTE: The data set WORK._SEM_RC_ has 1 observations and 5 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      cpu time            0.00 seconds


       ods xml(ID=JMPXML) close;
       ods output PATHListStd=work._semStdest_(type=est);
       proc calis data=work._semStat_ inest=work._semEstimates_
inmodel=work._semModel_
     ! genpath short;
       run;

NOTE: The input model is recognized as a PATH model in the INMODEL= or
INRAM= data set.
NOTE: At least one of the initial estimates for the variance or covariance
of exogenous manifest
      variables is replaced with the observed value, or with the weighted
average of the observed
      values among groups.
NOTE: Convergence criterion (GCONV=1E-8) satisfied.
NOTE: At least one element of the gradient is greater than 1e-3.
NOTE: The Moore-Penrose inverse is used in computing the covariance matrix
for parameter
      estimates.
WARNING: Standard errors and t values might not be accurate with the use of
the Moore-Penrose
         inverse.
NOTE: The data set WORK._SEMSTDEST_ has 56 observations and 8 variables.
NOTE: PROCEDURE CALIS used (Total process time):
      real time           0.17 seconds
      cpu time            0.03 seconds



       /*======== BEGIN JMP Generated Code ========*/
       ;*';*";*/;quit;run;
       ODS _ALL_ CLOSE;
       ODS LISTING;
       QUIT; RUN;
       /*========  END  JMP Generated Code ========*/

==========================================================================
```