Final Report

Identifying State-Specific Distracted Driving Target Group

Principal Investigator
Mansoureh Jeihani, Ph.D., PTP
Email: Mansoureh.jeihani@morgan.edu

Ramina Javid, Student
Email: rajah1@morgan.edu

Eazaz Sadeghvaziri, Ph.D.
Email: eazaz.sadeghvaziri@morgan.edu

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Prepared for the National Transportation Center, Morgan State University, CBEIS 327, 1700 E Cold Spring Lane, Baltimore, MD 21251

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16. Abstract

Using electronic devices or cell phones in the vehicle is the most common distraction among drivers of all ages. All studies emphasize that distracted driving is particularly acute among younger drivers. Because of their immaturity and lack of driving experience, teen drivers, have a high fatal crash rate. This study investigates the target group of distracted drivers and the most distractive behavior and technology. No previous studies have thoroughly investigated the socio-demographic of distracted drivers or the most distracting technology or devices in Maryland. Also, no research has been conducted on distracted driving during the COVID-19 pandemic in Maryland. Some 158 Maryland drivers filled out the online survey related to distracted driving both before the COVID-19 pandemic (from 3/1/2019 to 3/1/2020) and during the pandemic (from 3/1/2020 to 3/1/2021). The statewide statistics indicates that during the COVID-19 pandemic (2020), the total number of injured and total crashes due to distraction decreased which is the same as the result of this study, however, the fatalities due to distraction increased. The descriptive and statistical analysis revealed that those between 16 to 19 years old use hands-free and handheld cell phone, texting, voice to text, reading or updating social media, reading, or responding to emails, taking pictures/recording video, using GPS, eating, or drinking while driving more than other age groups. The most common distracted driving behaviors among older drivers (more than 65) are talk on the phone (hands-free), using GPS and eating and drinking. Moreover, those between 50 to 64 and 65 and older use cell phone apps that assist with avoiding distraction while driving more than other age groups. Also, the risk of having a near-crash experience due to using a cell phone while driving was higher in males than females, and those between 16 to 19 among distracted drivers. Moreover, several regression models investigated if the handheld cell phone causes the most distraction. It increases the risk of distraction by a factor of 13 and increases the risk of a near-crash experience due to distraction by 7.6. Younger drivers are the most distracted, and among other age groups, as the age of the driver decreases, the risk of engaging in more than five distractive behaviors while driving increases. Younger drivers engage more in distractive behaviors. The results of the study will help the Maryland Highway Safety Office (MHSO) target drivers and effectively raise awareness of and educate those drivers about the distractive activities they usually participate in while driving.

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LIST OF ACRONYMS

MHSO	Maryland Highway Safety Office
NHTSA	National Highway Traffic Safety Administration
AAA	American Automobile Association
GHSA	Governors Highway Safety Association
SHRP 2 NDS	Second Strategic Highway Research Program Naturalistic Driving Study
FARS	Fatality Analysis Reporting System
DND	Do Not Disturb While Driving application
ADAS	Advanced Driver Assistance Systems
CDC	Centers for Disease Control and Prevention
NSC	National Safety Council
MNL	Multinomial Logistic Regression

EXECUTIVE SUMMARY

Distracted driving is one of several significant factors contributing to crashes and causes of death. In 2019, some 3,142 people were killed by distracted driving in the United States. There are several possible sources of distraction. In-vehicle and distraction outside the vehicle which can be technology- and non-technology-based distractions. According to the studies, cell phone use and texting are the most alarming distractions. Both dialing and talking, increases the probability of a crash by a factor of four. Drivers 16 to 24 years old used their cell phones (handheld) the most, while those 70 and older used them the least in the U.S. Also, 20- to 29-year-old age group having the highest proportion of fatalities in the state of Maryland. The goal of this study was to investigate the socio-demographic and target group of distracted drivers and understand the most distracted driving behavior and technologies in Maryland to help MHSO effectively raise awareness of distractive activities. Based on the literature review, no previous studies have thoroughly investigated the socio-demographic of distracted drivers or the most distracting technology or devices in Maryland. Also, no research has been conducted on distracted driving during the COVID-19 pandemic in Maryland.

An online survey was conducted to examine the state-specific socio-demographic characteristics of distracted drivers in the last two years (from 3/1/2019 to 3/1/2021), which includes both before and during the pandemic. Some 158 people were recruited from Maryland to fill out a stated preference online survey. The answers were monitored one by one and inattentive respondents were removed from the final data set by the authors. The first section collected basic information about the drivers, including gender, age, income, etc. The second section was designed to investigate respondents' driving behavior and the types of devices and technologies they use while driving. The last section was specifically designed for drivers who had experienced a crash due to distraction in the last two years to investigate the cause of their distraction. The statewide statistics indicates that during the COVID-19 pandemic (2020), the total number of injured and total crashes due to distraction decreased, however, the fatalities due to distraction increased. The results of this study are aligned with the statewide statistics which indicate that distracted driving crashes dropped in 2020 during the pandemic. The respondents were asked whether they usually get distracted while driving, and 21.5% of them answered affirmatively during the pandemic (from 3/1/2020 to 3/1/2021). Self-reported distractions among females are higher than among males. Among different age groups, those between 16 to 19 and 20 to 34 were more distracted. Participants who had more children in the household were more distracted. Also, respondents who had their driver’s license for one year were more distracted than others. Several analyses were performed to assess the impact of various socio-demographic and driver behaviors on the likelihood of distraction while driving including descriptive statistics, including binary logistic regression, and multinomial regression.

Respondents were presented with a series of behaviors and asked whether they engage in each while driving. The most common behaviors were using GPS and talking on the phone (hands-free). When asked specifically about answering calls while driving, most respondents (42%) answered they would answer the call immediately using a hands-free cell phone. The most popular restricted driving apps used by participants are Do Not Disturb While Driving on the phone's setting. Respondents were also asked about distraction due to several car technologies including Blind Spot Warning, Collision Warning Systems, Lane Departure Warning Systems or Lane

Keeping Assistant, Automatic Emergency Braking or Crash Imminent Braking and Hands-Off Detection. Most participants (almost 50% for each category) answered "my car does not have this technology." Moreover, "Automatic Emergency Braking or Crash Imminent Braking" has the greatest amount of distraction. Also, the most frequent types of crashes due to distraction were left turns and rear end collisions. Among all the aggressive behaviors while driving (swear under my breath, drive well over speed limit, use horn when annoyed, fail to signal, tailgating, weave in/out traffic, failing to stop at stop sign, and speed up to get through light), driving well over speed limit and swearing under one's breath were repeated more than other behaviors. Moreover, respondents were asked about their county of residence. Worcester and Calvert counties have the most distracted drivers, followed by Carroll, Cecil, and Allegany counties.

Among distracted drivers, those between 16 to 19 years old use hands-free and handheld cell phone, texting, voice to text, reading or updating social media, reading, or responding to emails, taking pictures/recording video, using GPS, eating, or drinking while driving more than other age groups. The most common distracted driving behaviors among older drivers (more than 65) are talk on the phone (hands-free), using GPS and eating and drinking. Moreover, those between 50 to 64 and 65 and older use cell phone apps that assist with avoiding distraction while driving more than other age groups. Also, the risk of having a near-crash experience due to using a cell phone while driving was higher in males than females, and those between 16 to 19 among distracted drivers. The results of the binary logistic regression models indicated that the odd of self-reported distraction is 13.33 times higher among drivers who use handheld cell phone while driving than other drivers. Also, using voice to text while driving increase the odd of self-reported distraction by 6.49 times higher than other drivers. The results indicate that the odds of having self-reporting distraction for drivers with incomes of 40,000 to 79,999 and 80,000 to 119,999, increase by 6.55 and 6.36, respectively, compared to drivers with incomes of less than 40,000. Using a handheld cell phone while driving increased the odds of near-crashes by 7.61. Moreover, the results indicate that the odds of having a near-crash experience for drivers who drove an average 8,001 to 15,000 annually increase by 8.76 compared to drivers who drove less than 8,000 on average annually. The model also indicates that the odds of having a near-crash experience due to using a cell phone is 12.68 times higher in the Asian population than the African American population.

The results of multinomial regression showed that the results indicate that the relative log odds of engaging in five or more distracted driving behaviors vs. engaging in none decreases by 14.85 when comparing those between 16 to 19 to those age 65 or more. The relative log odds of engaging in five or more distracted driving behaviors vs. engaging in none increases by 1.84 when comparing those who reported getting distracted while driving to those who did not report distraction.

Because the data collected during the pandemic are not comparable to the data of previous years, all the questions were asked of the respondents before and after the pandemic to compare the changes in drivers' behavior before and after the pandemic. The result of this study revealed that having at least one crash due to distraction dropped significantly from before the pandemic to during the pandemic. This could be due to less cars on the road and the fact that the average mileage of driving, daily commutes, work-related long-distance trips, and non-work travels decreased during the pandemic. Moreover, there is a statistically significant decrease in self-reported distraction during the pandemic compared to before the pandemic.

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1. INTRODUCTION

Distracted driving is one of the main traffic safety problems and one of several significant factors contributing to crashes and causes of death for those under the age of 35 in the United States (*1*). Some 3,142 people were killed by distracted driving in 2019. Moreover, 8% of fatal crashes, 15% of injury crashes, and 14% of all crashes necessitating a police response in 2018 were reported as distracted driving crashes (*2*). According to the National Highway Traffic Safety Administration (NHTSA), distractions can be caused by anything that takes a driver's attention away from the task of safe driving. The number and type of distractions are increasing due to the advancement of technology, such as Global Positioning System (GPS) navigation systems, cell phones, and satellite radio (*2*). Accidents have historically been triggered by behaviors such as eating/drinking while driving, sleepiness, adjusting car speakers, not watching for blind spots, and so on. However, in the last decade, several other sources have been added to such risky habits, including using embedded devices such as smartphones, smartwatches, and hand-held GPS devices when driving (*3*).

A growing number of studies have created deeper ties between crash risk and how and where drivers participate in technology- and non-technology-based distractions. There are several possible sources of in-vehicle distraction. According to the studies, cell phone use and texting are the most alarming distractions (*4-8*). Studies have shown that cell phone use among experienced drivers, both dialing and talking, increases the probability of a crash by a factor of four (*1; 9*). According to the naturalistic driving research performed in the U.S., the risk of collision increases by 73% for drivers engaging in visual-manual activities with cell phones (*10*). Moreover, based on a nationwide study, 28.6% of all respondents admitted to texting and driving as their No. 1 distracted driving behavior (*11*). The same result was found by the American Automobile Association (AAA) Foundation for Traffic Safety; 43.2% of drivers admitted to using a handheld cell phone while driving. Fewer people engaged in distracted driving by reading (38.6%) or typing a text/email (29.3%) on their handheld cell phones while driving during a 30-day study in 2019 (*12*).

In addition to cell phone use, changing the radio station and inserting or removing CDs were critical causes of distraction-related accidents (*13*). Data from crashes and near-crashes in the 100-Car Naturalistic Driving study conducted by the Virginia Tech Transportation Institute showed that engaging in a complex secondary task – such as reaching for a moving target, applying makeup, or dialing – tripled the risk of a crash or near-crash and mild secondary tasks – talking/listening, eating, or inserting a CD – doubled the risk (*14*). The in-vehicle task of engaging with devices impacts driving behavior efficiency, such as maintaining speed and preparedness to adapt to unexpected threats (*4; 15; 16*). Activities like smoking, eating, drinking, reaching for items, engaging in grooming activities, attempting to get rid of an insect inside the car, reading, writing, and engaging with passengers are non-technology-based causes of distractions. A driver can often lose concentration by getting lost in thought or worrying about personal or financial issues, too. Furthermore, some crash-related factors such as driver age and gender, fatigue, and experience can distract a driver (*17*). Also, drivers who have been in more than one accident in the last two years are more likely to engage in some form of self-reported distracted driving behavior (*12*). However, it must be stressed that the distraction of drivers is not only connected to what is happening inside the car. The distractions caused by elements of the highway environment are also

a serious concern. Roadside advertisements, street-side vendors, and an increased traffic flow all contribute to this issue (*4*). Other factors such as environmental and road conditions (e.g., curves, turns, crossings, and heaviness of traffic), can also cause different distracted behaviors. Several studies indicate that driver performance and crash rates are negatively impacted by highway environmental variables such as billboards, urban/rural conditions, intersections, and elevated traffic density (*18-23*).

1.1. Problem Statement

Distracted driving claimed 3,142 lives in 2019 in the U.S., accounting for 8.5% of all crash fatalities, and caused an additional 400,000 injuries alone (*24*). This means an average of eight people a day were killed in the U.S. due to distracted driving. In 2015, 48,674 crashes were caused by distracted driving and that rose to 56,690 in 2019 in the State of Maryland. Moreover, an average of 181 people were killed in distracted driving-involved crashes in Maryland from 2015 to 2019 (*25*). The problem is particularly acute among younger drivers, who are visually distracted due to their high use of cell phones (*3; 26; 27*). Among drivers of all ages, teenagers are the group most exposed to visual driving distractions (*5; 19*). Distracted driving-related fatalities are on the increase, with the 20- to 29-year-old age group having the highest proportion of fatalities. In the distracted driving involved crashes in Maryland, 25- to 29-year-old drivers had the most injury and fatal crashes among different age groups from 2015 to 2019. Also, drivers 16 to 24 years old used their cell phones (handheld) the most, while those 70 and older used them the least in the U.S. (*28*). The percentage of younger drivers who never text and drive under any circumstances is very low (*29*).

The risks, however, were not limited to teenagers. In 2016, older adults (60 years and older) were involved in 18% of distracted driving-related fatal accidents in the U.S (*2*). Cell phone and in-vehicle technology usage among older drivers has increased as well. In a 30-day study, 42% of adults 60 to 74 said they had spoken on a handheld cell phone while driving, and 23% said they had read a text message or email on a cell phone while driving (*12*). Distracted drivers put not only themselves at risk, but everyone else using the road. These statistics show the prominent role of distraction in accidents. To have effective countermeasures, the characteristics of distracted drivers and the technologies that distract drivers must be identified.

1.2. Goal

The main goal of this study is to investigate distracted drivers in Maryland. To reach this goal, the following objectives will be undertaken:

- Find the socio-demographic and target group of distracted drivers in each distraction type in Maryland.
- Understand what kind of devices, technologies, and behaviors distract drivers the most in Maryland.

This will help the Maryland Highway Safety Office (MHSO) target each group specifically, and effectively raise awareness of and educate drivers about the distractive activities they usually participate in while driving. For this purpose, we will conduct a comprehensive online survey questionnaire throughout the state. This questionnaire examines the status of the target group in the last two years, both before and during the COVID-19 pandemic.

2. LITERATURE REVIEW

This review of the literature focuses on the impact of different types of distractions on driving behaviors. Numerous researchers have investigated different types of distraction. The results summarized in this review encompass multiple domains of distracted driving. Previous studies related to distracted driving fall into five main categories: investigating the characteristics of distracted drivers (e.g., age, gender, etc.), exploring the in-vehicle and out-of-vehicle distractions, focusing on the technology related to distracted driving, and the effect of the COVID-19 pandemic on distracted driving.

2.1. Characteristics of Distracted Drivers

The growing epidemic of distracted driving, which has expanded with the proliferation of cell phones and increased mobilization of people around the world, is one of the most dangerous driving habits (*30*). Internal and external factors may contribute to distracted driving and can be caused by a variety of factors, including task loads, the environment, and medical conditions. In the literature on distracted driving behavior, there are numerous influential characteristics such as age, gender, having children, race, education, geographic area, and so on (*31*). While it is difficult to pinpoint the exact effects of distracted driving in accidents, evidence shows that distraction increases the likelihood of a crash, and that younger drivers are more vulnerable to distractions due to their higher cell phone use rates.

According to fatality and injury crash figures, the youngest and oldest drivers have the highest crash risk based on their driving exposure (*32*). The reasons for this variable crash involvement among these age groups may be due to differences in each group's characteristics. However, the younger age group may be more likely to be involved in crashes due to a combination of premature brain growth, inexperience, and a higher incidence of risky driving behaviors (*1; 33*). Poor anticipation of road hazards, speeding, and distractions are all common errors that result in crashes among teenage drivers (*34*). Despite a 28% decrease in 15- to 18-year-old driver deaths between 2010 and 2019, teenagers continue to be substantially overrepresented in fatal accidents. The NHTSA states that immaturity and inexperience are the main causes of these fatal collisions. In 2018, 9% of all teenagers killed in car accidents were distracted drivers (*35*). Furthermore, 20- to 29-year-olds accounted for 25% of distracted drivers involved in fatal accidents (*24*). For teen drivers, speeding is a major safety concern. In 2018, it was a factor in 28% of fatal accidents involving teen drivers in passenger vehicles. Moreover, teens were involved in 19,447 speeding-related collisions between 2000 and 2011, according to a report by the Governors Highway Safety Association (GHSA) (*35*).

Many teens are distracted by the addition of passengers in the vehicle. Teen drivers were two-and-a-half times more likely to engage in one or more potentially risky activities while driving with one teenage peer than while driving alone, according to a NHTSA report (*35*). Teen drivers' chances of participating in one or more risky activities increased by three times while riding with multiple passengers when compared to driving alone. Research indicates that the number of teenagers in the car increases the risk of a fatal collision (*35*). Several studies (*1; 9; 15; 29; 36-39*) explore the link between the driver’s age and distracted driving. All studies emphasize that the problem is particularly acute among younger drivers. Teen drivers are involved in car collisions not because they are unaware of common road laws or safe driving practices; rather, statistics

suggest that teenagers are involved in collisions due to inexperience and risk-taking behavior. Because of their immaturity and lack of driving experience, teen drivers, especially those 16 and 17, have a high fatal crash rate. These traits also lead to high-risk actions behind the wheel (*35; 39*).

To examine the relationship between risk of crash and near-crashes and secondary task performance, Klauer et al. (*9*) conducted two studies on newly licensed drivers and adults who have more driving experience. The results showed that if novice drivers engage in a secondary task, including texting or dialing a cell phone, the risk of a crash or near-crash increases significantly. Moreover, among new drivers, high-risk attention to secondary activities has increased over time but did not increase among experienced drivers. Dialing a cell phone among professional drivers had a considerably greater chance of a collision or near-crash. This was previously explored by Neyens et al. (*36*) who attempted to discuss how teenage drivers and their passengers can be injured from inattention or distraction while driving. This research revealed that all adolescent drivers were more likely to be seriously injured when interrupted by cell phones or passengers. Moreover, in all distraction categories and inattentiveness, female drivers were more likely to be injured than male drivers. More specifically, Stavrinos et al. (*37*) used a driving simulator to examine the behavior of teens and adults, which revealed that, in general, more lane deviations and crashes occurred during texting. Distractions, in most cases text messaging, negatively impacted traffic flow significantly.

Another study (*29*) investigated the relationship between texting and driving patterns by answering how and when drivers choose to text and why younger drivers engage in such a risky behavior. To answer these questions, a survey among undergraduate students was conducted. The data showed that only 2% of drivers never text and drive under any circumstances. Seventy-five percent of drivers texted using both hands. The drivers were aware of the risk of these behaviors, but the perception of risk was a very weak predictor of behavior (for initiating texts) or had no effect on texting. Regardless of age, all drivers when distracted drive in a manner that impacts safety and traffic flow negatively. Results from a national survey of over 1,200 drivers revealed that drivers 25 to 29 years old were the most likely to talk on a cell phone while driving on a regular basis (39%), compared to 20% for drivers 18 to 24 and 24% for those 30 to 59 (*40*). In a similar study, among young drivers who report cell phone use while driving, 42% reported reading a text, 33% said they were sending a text, and 23% said they were using a mobile app (*27*). Guo et al. (*1*) comprised 3,454 participants identified from the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS) data to explain that one of the significant factors contributing to crashes and cause of death for the population under 35 in the U.S. is distracted driving. Also, they found that compared to middle-aged drivers, secondary-task-induced distraction posed a consistently higher threat to drivers under 30 and above 65.

To identify distracted driving beliefs and their factors and examine if individual difference factors broadly predict the causes of distracted driving belief in teenagers, Stavrinos et al. (*41*) surveyed teenagers between 15 and 19. The results showed that many teens (82%) found hands-free cell phone conversations to be at least somewhat appropriate. Moreover, the study factor analysis discovered four factors of distracted driving beliefs: 1) self-acceptance of communicating while driving with a cell phone; 2) perceived peer recognition of interacting while driving with a

cell phone; 3) perceived danger of distracted driving to personal safety; and 4) self- and peer-acceptance of chatting on a cell phone while driving.

Several studies focus on middle-aged adults. A comprehensive study (*38*) used an anonymous survey that was designed for 30- to 64-year-old drivers. Results showed that 65.1% of drivers texted while stopped at a red light or driving on the freeway. The findings also showed that the main distracted behaviors in middle-aged drivers were talking on the phone or texting. However, the elderly drove more slowly and showed a lower speed variability during distractions than middle-aged drivers (*15*). Moreover, the elderly who live alone have more trips that those who live with others (*42*). Also, investigating trends for cell phone usage from 1999 to 2008 showed that drivers in distracted deadly crashes were more likely to be young, male, white, and non-Hispanic, but were less likely to have previous driving violations. Also, crashes increasingly involved lone male drivers colliding with roadside obstructions in urban areas (*43*). While it is difficult to pinpoint the exact effects of distracted driving in accidents, evidence shows that distraction increases the likelihood of a crash, and that younger drivers are more vulnerable due to their higher cell phone use rates.

The effect of gender on distracted driving has also been the subject of a number of studies. For instance, female drivers overlooked more technological interactions than did male drivers (*44*). Also, a study of over 1,200 drivers in 48 U.S. states revealed that males talk on the phone more than females (*40*). A similar study conducted in Canada showed that males were 62% more likely to use a handheld phone and 50% more likely to use a hands-free phone than females (*39*). Another study of 379 adolescents aged 15 to 19 showed that, as opposed to male adolescents, female adolescents were twice as likely to endorse a law prohibiting texting/emailing while driving (*45*). Female drivers tended to use handheld cell phones at higher rates than male drivers, according to the 2018 NOPUS (*28*). However, Jeihani et al. (*19*) indicated that males on the cell phone had less gaze fixation time than females.

2.2. Inside the Vehicle Distractions

With the advancement of technology, the use of electronic devices has become one of the main causes of distractions and crashes. Emerging technologies have enormous potential for enhancing driving safety and mobility. According to the NHTSA, dialing a phone number while driving increases a teenager's risk of crashing by six times, while texting while driving increases the risk by 23 times. Talking on the phone diverts a teenager's attention from the task of driving, reducing their ability to respond to a road hazard, crash, or inclement weather (*35*). It is important that in-vehicle devices are designed to meet driver weaknesses and capacities so that any negative effect that they might have on distraction is minimized. Using in-vehicle devices can cause distractions, and studies have shown a significant effect on a driver's ability to maintain speed on the road. One critical finding is that tasks generally considered low risk, such as adjusting the radio and climate controls, increase the crash risk more than two times for teenage and young adult drivers. Tasks with high visual demand, including looking outside of the vehicle and reaching for in-vehicle objects, have a six times or greater increase in crash likelihood across all age groups, according to the Second Strategic Highway Research Program Naturalistic Driving Study (*1*). Also, passengers of distracted teenage drivers were more likely to be fatally injured when a cell phone or even the passengers themselves distracted the driver (*36*).

Wilson and Stimpson (*43*) studied trends in distracted driving fatalities, driver and crash characteristics, and trends in cell phone use and texting volume from 1999 to 2008 by using the Fatality Analysis Reporting System (FARS) records data. These trends showed that although fatalities from distracted driving declined from 1999 to 2005, they increased 28% after 2005 (from 4,572 fatalities to 5,870 in 2008), and the recent and dramatic changes in texting volumes have resulted in thousands of new deaths annually in the U.S. According to a 2018 national observational survey, at any given time during the day, 3.2% of drivers were talking on their handheld cell phones when they stopped at intersections (*28*). To examine distracted driving among teenagers who were mostly in their initial six months of unsupervised driving, Foss and Goodwin (*46*) conducted a naturalistic study, which showed that electronic device use (6.7%) was the most common single type of distracted behavior, followed by adjusting vehicle controls (6.2%) and grooming (3.8%). Distracted driver activities when passengers were present happened less frequently. The effects of using electronic devices while driving was investigated by Rakauskas et al. (*16*) as well. This study integrated natural conversations within a driving simulator to determine the effects of naturalistic cell phone conversations on driving performance. The results showed that having a conversation while driving and using a hands-free cell phone leads to decreased average speeds and can cause decrements in speed maintenance performance. Also, cell phone use caused participants to drive slowly and with more variation in speed.

The importance of cell phone use and distraction is well illustrated in another study by Gliklich et al. (*47*) who described the regularity of cell phone-related distracted driving behaviors. For this purpose, 1,211 drivers in the U.S. completed a questionnaire. The result was as follows: Almost 60% of drivers reported cell phone activity (reading or writing). The most frequent activities related to cell phone were reading texts (48%), viewing maps (43%), and writing texts (33%). Among drivers, only 4.9% of them had a cell phone app to lower cell phone-related distracted driving.

Although the majority of distracted driving research has largely concentrated on driver cell phone use, studies have shown that other technologies inside the vehicle can often increase visual and cognitive demand while traveling as well. Some studies (*48*) attempted to investigate the relative impact on driving performance using route guidance interfaces. If a driver inserts destination information or responds to guidance directions, the route guidance systems become a form of distraction. The navigation system must be programmed at the beginning of the trip to provide the correct route directions. In addition to the destination input, for various other purposes, drivers can control the system, such as changing the volume or screen or checking for current traffic jams. This is mostly achieved with a touch screen, but there are also other choices, such as voice control and remote controls (*48*). To examine how experienced users' driving behaviors are influenced by in-vehicle technologies (i.e., cell phone and navigation system tasks), Knapper et al. (*48*) used a fixed-base driving simulator. The findings indicate that only during visual-manual tasks, i.e., text and destination entry, in which the participants looked away from the road for a significant period, did the lateral performance decline. There are some other prevailing distractions such as eating and drinking during driving which need to be investigated for further knowledge of overall distraction impacts.

2.3. Outside the Vehicle Distractions

Most studies focus on distractions from inside the car, but items outside of the vehicle can also distract drivers. Several factors can affect gaze fixation duration on billboards, such as content, visibility, and gender. Signs with low amounts of information resulted in only a small reduction in speeds, while the signs with a high amount of information significantly reduced the drivers' speed (*49*). Gaze fixation is extended for the long-distance visibility of a billboard. A study revealed that female participants had a lower gaze fixation duration than males on billboards (*19*). A naturalistic driving study included 1,912 drivers who were injured in traffic crashes to examine the connection between driving while being distracted and the risk of being in a car accident. The results showed that exposure to events that take drivers' eyes off the road and take drivers' hands off the wheel was linked to a substantially increased risk of being responsible for a traffic accident (*50*). In a recent study, Lym and Chen (*20*) analyzed the association between the built environment and the incidence of car collisions caused by distracted driving using accident data from 15 states in the U.S. from 2013 to 2017. They found that distracted driving accidents were less severe at roundabouts or in urban areas. Simultaneously, the risk of injury rather than property loss only rises when a collision involves speeding or occurs at an intersection or on a curved road. In contrast, the chances of a significant (or fatal) injury relative to minor accidents and property damage were greater only in a work zone, a curved roadway, or where extreme speed was involved at a higher severity level.

Another study showed that road features, including a median and a shoulder of asphalt pavement, had significant and negative associations with the incidence of distracted driving-related accidents (*51*). Familiarity with the roads can also cause distractions. The results of a naturalistic driving study using 155 drivers showed that when comparing familiar and unfamiliar roads, the frequency and length of distracted driving behaviors were higher on familiar roads. On familiar paths, additional types of secondary tasks were discovered. Also, the most popular distracted driving behavior was focusing on objects (*52*).

The relationship between age and sensitivity to the environment is well observed in a study (*21*) that examined the impacts of billboards on drivers, including older and novice drivers. It showed that billboards' existence changed drivers' patterns of visual attention, raised the number of errors in this driving assignment, and resulted in distracting eye movements from the road ahead. In the presence of billboards, the responses to road signs have been postponed by 0.5 to 1 second, at which point a vehicle driving at 70 km/h would have moved nearly 20 meters. More specifically, Plant et al. (*22*) examined the effect of road safety ads on drivers' actions using a driving simulator on licensed drivers between 17 and 25. The results showed that the average driving speed of young drivers decreased instantly after viewing an advertisement that depicted social consequences for speeding and employed a positive emotional appeal compared to an emotion-matched control advertisement. Another naturalistic driving study (*23*) analyzed drivers' visual attention to roadside advertising signs. These signs were categorized as vendor signs, billboards, movable display boards, single and multiple commercial directional signs, and gas price LED displays. Twenty-four percent of the roadside advertisement signs were fixated. The fixation rate for billboards was the highest. Advertising signs located on the driving side were fixated more than the signs on the reverse side.

Taken together, the studies mentioned above suggest that in the road setting, billboards, especially advertising, almost certainly have negative safety consequences, particularly for older or younger drivers.

2.4. Distracted Driving and Technology

In recent years, fatality rates in the U.S. have risen, bucking a long-standing trend, which may be due in part to increased driver distraction from electronic devices; traffic incidents continue to be a significant public health and safety problem (*53; 54*). Due to the evolving nature of distracting activities, the rapid advancement of technology-based distractions, and the scarcity of distracted driver data sources, efforts are underway to gain a better understanding of distraction factors and associated risk (*54; 55*). When it comes to driver distraction, smartphones are proving to be a game-changer. Although smartphones can help in travel pattern analysis by providing traffic data (*56*), they are one of the primary sources of drivers' distraction. Motorists can use their mobile phone not only to text or email, but also to connect with social media and other "infotainment" systems thanks to wireless technology. With the rapid advancement of modern technologies, the issue of driver distraction is only going to get worse (*57*).

A variety of cell phone applications have been invented to avoid dangerous phone behaviors by drivers. The common implementations of these applications are that the cell phones will prevent interactions while the vehicle is moving. One of the most common examples is "Do Not Disturb While Driving," developed by Apple. Reagan and Cicchino (*58*) examined the use of cell phone blockers to restrict the use of cell phones while driving. They conducted a survey to estimate cell phone blocker use. The results showed that Apple's Do Not Disturb While Driving application (DND) is the most common application among adult drivers who own the DND compatible iPhone. When driving or connecting to a vehicle's Bluetooth, only 20.5% of respondents with DND compatible iPhones had DND set to activate automatically. Among those who did not have DND compatible cell phones, 18.7% reported that they had an alternative non-DND blocker.

In order to review the safety implications and potential effectiveness of current smartphone applications designed to avoid distracted driving, Oviedo-Trespalacios et al. (*59*) explored that simply blocking phone functions may not be attractive to drivers who view their phone as a necessity. As such, these drivers are unlikely to use these voluntary applications at all while driving. Moreover, certain classes of the population who have developed strong cell phone use patterns do not benefit from blocking tasks and may not support this technology. This issue was fully explored in the next study (*60*), which interviewed drivers to investigate the acceptability of cell phone apps designed to stop distracted driving. The results indicated that the apps that are freely accessible to drivers on both iOS/Android devices to discourage cell phone usage while driving helped minimize distracted driving and promoted healthy driving behavior. However, it was demonstrated that other categories of drivers who use cell phone apps as part of their daily jobs, such as taxi drivers or Uber drivers, do not use the technology as part of their work because they focus on certain cell phone features.

As part of a comprehensive study about smart cell phone applications in transportation (*61*), Siuhi and Mwakalonge identified the advantage of cell phone applications designed to improve traffic safety. These applications typically act like a vehicle black box, with voice-to-text, teenager/inexperienced driver management, and vehicle crash monitoring. Some of these applications are also being created to provide distraction-free driving. Applications that were

mentioned in the study are ZoomSafer, Text'nDrive, IGuardianTeen, TextArrest, Drivesafe.ly Pro, SafeCell 360, tXtBlocker, SaferCar, AT&T DriveMode, and DND. A survey conducted in Australia used 712 participants to investigate their views and thoughts on smartphone apps that assist with avoiding distracted driving and using a cell phone. The results showed that females were significantly more likely to install and activate the app. Also, the ability to use music-playing features was essential to the participants. They also preferred to be able to speak commands to the phone using a hands-free device or Bluetooth (*62*).

Different applications have different ways of solving this problem. For instance, Bergasa et al. (*63*) presented the DriveSafe application in their study, which is a safety iPhone application for driving. It detects inattentive driving habits, provides drivers with relevant input, tests their driving, and warns them if their behaviors are not safe. They evaluated the application performance by using data from 12 drivers in two studies. The results showed detecting certain inattentive driving habits with an average accuracy of 82% at 92% of the recall. Also, certain applications work automatically by spotting the acceleration of the vehicle. Spring's Driver First, for instance, is a mobile application that locks phones when the car goes faster than 10 miles per hour using the cell phone's accelerometer, not GPS, to prevent battery drainage. Calls are immediately sent to voicemail by using the program (*64*). Dumitru et al. (*65*) examined the effects of using Advanced Driver Assistance Systems (ADAS) in smartphones on drivers' behaviors when they are distracted by social networking applications. ADAS guarantees that when the driver is tempted to use a mobile phone, his/her attention will return to the road. The Facebook application was used as a distraction factor in the current analysis based on the statistical data. The investigation conducted by this group showed that using the ADAS application helps minimize driving infractions by an average of 43%. Another study (*66*), investigated the use of voluntary applications designed to prevent distracted driving using a mixed methods design. The findings showed that engagement in 1) visual-manual, 2) cognitive-auditory, and 3) music cell phone experiences declined dramatically when using these apps. The results revealed several areas of improvement that need to be addressed, e.g., activation of the application and Bluetooth connection reliability.

Vehicles are filled with technologies that draw the attention of drivers. Most of these are designed to help with the task of driving. However, technologies like communication, navigation, and entertainment tasks might conflict with the safe management of the vehicle (*67*). To better understand this issue, a study conducted by Parnell et al. (*44*) asked drivers to record all of the technological distractions they experienced over a span of four weeks as well as interactions they missed or chose not to interact with. These distractions include external variables and technologies and the conditions around them. The goal was to classify the variables that lead to distracted driving from using technology in the vehicle through a diary study. The results showed that 56% of the drivers interact with technologies, and most of them were in their cars.

Cell phone use while driving is a global phenomenon that has been identified as a key source of concern for road safety. Based on a nationwide study, 28.6% of all respondents admitted to texting and driving as their No. 1 distracted driving behavior (*68*). According to the AAA Foundation for Traffic Safety, 43.2% of drivers admitted to driving using a handheld cell phone (*69*). The apps in this category are designed to reduce injury crashes and contribute to road safety. According to Albert et al. (2016), these apps can be divided into three main categories: blocking

apps, apps which present fewer distracting interfaces by enabling “Eyes on the road hands on the wheel,” and driving feedback and coaching apps.

2.5. Distracted Driving and the COVID-19 Pandemic

The COVID-19 virus (also known as the coronavirus) outbreak began in Wuhan, China, in December 2019 and quickly spread to several countries worldwide. This pandemic has caused significant negative effects on public health and the global economy. The COVID-19 pandemic’s impacts are being felt throughout the transportation industry. It has impacted all modes of transportation, including cars and public transportation in cities as well as buses, trains, and planes on a national and international scale. One of the most significant effects has been a decrease in passenger transport demand. By the end of March 2020, global road transport activity had fallen nearly 50% below the 2019 average, and commercial flight activity dropped almost 75% below the 2019 average by mid-April 2020. Public transportation has been impacted as well (*70*).

This pandemic also caused a significant shift in people's travel behaviors and distractions while driving. To stop the virus from spreading, the U.S. Centers for Disease Control and Prevention (CDC) recommended social distancing, self-quarantine, and working from home starting in early February 2020. States and localities implemented these, closing schools and businesses and residents were urged to stay home. Travel demand fell across the board because of these unexpected and extraordinary shutdowns (*71; 72*). According to the U.S. Department of Transportation Federal Highway Administration, miles driven dropped by 40% during April 2020. Even though traffic has decreased dramatically since the outbreak of COVID-19, roads have become much riskier. According to the National Safety Council, 42,060 people died in car accidents in 2020, which is up 8% from 2019. It is the most significant year-over-year growth since 1924. Last year, 4.8 million people were seriously injured in car accidents, raising the question of how many of those were caused by distracted driving (*73*). Moreover, data revealed that in 2020, drivers' phone use increased by 17%, and the number of crashes per million miles increased by 63% (*70; 74; 75*). Experts, however, emphasized that distracted driving predates the pandemic and that the recent shift in travel habits merely highlights a long-standing problem.

The COVID-19 pandemic's network effects will continue to have an impact on U.S. highways. With phone distraction behind the wheel causing 57% of all crashes on U.S. highways, all stakeholders must work together to tackle the Distracted Driving epidemic (*76*). In an analysis of 86,000 crashes that occurred on U.S. roads in 2020, mobility analysis company Zendrive discovered that risky distracted driving habits like texting while driving, which is illegal in 41 states, were often implicated in our country's record-breaking crash rates during the lockdown months (*76*). It is important to understand the impacts of the COVID-19 pandemic on daily travel and distracted driving behaviors. These changes in daily travel subsequently will affect the safety of drivers.

In March 2020, the first case of COVID-19 was confirmed in Maryland. Initial statewide lockdowns took effect and continued in some degree until July 1, 2021. Early evidence suggests that as a result of the pandemic, people have shifted from taking public transportation to driving (*77*). The pandemic resulted in several state-mandated stay-at-home orders and fewer outings. However, careless, and distracted driving have made the roadways more dangerous. According to the most recent National Safety Council (NSC) Distracted Driving Survey, 2% of drivers admitted

to driving distracted due to less congested roadways. As a result, the NSC advises that all cell phone usage while driving be prohibited nationwide, including hands-free options (*73*). According to the University of California, Davis researchers, the shelter-in-place order resulted in approximately 15,000 fewer crashes per month and 6,000 fewer injuries or fatal incidents per month (*78*). However, another study (*79*) indicates that during the time of the COVID-19 pandemic, major speeding has almost tripled as a percentage of total speeding violations. Even though fewer motor vehicles were on the road during the pandemic, a recent report found that distracted driving increased in the U.S. in 2020 (*76*).

Because of the COVID-19 pandemic, teen drivers are more likely to be involved in a distracted driving crash. According to NHTSA data, teens are the most at risk behind the wheel, and the empty roads during the pandemic just give them a false sense of protection (*80*). The Washington Traffic Safety Commission stated that distracted driving rose from 6.8% to 9.4% in Washington state. While the increase in the statewide rate was not statistically significant, the findings clearly show that this high-risk activity is on the rise. Cell phone use while driving rose by 86% on city streets, and the number of users rose from 6.3% to 11.7%. The percentage of people using their cell phones on state highways remained unchanged at 4.2% (*81*). This has also been explored by another study regarding the impact of COVID-19 on driving risk in Atlanta, Georgia, from March to May 2020, showing that the following dangerous driving habits increased frequently: Handheld cell phone distraction – increased by 58%; Incomplete stop – increased by 72%; Posted speed violation – increased by 45% and food/drink distraction – increased by 41% (*82*).

In March 2020, Governor Larry Hogan announced the first three positive cases of COVID-19 in Maryland (*83*). Since the pandemic began, as of October 1st, 2021, there have been 536,000 total confirmed cases and 10,478 deaths. Effective July 1, 2021, all emergency mandates and restrictions were terminated (*84*). The events in 2020 related to the COVID-19 pandemic response were unprecedented. Traffic volumes in the United States decreased so rapidly and dramatically that it is unlikely to be replicated. During this time, driving patterns and behaviors changed, creating new issues for traffic safety professionals. Because of the varying levels of statewide reactions and constraints, these shifting patterns and difficulties may change from state to state.

Essentially, there is limited literature that has systematically explored the effects of the COVID-19 pandemic on distracted driving. The global outbreak of COVID-19 has brought many modes of transportation to a halt, with major implications for all forms of transportation. Our transportation networks and systems started to look very different as we went through this crisis: very few cars on the road, empty lines at airports, clean air, very little noise, and so on. Existing research has made a significant contribution to the methods and data analysis related to transportation during the pandemic; however, the extensive influence of COVID-19 on distracted driving still needs to be investigated.

2.6. Summary of the Literature Review

Based on this review, using electronic devices or cell phones in the vehicle is the most common distraction among drivers of all age groups. When using cell phones or other devices, drivers drive more slowly, with more variation in speed, and look less at the road. More lane deviations and crashes occur during texting. Young drivers are aware of the risk of texting and driving, but the perception of risk is a very weak predictor of behavior or has no effect on texting. Many teens

found hands-free cell phone conversations to be at least somewhat appropriate. The percentage of young drivers who never text and drive under any circumstances is very low. All drivers, regardless of age, may drive in a way that affects safety and traffic flow negatively when distracted – yet educating and informing young people about the risks of using a cell phone while driving is needed. A variety of cell phone applications have been developed to avoid dangerous phone behaviors. One of the common examples of these applications is "Do Not Disturb While Driving," developed by Apple. Some of the other applications are ZoomSafer, Text'nDrive, IGuardianTeen, TextArrest, Drivesafe.ly Pro, SafeCell 360, tXtBlocker, SaferCar, AT&T DriveMode, and No Texting While Driving App. According to the studies, a small percentage of drivers who have these apps on their cell phones had set them to activate automatically. Table 3 shows a summary of the literature review of this study.

The current study seeks to find the target group of distracted drivers in each distraction type in Maryland. Based on the literature review and to the best of authors' knowledge, no previous studies have thoroughly investigated the socio-demographic of distracted drivers or the most distracting technology or devices in Maryland. Also, no research has been conducted on distracted driving during the COVID-19 pandemic in Maryland. To this end, we conducted an online survey in which we examined the state-specific socio-demographic characteristics of distracted drivers. This survey examines the status of the target group in the last two years, both before and during the pandemic. The survey was implemented using the Qualtrics' survey. Web-based surveys are commonly used and are comparable to paper-based surveys. Additionally, online surveys can prevent items from being skipped, be used to contact groups that are difficult to reach, and people tend to be more honest in online questionnaires (*85*).

2.7. Maryland Distracted Driving Statistics

The Maryland Highway Safety Office (MHSO) annually produces 5-year County, Statewide, and Program Area tabulations of fatalities and injuries by route type, month, day of week, time of day, driver age, driver gender, driver safety equipment use, passenger age, passenger gender, passenger safety equipment use, pedestrian age, pedestrian gender, pedestrian location (e.g., shoulder, curb, sidewalk), and pedestrian movement (e.g., crossing at intersection, walking against traffic) (*25*).

As shown in Table 1, for this latest five-year period, distracted driving was reported as a factor in an annual average of more than 40% of all traffic crashes. Distracted driving is significantly over-represented statistically in all crashes, and even more so in injury crashes. Because of the major impact of identified distracted driving and the difficulties in effectively capturing it as a cause on crash reports, distracted driving may be under-reported, and a larger problem than currently shown. Distracted driving is a big concern for Maryland and national traffic safety officials (*86*).

Table 1. Total and distracted driving crashes numbers in Maryland, 2015–2020

	2015	2016	2017	2018	2019	2020	Average (2016-2020)
Total Crashes	108,118	120,278	115,429	118,026	115,926	95,507	115,555
Distracted Driving Involved Crashes	48,674	56,371	56,348	57,197	56,960	45,378	55,063

Source: (*86*), (*87*)

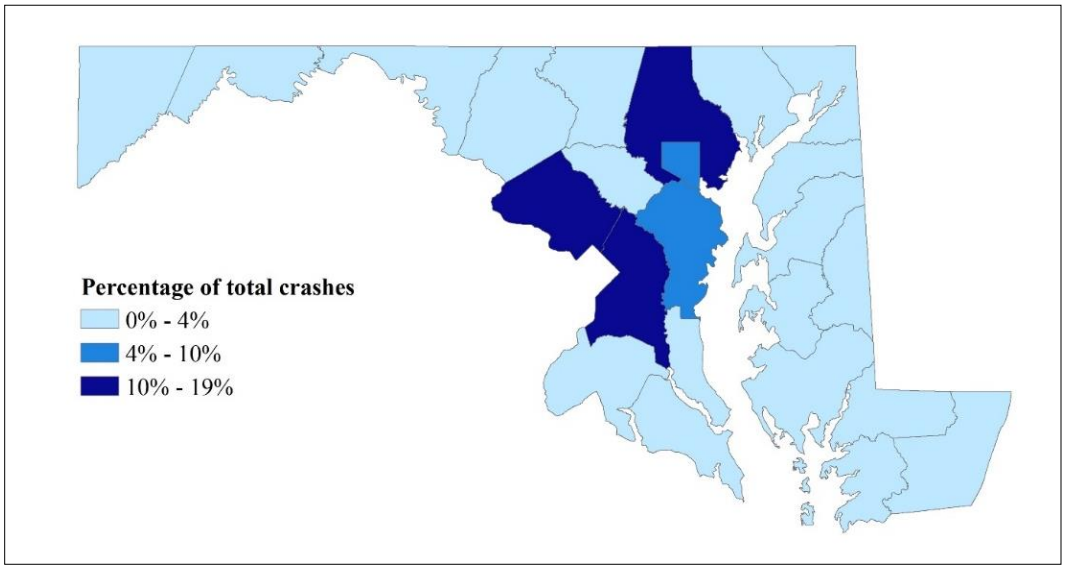
The use of a handheld phone while driving is prohibited by law in Maryland. Driving while writing, sending, or reading a text or electronic communication can also result in a ticket. A driver that causes serious injury or death while talking on a handheld cell phone or texting may receive a prison sentence of up to three years and a fine up to $5,000 (*88*). As shown in Table 2, distracted driving causes an average of 25,672 injuries and 181 fatalities every year in Maryland. Moreover, during the COVID-19 pandemic (2020), the total number of injured and total crashes due to distraction decreased, however, the fatalities due to distraction decreased.

Table 2. Numbers of different types of crashes due to distraction in Maryland, 2015–2020

	2015	2016	2017	2018	2019	2020	Average (2016-2020)
Fatal Crashes	108	171	208	176	183	205	189
Injury Crashes	16,427	18,764	18,664	18,126	17,660	13,215	17,286
Property Damage Crashes	32,139	37,436	37,512	38,895	38,847	31,958	36,935
Total of All Fatalities	120	180	220	189	196	216	200
Total Number Injured	24,401	27,785	27,968	26,979	26,388	19,237	25,672
Total Crashes	48,674	56,371	56,384	57,197	56,690	45,378	54,410

Source: (*86*)

On average, more than 26,000 people were injured or killed per year because of distracted driving until 2020. Also, weekends and afternoons to early evening hours have the highest number of crashes. As shown in Figure 1, the average of five-year of percentage of total number of crashes and injury crashes in Prince George's, Montgomery, and Baltimore counties were higher than the other Maryland counties. However, Prince George's County averaged the most fatal crashes in the state.



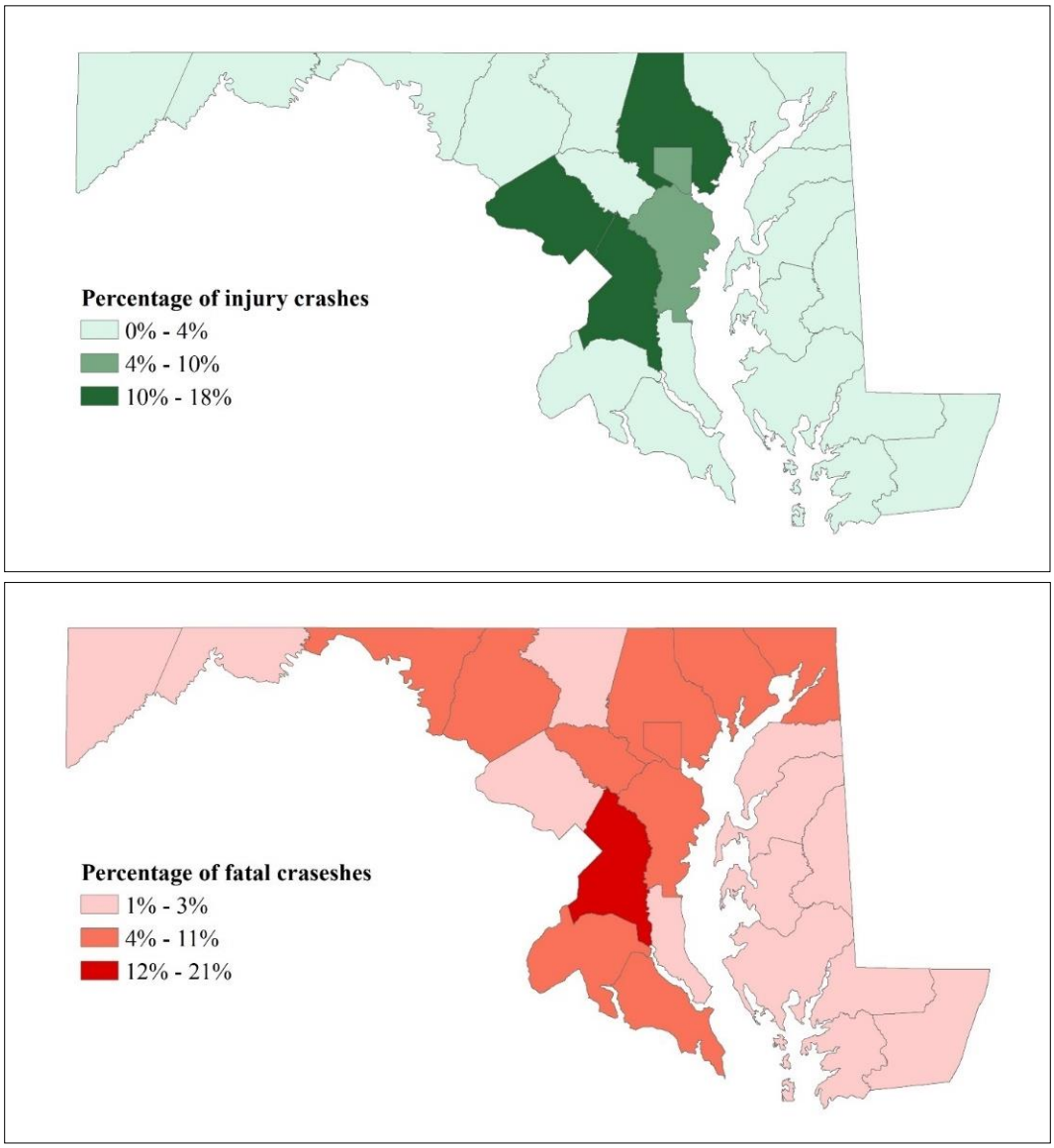


Figure 1. Percentage of number of different types of crashes due to distraction

As seen in Figure 2, those between 25 to 29 and 21 to 24 had the most injury and fatal crashes among all age groups. Moreover, as seen from Figure 3, males were responsible for the majority of injury and fatal crashes in Maryland.

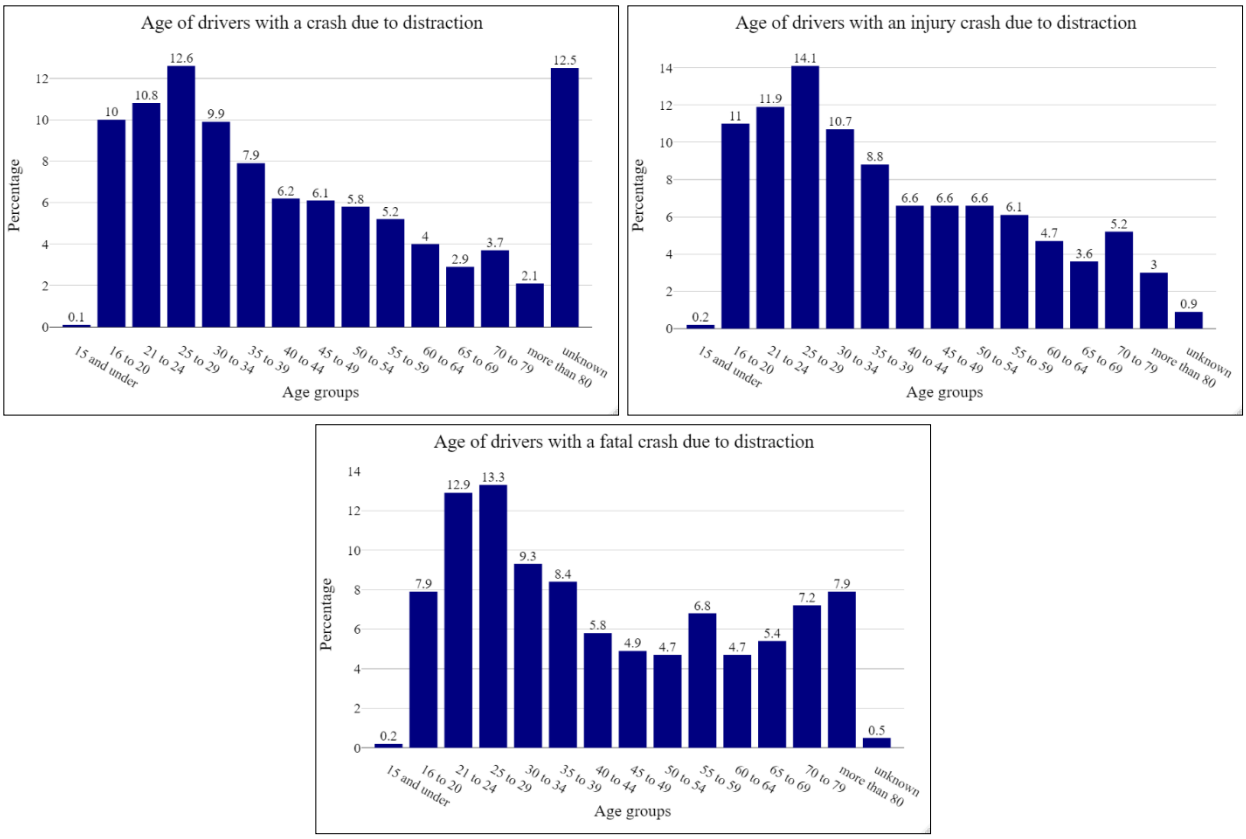


Figure 2. Age of distracted drivers

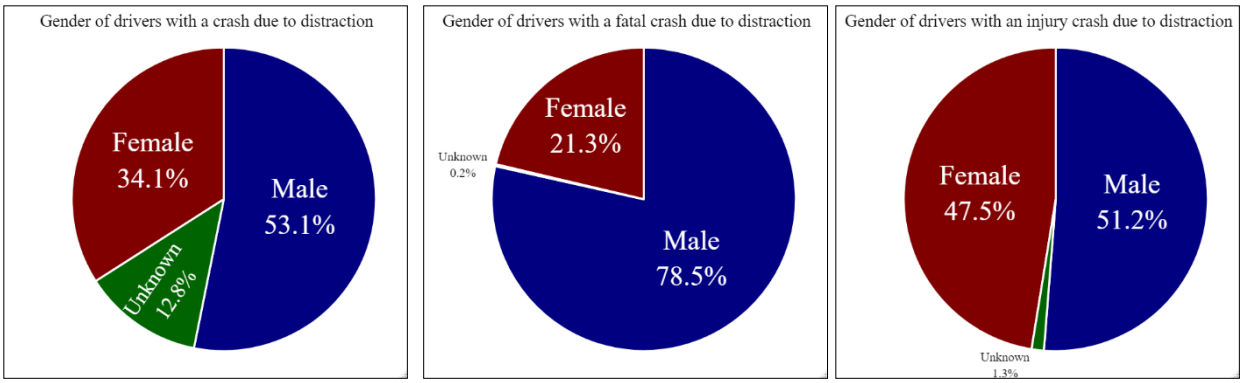


Figure 3. Gender of distracted drivers

Table 3. Summary of literature review

Authors	Goal	Methodology	Results
Klauer et al. (2014)	Examining the risk of a crash or near-crash among novice and experienced drivers.	Statistical Analysis	The prevalence of high-risk attention to secondary tasks increased over time among novice drivers but not among experienced drivers.
Guo et al. (2017)	Evaluating the prevalence and crash risk of distraction caused by secondary-task engagement across all spectrum of age groups.	Naturalistic Driving Observation and Statistical Analysis	Compared to middle-aged drivers, secondary-task-induced distraction posed a consistently higher threat for drivers under 30 and above 65.
Rakauskas et al. (2004)	Assessing the effect of naturalistic cell phone conversations on driving performance.	Simulation	Having a conversation while driving and using a hands-free cell phone leads to decreased average speeds and can cause decrements in the speed maintenance performance.
Wilson and Stimpson (2010)	Investigating trends in distracted driving fatalities and cell phone use and texting volume.	Statistical Analysis	Distracted driving fatalities rose increasingly from 2005. Crashes increasingly involved lone male drivers in collisions with roadside obstructions in urban areas.
Atchley et al. (2011)	How, when, and why drivers choose to text while driving?	Statistical Analysis	Only 2% of drivers never text and drive in any circumstances. 75% of drivers text using both hands. The drivers were aware of the risk but that had no effects.
Neyens and Boyle (2008)	How driver distraction and inattention influence the injury severity of teenage drivers and their passengers?	Statistical Analysis	All teenage drivers were more likely to be seriously injured when interrupted by cell phones or passengers. In all distraction categories, as well as for inattentiveness, female drivers were more likely to be injured than male drivers.
Foss and Goodwin (2014)	Examining distracted driver behaviors and distracting conditions among adolescent drivers.	Naturalistic Driving Observation	Electronic device use (6.7%) was the most common single type of distracted behavior, followed by adjusting vehicle controls (6.2%) and grooming (3.8%).
Lym and Chen (2020)	Investigation of the role of the built environment on the severity of vehicle crashes caused by distracted driving.	Statistical Analysis	Distracted driving accidents were less serious at a lower degree of severity at roundabouts or in urban areas, while the risk of injury rather than property loss only rises where a collision involves speeding or occurs at an intersection or a curved road.
Stavrinos et al. (2013)	Examining the impact of distracted driving on overall driving performance of young adults and teens.	Simulation	The results indicate that distracted driving, particularly texting, may lead to reduced safety and traffic flow.
Engelberg et al. (2015)	Determining distracted driving due to cell phone use among middle-aged drivers.	Statistical Analysis	Sixty-five percent of drivers text while they are stopping at a red light and driving on the freeway. The findings showed that the main distracting behaviors in middle-aged drivers are on calls and mobile texting.

Oviedo-Trespalacios et al. (2019)	Reviewing safety implications and potential effectiveness of current smartphone applications which are designed to avoid distracted driving.	Content Analysis	Diversity of application for preventing distracted driving is very low. The blocking strategy that they are using is not flexible enough to safely handle instrumental communications between cell phones and Maps and Music applications. Moreover, certain classes of the population that have developed strong cell phone use patterns do not benefit from blocking tasks and, thus, may not support this technology.
Bergasa et al. (2014)	Presenting Drivesafe application for iPhone in their study.	Simulation	The results showed detection of certain inattentive driving habits with an average accuracy of 82% at 92% of the recall.
Dumitru et al. (2018)	Investigating the effect of the use of advanced driver assistance systems (ADAS) based in vehicle smartphone on the behavior of drivers when they are distracted by social networking applications.	Simulation and Statistical Analysis	The use of the ADAS application helps to minimize driving infractions by an average of 43.43%.
Knapper et al. (2015)	Examining how the driving behavior of experienced users is influenced by in-vehicle technologies.	Simulation	Only during visual-manual Tasks, i.e., text and destination entry, in which the participants looked away from the road for a significant period of time, lateral performance deteriorated.
Reagan and Cicchino (2020)	Investigating the use of cell phone blockers designed to limit phone use while driving.	Statistical Analysis	Only 20.5% of respondents with Do Not Disturb (DND) compatible iPhones had DND set to activate automatically. Among those who did not have DND compatible cell phones, 18.7% reported that they had an alternative non-DND blocker
Oviedo-Trespalacios et al. (2020)	Discovering the acceptability of mobile apps designed to stop distracted driving.	Statistical Analysis	The apps that are freely accessible to drivers on both iOS/Android devices to discourage cell phone usage while driving were helpful in minimizing distracted driving and promoting healthy driving behavior. However, other drivers who use mobile apps as part of their daily jobs, such as taxi drivers or Uber drivers, do not use the technology as part of their work because they focus on certain cell phone features.
Parnell et al. (2019)	Classify the variables that lead to distracted driving from technology in the vehicle through a diary study.	Diary Studies	Fifty-six percent of the drivers interact with technologies. Most of them were in their cars.
Siuhi and Mwakalonge (2016)	Analyzing mobile apps with potential transportation applications and to recognize their potential benefits and drawbacks.	Review	Most applications may have substantial benefits individually or collectively, in decreasing travel time and expenses, reducing road congestion and automobile pollution.
Edquist et al. (2011)	Examining the impacts of billboards on drivers, including older and novice drivers.	Simulation	The existence of billboards changed drivers' patterns of visual attention and raised the number of errors in this driving assignment.
Stavrinos et al (2020)	Identifying distracted driving beliefs in teenagers (high school students).	Statistical Analysis	Many teens (82%) found hands free cell phone conversations to be at least somewhat appropriate.

Gliklich et al. (2016)	Describing the regularity of cell phone-related distracted driving behaviors.	Statistical Analysis	Sixty percent of drivers reported cell phone activity (reading or writing). The most frequent activities were reading texts (48%), writing texts (33%) and viewing maps (43%). Among drivers, only 4.9% of them had a program to lower cell phone related distracted driving
Jeihani et al. (2019)	Analyzing the effect of in vehicle distractions on drivers' behavior.	Simulation	In the face of all in-vehicle distractions on all routes, participants decreased their speed. Also, distance and content of the billboard and gender had a considerable effect on gaze duration.
Plant et al. (2017)	Investigating the results of real-world anti-speeding commercials featuring negative and optimistic moral appeals.	Simulation	Average driving speed of young drivers decreased instantly after viewing an advertisement that depicted social consequences for speeding and employed a positive emotional appeal when compared to an emotion-matched control advertisement.
Costa et al. (2019)	Analyzing drivers' visual attention to roadside advertising signs.	Naturalistic Driving Observation	Twenty-four percent of the roadside advertisement signs were fixated. The fixation rate for billboards was the highest. Advertising signs located on the driving side were fixated more than the signs on the reverse side.
Oviedo-Trespalacios et al. (2020)	Exploring the use of voluntary applications designed to prevent distracted driving.	Mixed Method Design	Engagement in 1) visual-manual, 2) cognitive-auditory and 3) music cell phone experiences declined dramatically when using the apps.
Thompson et al. (2012)	Examining distracted driving performance in elderly and middle-aged drivers.	Instrumented Vehicle	The elderly drove slower and showed decreased speed variability during distraction compared to middle-aged drivers.
Klauer et al. (2006)	Conducting in-depth analyses of driver inattention using the driving data collected in the 100-Car Naturalistic Driving Study.	Naturalistic Driving Observation	Doing a complex secondary task (e.g., reaching for a moving target, applying makeup, or dialing) increased the risk of a crash or near-crash by three times; mild secondary tasks (e.g., talking/listening, eating, or inserting a CD) increased the risk by two times.
Lyon et al. (2021)	Evaluating prevalence and trends in distracted driving in Canada.	Statistical Analysis	In comparison to 2010, the number of Canadians who indulged in talking on their phone or driving while using a hands-free or portable phone significantly increased in 2019. The number of people who admitted to texting while driving increased by 102% in 2019.
Horberry et al. (2006)	Examining the effects of distraction on driving performance for drivers.	Simulation	Both in-vehicle tasks (operating the vehicle entertainment system and hands-free cell phone conversation) reduced many aspects of driving efficiency, with the entertainment system distracter having the most effect.
Oviedo-Trespalacios et al. (2019)	Investigating the influence of using voluntary smartphone applications to reduce the distraction associated with cell phone use while driving.	Statistical Analysis	Females were significantly more likely to install and activate the app. The ability to use music-playing features was essential to the participants. They also preferred to be able to send commands to the phone via audio using a hands-free device or Bluetooth.

Braitman (2010)	Obtaining detailed information on patterns of driver cell phone use.	Statistical Analysis	At least a few days per week, 40% of drivers spoke on their cell phone while driving, and males did so more than females. Laws for banning handheld cell phone use seem to prohibit some drivers from chatting on any kind of phone while encouraging others to speak hands-free. Texting while driving laws have had no impact on the observed prevalence across all age groups.
Braitman (2017)	Identifying naturally occurring profiles of distracted driving behaviors, and risk or protective factors (i.e., personality traits) associated with these profiles. Also, examining relationships between distracted driving behaviors and perception of risk.	Statistical Analysis	Talking with passengers, changing music, eating or drinking, and using navigation were the most frequently recorded distractive habits.
Carter et al. (2014)	Analyzing the impact of risk perception and sensation seeking, as well as descriptive and injunctive social norms on adolescent distracted driving behavior.	Statistical Analysis	Distracted driving was recorded by 92% of adolescents on a regular basis. Adolescents believed that their parents and friends were more likely to engage in impaired driving than they were.
Hill et al. (2015)	Determining the prevalence of distracted driving among college students.	Statistical Analysis	The likelihood of a student engaging in distracted driving was significantly increased when drivers' self-efficacy for driving and multitasking in the car was combined with a higher likelihood of having observed DD activities in others. Most students believed that legislation affecting their driving privileges and insurance premium rises would have an effect on their conduct.
Curry et al. (2011)	Estimating the frequency of crucial causes for teen driver collisions, and examining in more depth specific teen driver errors.	Statistical Analysis	A teen was involved in 79.3% of collisions involving a driver mistake (75.8% of all teen-involved crashes). Recognition errors (e.g., insufficient surveillance, distraction) accounted for 46.3% of all teen errors, followed by decision errors (40.1%) and performance errors (e.g., lack of control) (8.0 %).
Shaaban (2019)	Investigating the installation and usage of two mobile apps (a distraction-prevention application and a real-time traffic information and navigation application) in Qatar.	Statistical Analysis	The potential market for these types of smartphone applications in Qatar is high, especially among female drivers. A large percentage of drivers, especially younger and local drivers, were uninterested in downloading and using the distracted driving prevention app.
Wu and Xu (2018)	Examining the impact of familiarity on the involvement of secondary tasks and driving.	Naturalistic Driving Observation	On familiar paths, the frequency and duration of distracted driving activities were higher, and there were more types of secondary tasks.
Chen and Lym (2021)	Assessing the effect of the built environment on the frequency and severity of vehicle collisions.	Statistical Analysis and Regression models	In an urbanized road environment, the incidence of distracted driving accidents is far higher than that of non-distracted driving crashes. Distracted driving crashes are usually more severe than non-distracted driving crashes.

Pope et al. (2019)	Investigating the relation between demographic factors, perceived threat to safety, and peer influences with adolescence support distracted driving legislations.	Statistical Analysis	Female adolescents were twice as likely as male adolescents to endorse a law prohibiting texting and emailing while driving.
Taylor and Blenner (2021)	Investigating the factors that lead to younger drivers being distracted by cell phone use while driving	Statistical Analysis	Forty-two percent of younger drivers reported reading a text, 33% reported sending a text and 23% reported smartphone app use.
Hassani et al. (2017)	Developing and evaluating a distracted driving presentation for college students in order to change their awareness, attitudes, and behaviors about distracted driving.	Statistical Analysis	The method of the study was successful in improving the short term of attitude and behavior on distracted driving. Work is needed to sustain long term effects.
Hunter et al. (2016)	Investigating the impact of roadside distractions on drivers who have and do not have attention deficit disorders.	Simulation	Roadside events have statistically significant effects on variability of lane position and speed. Additionally, drivers with attention deficit tendencies showed more lane position variability. Billboards and work zones were found to have the greatest effect on driver inattention among the distractors studied.
Stutts et al. (2001)	Determining the most common sources of driver distraction and their relative importance as possible causes.	Descriptive and narrative analysis	From 1995 to 1999, 48.6% of drivers were found to be attentive at the time of their collision; 8.3% were found to be distracted, 5.4% to have "looked but did not see," and 1.8% to be sleepy or asleep. Drivers under 20 were the most likely to be involved in distracted driving accidents.
Choudhary et al. (2020)	Investigating and modeling the effects of distracted driving induced by cell phone and music player use, as well as to model and measure the direct and indirect effects of distracted driving.	Simulation (Structural Equation Modeling)	Of all the contributing factors to crash risk, deteriorated driving performance was found to be the most important. Texting had the greatest effect on crash risk of all the distractions, followed by tasks involving the music player.
Simons-Marton et al. (2014)	Investigating the connection between crash risk and the amount of time a driver's eyes are off the road during secondary tasks among newly licensed teenage drivers.	Naturalistic Driving Observation	Crashes and near-crashes were more likely when the eyes were diverted from the road ahead to perform secondary tasks. Regardless of the type of secondary task, the longer the eye gaze is away from the road, the greater the risk.

3. DATA AND METHODOLOGY

This section is devoted to the data gathering process as well as the various statistical methods used to interpret the gathered data. To achieve the goal of the study, various statistical tests are used on the data set which are explained in the methodology section.

3.1. Data Description

For this study, 158 people were recruited from Maryland. Participants were required to be older than 16. Data for this study were collected from a questionnaire-based survey. This questionnaire is a stated preference survey. The survey was implemented using the online platform, Qualtrics (98). Out of the 158 participants, 88 of them recruited from Qualtrics, and 70 participants were recruited from Morgan State University and the Baltimore metro area via flyers distributed manually, online, and through social media. Online surveys can prevent items from being skipped, be used to contact groups that are difficult to reach, and people tend to be more honest in online questionnaires (*85*). Moreover, the answers were monitored one by one and inattentive respondents were removed from the final data set by the authors.

The questionnaire consists of three sections. The first section collected basic information about the drivers, including gender, age, income, education level, family size, driving frequency, and employment. The second section was designed to investigate respondents' driving behavior and the types of devices and technologies they use while driving. The last section was specifically designed for drivers who had experienced a crash due to distraction in the last two years to investigate the cause of their distraction. The analysis was developed in R programming language. The information collected from the dataset about the socio-demographics of all drivers and distracted drivers are given in Tables 4 and 5, respectively.

3.1.1. Socio-Demographic Information of Participants

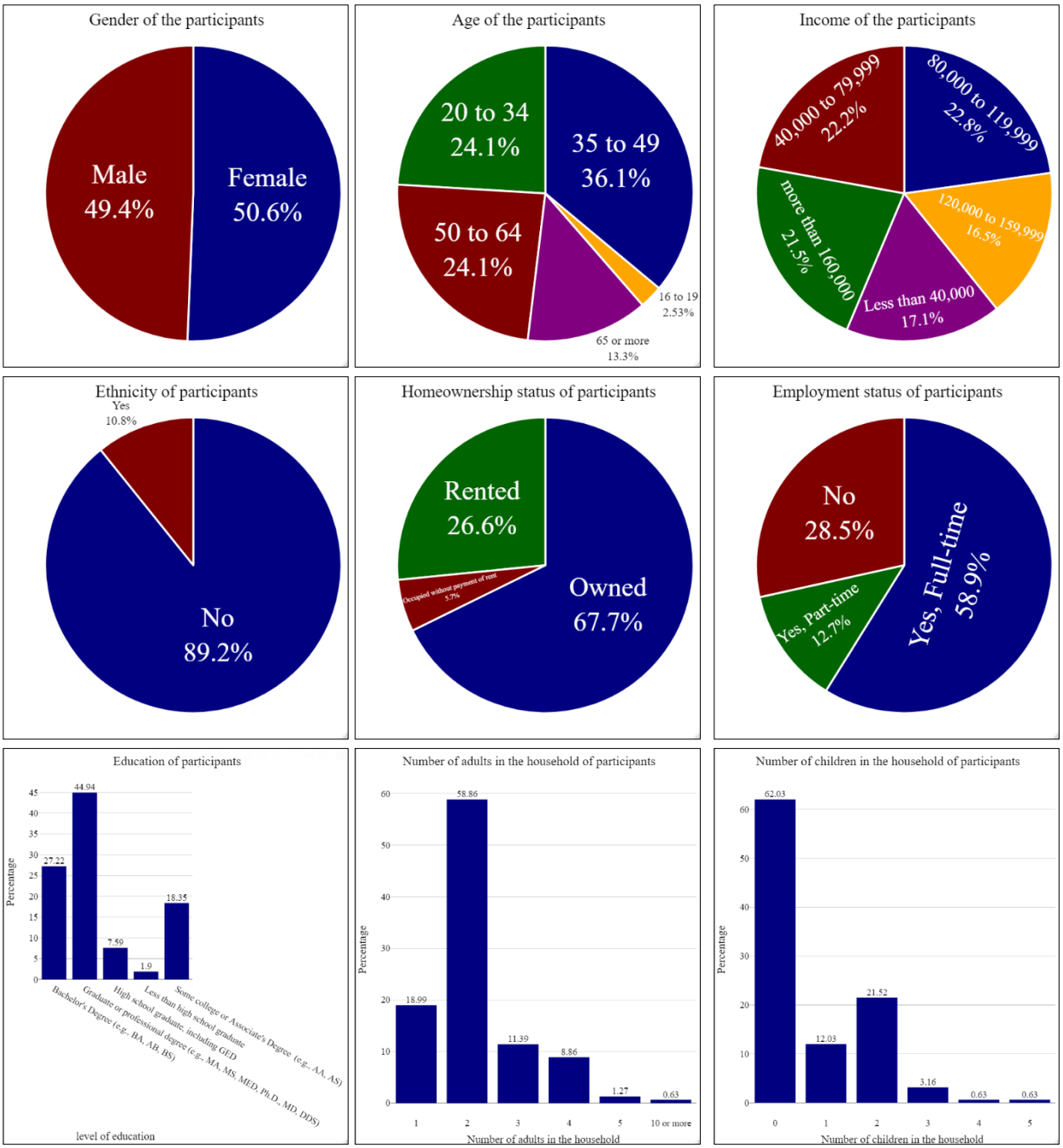
As shown in Figure 5, the sample was 49% male and 51% female. Moreover, 66% were white and 23% were African American. Some 7% were 24 years old or younger, 80% between 25 and 64, and 13% were 65 and older. The respondents reported their approximate household annual income as follows: 17% less than $40,000, 60% between $40,000 to $119,999, and 21% reported incomes of $160,000 and above. The highest completed level of education was also collected. Almost 2% of respondents had some high school education, 8% had high school degrees or GEDs, 18% reported some college, and 72% had at least a college degree (27% college degrees, 45% graduate or professional school degrees).

A little more than half (60%) reported driving cars most of the time. Also, 31% drive SUVs, 4% drive vans, and the remainder drive a variety of vehicles (e.g., pickup trucks, motorcycles, trucks other than pickups). To better understand the results, age groups were aggregated into five levels (16- to 19-years-old, 20 to 34, 35 to 49, 50 to 64, and 65 and older). Moreover, income levels were aggregated into five levels including less than $40,000, $40,000 to $79,999, $80,000 to $119,999, $120,000 to $159,999, and more than $160,000.

Table 4. Socio-demographic information of participants

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Gender	Female	80	50.63	**Ethnicity**	Not Hispanic	141	89.24
	Male	78	49.37		Hispanic	17	10.76
Age	16 to 19	4	2.53	**Race**	African American, Black	37	23.42
	20 to 34	38	24.05		White	104	65.82
	35 to 49	57	36.08		Asian	9	5.70
	50 to 64	38	24.05		Hispanic/Mexican	4	2.53
	65 or more	21	13.29		Multiracial	3	1.90
Income	Less than $40,000	27	17.09		American Indian, Alaskan Native, Native Hawaiian, or other Pacific Islander	1	0.63
	$40,000 to $79,999	35	22.15	**Homeownership**	Owned	107	67.72
	$80,000 to $119,999	36	22.78		Rented	42	26.58
	$120,000 to $159,999	26	16.46		Occupied without payment of rent	9	5.70
	More than $160,000	34	21.52	**Type of Vehicle**	Car	95	60.13
Education	Less than high school graduate	3	1.90		SUV	49	31.01
	High school graduate, including GED	12	7.59		Van	6	3.80
	Some college or Associate Degree (e.g., AA, AS)	29	18.35		Pickup Truck	5	3.16
	Bachelor's Degree (e.g., BA, AB, BS)	43	27.22		Other Truck	2	1.27
	Graduate or professional degree (e.g., MA, MS, MED, Ph.D., MD, DDS)	71	44.94		Car Light Electric Vehicle (Golf Cart)	1	0.63
Number of Adults in the Household	1	28	17.72	**Employment**	Full-time	93	58.86
	2	93	58.86		Part-time	20	12.66
	3	18	11.39		Not Employed	45	28.48
	4	14	8.86	**Number of Household Vehicle**	0	1	0.63
	5	2	1.27		1	57	36.08
	6	0	0.00		2	73	46.20
	7	0	0.00		3	15	9.49
	8	0	0.00		4	9	5.70
	9	0	0.00		5 or more	3	1.90
	10 or more	3	1.90		Single family attached house	36	22.78

Marital Status	Single, never married	45	28.48	**Home Type**	Single family detached house	91	57.59
	Married or domestic partnership	97	61.39		A building with 2 or more apartments or condos	29	18.35
	Separated/Divorced	14	8.86		Dorm room	1	0.63
	Widowed	2	1.27		A mobile home or trailer	1	0.63
Number of Children in the Household	0	98	62.03	**Driver License Type**	Learner's Permit	1	0.63
	1	19	12.03		Permanent License for all types of vehicles class A	15	9.49
	2	34	21.52		Permanent License for all types of vehicles class B	6	3.80
	3	5	3.16		Permanent License for regular vehicles class C	134	84.81
	4	1	0.63		Permanent License for regular vehicles class A and C	1	0.63
	5	1	0.63		Permanent License for regular vehicles class A, B and C	1	0.63
	6	0	0.00	**Years of Having a Driver's license**	Less than one year	2	1.27
	7	0	0.00		1 year	4	2.53
	8	0	0.00		2 years	2	1.27
	9	0	0.00		3 years	4	2.53
	10 or more	0	0.00		4 years	6	3.80
					5 years or more	140	88.61


Gender of the participants
Male 49.4%
Female 50.6%
Age of the participants
20 to 34 24.1%
35 to 49 36.1%
50 to 64 24.1%
16 to 19 2.53%
65 or more 13.3%
Income of the participants
40,000 to 79,999 22.2%
80,000 to 119,999 22.8%
120,000 to 159,999 16.5%
more than 160,000 21.5%
Less than 40,000 17.1%
Ethnicity of participants
Yes 10.8%
No 89.2%
Homeownership status of participants
Rented 26.6%
Occupied without payment of rent 5.7%
Owned 67.7%
Employment status of participants
No 28.5%
Yes, Part-time 12.7%
Yes, Full-time 58.9%
Education of participants
Percentage
27.22
44.94
7.59
1.9
18.35
Less than high school graduate
High school graduate, including GED
Some college or Associate's Degree (e.g., AA, AS)
Bachelor's Degree (e.g., BA, AB, BS)
Graduate or professional degree (e.g., MA, MS, MED, Ph.D, MD, DDS)
level of education
Number of adults in the household of participants
Percentage
18.99
58.86
11.39
8.86
1.27
0.63
1
2
3
4
5
10 or more
Number of adults in the household
Number of children in the household of participants
Percentage
62.03
12.03
21.52
3.16
0.63
0.63
0
1
2
3
4
5
Number of children in the household

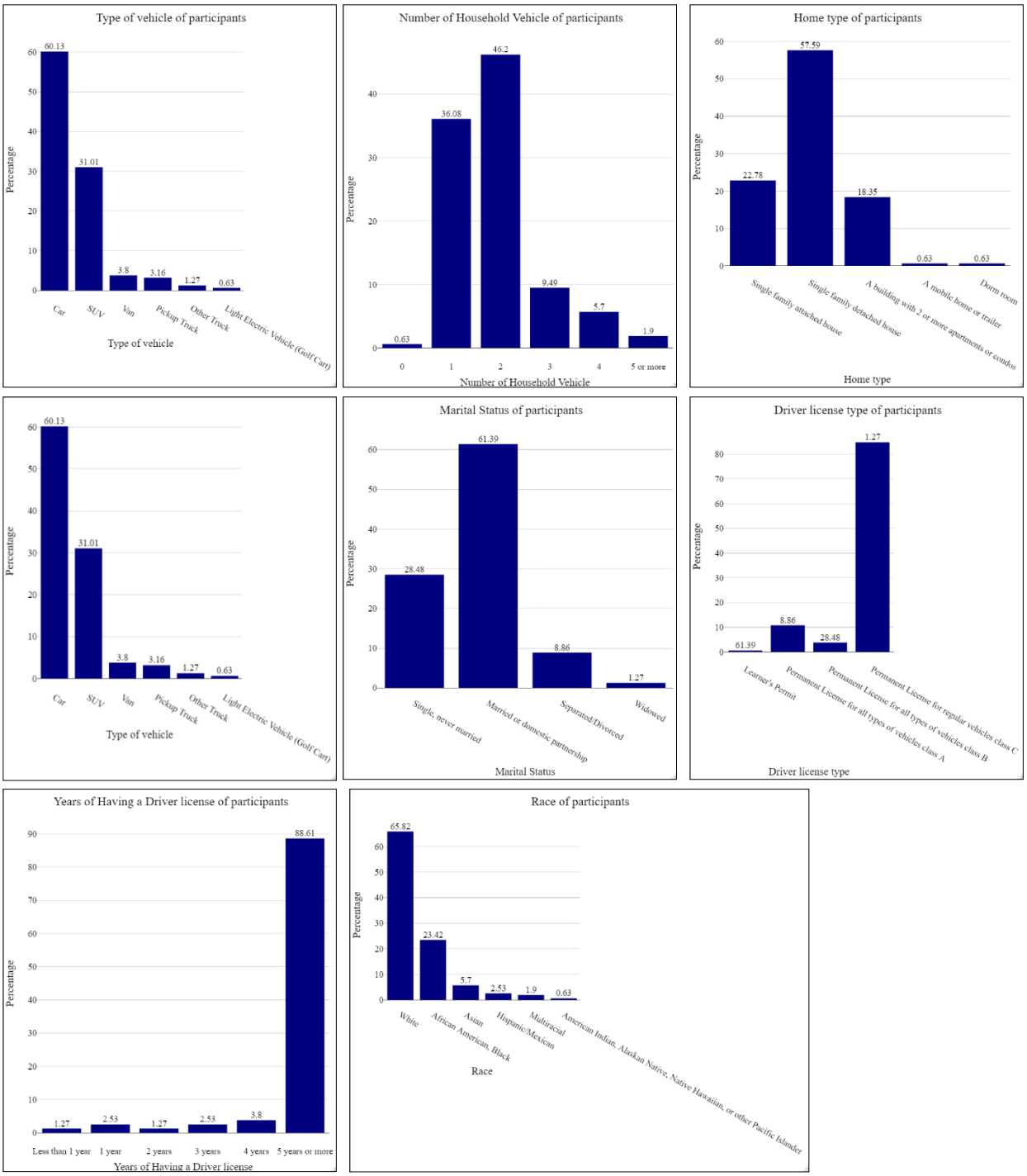


Figure 4. Socio-Demographic information of participants

3.1.2. Socio-Demographic Information of Distracted Drivers

The respondents were asked whether they usually get distracted while driving, and 21.5% of them answered affirmatively (see Figure 5). Moreover, Table 5 shows the socio-demographic information of the distracted drivers.

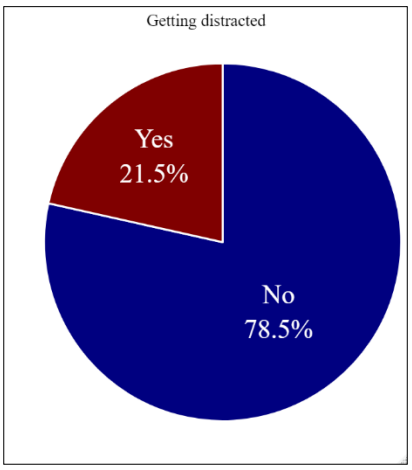


Figure 5. Distraction while driving among participants

As can be seen from Table 5, self-reported distractions among females are higher than among males. Among different age groups, those between 16 to 19 and 20 to 34 were more distracted. Participants who graduated from high school or have a graduate or professional degree become more distracted than participants with other educational levels. Moreover, those with incomes between $120,000 to $159,999 and more than $160,000 had the highest distraction while driving. Participants who had more children in the household were more distracted. Also, respondents who had their driver's license for one year were more distracted than others.

Table 5. Socio-Demographic information of distracted drivers

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Gender	Female	18	22.50	**Ethnicity**	Not Hispanic	32	22.70
	Male	16	20.51		Hispanic	2	11.76
Age	16 to 19	2	50.00	**Race**	African American, Black	7	18.92
	20 to 34	10	26.32		White	22	21.15
	35 to 49	13	22.81		Asian	2	22.22
	50 to 64	6	15.79		Hispanic/Mexican	0	0.00
	65 or more	3	14.29		Multiracial	2	66.67
Income	Less than $40,000	2	7.41		American Indian, Alaskan Native, Native Hawaiian, or other Pacific Islander	1	100.00
	$40,000 to $79,999	9	25.71	**Homeownership**	Owned	21	13.29
	$80,000 to $119,999	4	25		Rented	11	6.96
	$120,000 to $159,999	10	29.41		Occupied without payment of rent	2	1.27
	More than $160,000	9	25.71	**Type of Vehicle**	Car	21	22.11
Education	Less than high school graduate	1	0.00		SUV	11	22.45
	High school graduate, including GED	4	33.33		Van	1	16.67
	Some college or Associate Degree (e.g., AA, AS)	5	17.24		Pickup Truck	1	20.00
	Bachelor's Degree (e.g., BA, AB, BS)	6	13.95		Other Truck	0	0.00
	Graduate or professional degree (e.g., MA, MS, MED, Ph.D., MD, DDS)	18	25.35		Car Light Electric Vehicle (Golf Cart)	0	0.00
Number of Adults in the Household	1	5	16.67	**Employment**	Full-time	25	26.88
	2	17	18.28		Part-time	3	15.00
	3	4	22.22		Not Employed	6	13.33
	4	7	50.00	**Number of Household Vehicle**	0	1	100.00
	5	0	0.00		1	10	17.54
	6	0	0.00		2	14	19.18
	7	0	0.00		3	5	33.33
	8	0	0.00		4	2	22.22
	9	0	0.00		5 or more	2	66.67
	10 or more	1	100.00	**Home Type**	Single family attached house	9	5.70
	Single, never married	10	22.22		Single family detached house	17	10.76

Marital Status	Married or domestic partnership	22	22.68		A building with 2 or more apartments or condos	7	4.43
	Separated/Divorced	2	14.29		Dorm room	0	0.00
	Widowed	0	0.00		A mobile home or trailer	1	100.00
Number of Children in the Household	0	15	15.31	**Driver License Type**	Learner's Permit	0	0.00
	1	5	26.32		Permanent License for all types of vehicles class A	7	4.43
	2	12	35.29		Permanent License for all types of vehicles class B	1	16.67
	3	0	0.00		Permanent License for regular vehicles class C	26	19.40
	4	1	100.00	**Years of Having a Driver's license**	Less than one year	0	0.00
	5	1	100.00		1 year	2	50.00
	6	0	0.00		2 years	0	0.00
	7	0	0.00		3 years	0	0.00
	8	0	0.00		4 years	1	16.67
	9	0	0.00		5 years or more	31	22.14
	10 or more	0	0.00				

3.2. Methodology

Different information about the driver's behavior – including engaging in different distraction behaviors, distraction due to car technology, aggressive driving, and their reaction when they receive a phone call or a text while driving – is analyzed in the next section. The association between different characteristic information of drivers and different distractions is examined through several statistical analyses. Variables are analyzed to better understand distracted driving behavior, distracted technologies, and socio-demographic information of distracted drivers. Contingency tables are used to show the (multivariate) frequency distribution of the variables to find interactions among variables. Contingency tables (also called crosstabs or two-way tables) are used in statistics to summarize the relationship among several categorical variables. A contingency table is a special type of frequency distribution table in which two variables are shown simultaneously (*89*).

In order to determine whether there is a significant association between the two (categorical) variables, the Chi-square test of independence is used (*90*). The Chi-square test of independence is a statistical hypothesis test used to determine whether two categorical or nominal variables are likely to be related or not (*91*). Cell residuals, including standardized and adjusted residuals, are used in testing for cell significance, which is known as a post hoc test after a statistically significant Chi-square test. For post hoc tests following a Chi-square, the Bonferroni adjustment is used, which counteracts a type I error when multiple comparisons are made (*92; 93*).

Several Binary Logistic Regression Models are developed to determine the impact of multiple independent variables presented simultaneously to predict membership of one or the other of the two dependent variable categories (*94*). When the dependent variable is dichotomous or binary, Logistic regression is used. Logistic regression is the statistical technique used to predict the relationship between predictors (our independent variables) where the dependent variable is binary (e.g., sex, response, score, etc.). All predictor variables are tested in one block to assess their predictive ability while controlling for the effects of other predictors in the model (*95*). Moreover, Multinomial Logistic Regression (MNL) is selected for the chosen methodology due to the discrete variables used in the data and for its ability to account for variable interaction. MNL is a simple extension of binary logistic regression that allows for more than two categories of the dependent or outcome variable. Like binary logistic regression, multinomial logistic regression uses maximum likelihood estimation to evaluate the probability of categorical membership (*96*). Multinomial logistic regression is used to model nominal outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the predictor variables (*97*). MNL is used to predict categorical placement in or the probability of category membership on a dependent variable (different distraction behaviors) based on multiple independent variables (sociodemographic information of drivers). All statistical analyses used in the study are conducted with the 95% level of confidence.

4. ANALYSES AND RESULTS

Several analyses were performed to assess the impact of various socio-demographic and driver behaviors on the likelihood of distraction while driving. The results of each analysis are discussed in the following subsections.

4.1. Descriptive analysis

This section shows and summarizes patterns in frequency of driving, distracted behaviors, technology, and crash experience due to distraction of all respondents as well as distracted drivers.

4.1.1. Responses and Behaviors of Drivers

In this section, distracted driving behaviors, distracted driving technology, and aggressive behaviors of all respondents are examined.

4.1.1.1. Frequency of Driving

As shown in Figure 6, respondents were asked about their frequency of driving and average annual and weekly mileage of their cars. Many respondents (39%) reported driving a few days a week, 11% of the respondents reported driving every day, 17% drove almost every day, and the remainder drove a few days a month or a few days a year. The majority of respondents (68%) drove less than 8,000 miles annually on average. Moreover, more than 70% of respondents drove less than 100 miles weekly. Table 6 shows the frequency of each surveyed.

Table 6. Frequency of driving information of participants

Variables	Levels	Frequency	Percentage
Frequency of Driving	Everyday	18	11.39
	Almost Everyday	27	17.09
	Few Days a Week	61	38.61
	Few Days a Month	47	29.75
	Few Days a Year	5	3.16
Average Annual Driving Mileage	Less than 8,000	108	68.35
	8,001 to 15,000	36	22.78
	15,001 to 30,000	10	6.33
	30,000 or more	4	2.53
Average Weekly Driving Mileage	Less than 100 miles	111	70.25
	100 to 200 miles	22	13.92
	201 to 300 miles	15	9.49
	301 to 400 miles	4	2.53
	400 miles or more	6	3.80

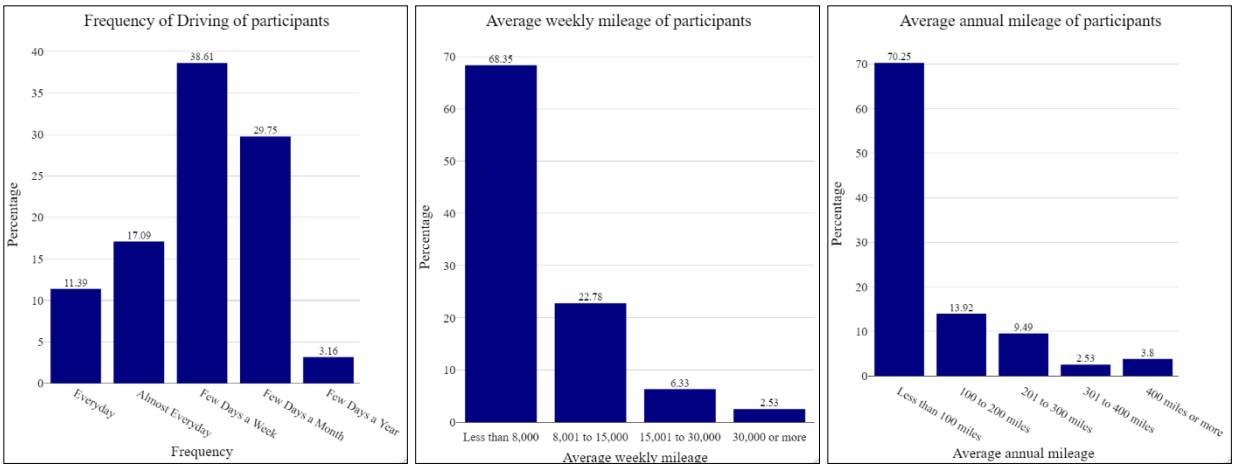


Figure 6. Frequency of driving of participants

4.1.1.2. Distracted Behaviors

As shown in Table 7, respondents were presented with a series of behaviors and asked whether they engage in each while driving. Choices were talking on the phone (hands-free), talking on the phone (handheld), texting, voice to text, reading or updating social media, reading or responding to emails, taking pictures or recording video, using GPS, eating or drinking, and taking on or off clothes. The most common behaviors were using GPS and talking on the phone (hands-free) (See Figure 7). Other common behaviors include eating/drinking, using voice to text, texting, and talking on the phone (handheld). Table 5 shows the frequency of each surveyed behavior.

Table 7. Distracted driving behaviors

Variables	Frequency	Percentage	Variables	Frequency	Percentage
Talk on the phone (hands-free)	101	63.92	**Read/respond to Emails**	19	12.03
Talk on the phone (handheld)	26	16.46	**Take pictures/record video**	20	12.66
Texting	29	18.35	**Using GPS**	119	75.32
Voice to text	35	22.15	**Eat/Drink**	90	56.96
Read/update Social Media	20	12.66	**Taking on/off clothes**	15	9.49

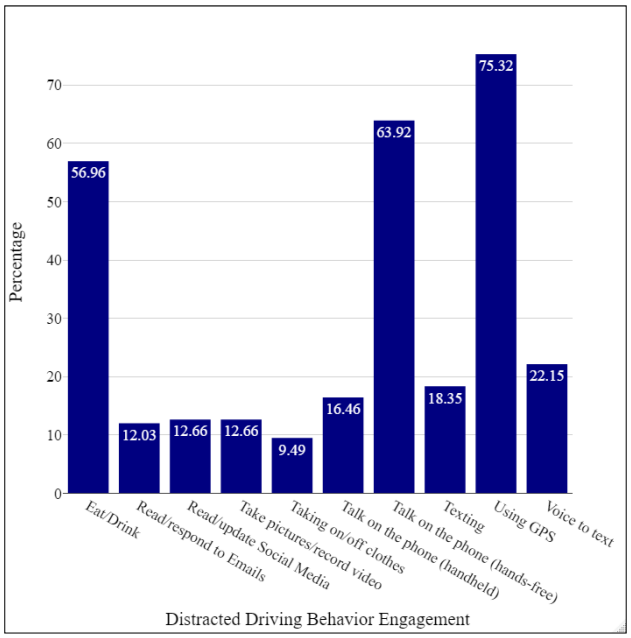


Figure 7. Distracted driving behavior engagement among participants

4.1.1.3. Distracted Technology

When asked specifically about answering calls while driving, most respondents (42%) answered they would answer the call immediately using a hands-free cell phone. Only 6% set their phone to automatic messaging while driving, and 21% of participants reported being willing to ignore it. However, the majority (51%) responded that they would ignore a text message while driving. Others will answer it in a safer situation (e.g., red light, parking, etc.). Table 8 shows that most drivers have an ability or feature on their phone that restricts using it while driving. However, only 13% of them always use it. The most popular restricted driving apps used by participants are Do Not Disturb While Driving on the phone's setting (28%), T-Mobile Drive Smart (4%), and AT&T ICW (3%).

Table 8. Answering calls or reply to text while driving

Variables	Levels	Frequency	Percentage
Restricted driving ability/feature on participant's phone	Yes	99	62.66
	No, my phone does not have such an app	59	37.34
Frequency of using restricted driving app	Yes, Always	21	13.29
	Yes, Almost always	13	8.23
	Yes, Sometimes	23	14.56
	Yes, Rarely	16	10.13
	Yes, Never	26	16.46
	No, my phone does not have such an app	59	37.34
Restricted driving app Used by participants	AT&T ICW	6	3.80
	T-Mobile Drive Smart	7	4.43
	Do Not Disturb While Driving on your phone's setting	45	28.48
	Drive Mode	7	4.43

	KyrusFleet	1	0.63
	Sprint Drive app	5	3.16
	tXt Blocker	2	1.27
	Drivesafe.ly	4	2.53
	Hum by Verizon	6	3.80
	KyrusFleet	2	1.27
	LifeSaver	3	1.90
	Sprint Drive First	1	0.63
	None	87	55.06
Response of participants when their phone rings while driving	My phone is set with automatic messaging while driving	9	5.70
	I will ignore it	34	21.52
	I will stop on the road shoulder and answer it	7	4.43
	I will answer it in a safer situation (e.g., red light, parking, etc.)	28	17.72
	I will answer it immediately if it is an emergency situation (hands-free or handheld)	10	6.33
	I will answer it immediately (handsfree)	67	42.41
	I will answer it immediately (handheld)	3	1.90
Response of participants when they receive a text while driving	My phone is set with automatic messaging while driving	14	8.86
	I will ignore it	80	50.63
	I will stop on the road shoulder and answer it	5	3.16
	I will answer it in a safer situation (e.g., red light, parking, etc.)	47	29.75
	I will answer it immediately if it is an emergency situation (Texting or Voice to Text)	7	4.43
	I will answer it immediately (Voice to Text)	1	0.63
	I will answer it immediately (Texting)	4	2.53

Respondents were also asked about distraction due to several car technologies including Blind Spot Warning, Collision Warning Systems, Lane Departure Warning Systems or Lane Keeping Assistant, Automatic Emergency Braking or Crash Imminent Braking and Hands-Off Detection. The majority of participants (almost 50% for each category) answered "my car does not have this technology." Table 9 shows the percentage of distractions due to any of the car technologies while driving.

Table 9. Distracted driving car technology

Variables	Levels	Frequency	Percentage
Distraction due to Blind Spot Warning	Yes	16	10.13
	My car does not have this technology	83	52.53
Distraction due to Collision Warning Systems	Yes	11	6.96
	My car does not have this technology	81	51.27
Distraction due to Lane Departure Warning Systems or Lane Keeping Assistant Systems	Yes	17	10.76
	My car does not have this technology	86	54.43
Distraction due to Automatic Emergency Braking or Crash Imminent Braking	Yes	19	12.03
	My car does not have this technology	82	51.90
Distraction due to Hands-Off Detection	Yes	10	6.33
	My car does not have this technology	91	57.59

As seen from Figure 8, hands-off detection has the least amount of distraction, and automatic emergency braking or crash imminent braking has the greatest amount of distraction among all five car technologies.

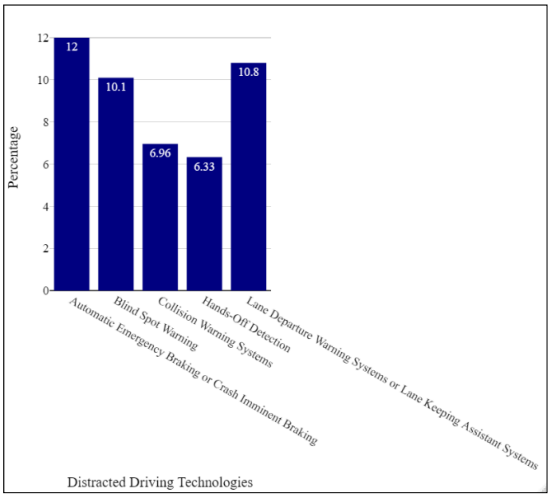


Figure 8. Percentage of distraction due to any of the car technologies

4.1.1.4. Near-Crash Experience

As shown in Table 10, 11.39% of respondents said they had been involved in at least one crash due to distraction, or at least one near-crash experience (12.03%) due to using a cell phone while driving. Of those who had a crash due to distraction, 2% admitted they looked but did not see at the time, 3% were distracted by a person outside, and 1% were distracted by moving objects in the vehicle. The most frequent types of crashes due to distraction were left turns and rear end collisions.

Table 10. Near-crash and crash due to distraction

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Having a near-crash experience due to using a cellphone while driving	0	139	87.97	**Category of the crash**	No Crash	140	88.61
	1 to 3	13	8.23		Property Damage Only Crash	18	11.39
	4 to 6	4	2.53		Injury Crash	0	0.00
	7 to 9	0	0.00		Fatal Crash	0	0.00
	10 or more	2	1.27	**Type of crash**	No crash	140	88.61
Having a crash due to distraction in the last two years	0	140	88.61		Left Turn	5	3.16
	1	12	7.59		Rear End	5	3.16
	2	5	3.16		Sideswipe	2	1.27
	3	0	0.00		Fixed Object	2	1.27
	4 or more	1	0.63		Opposite Direction	2	1.27
Year of the crash due to distraction	No crash	140	88.61		Parked Vehicle	1	0.63
	2019	10	6.33		U-Turn	1	0.63
	2020	6	3.80	**Month of the crash due to distraction**	Jan	4	2.53
	2021	2	1.27		Feb	1	0.63

Reason for the crash	No crash	140	88.61		Mar	4	2.53
	By Outside, person	4	2.53		Apr	4	2.53
	Looked But Did Not See	3	1.90		May	0	0.00
	By Moving Object in Vehicle (e.g., kids or dogs jumping around)	2	1.27		Jun	2	1.27
	Texting from a Cell Phone	2	1.27		July	0	0.00
	Adjusting Audio or playing music	2	1.27		Aug	0	0.00
	By Outside, animal	2	1.27		Sep	1	0.63
	Talking on the Phone (handheld)	1	0.63		Oct	1	0.63
	Other Distraction	2	1.27		Nov	1	0.63
					Dec	0	0.00

4.1.1.5. Aggressive Driving

Respondents were presented with a series of behaviors and asked how many times they indulge in each while driving. Choices were swear under my breath, drive well over speed limit, use horn when annoyed, fail to signal, tailgating, weave in/out traffic, failing to stop at stop sign, and speed up to get through light. Table 11 shows among all the aggressive behaviors while driving, driving well over speed limit and swearing under one's breath were repeated more than other behaviors.

Table 11. Aggressive driving behavior

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Swear under my breath	0	73	46.20	**Tailgating**	0	144	91.14
	1 to 3	56	35.44		1 to 3	9	5.70
	4 to 6	14	8.86		4 to 6	4	2.53
	7 to 9	4	2.53		7 to 9	0	0.00
	10 or more	11	6.96		10 or more	1	0.63
Drive well over speed limit	0	81	51.27	**Weave in/out traffic**	0	133	84.18
	1 to 3	51	32.28		1 to 3	14	8.86
	4 to 6	11	6.96		4 to 6	8	5.06
	7 to 9	3	1.90		7 to 9	2	1.27
	10 or more	12	7.59		10 or more	1	0.63
Use horn when annoyed	0	101	63.92	**Failing to stop at stop sign**	0	141	89.24
	1 to 3	46	29.11		1 to 3	10	6.33
	4 to 6	6	3.80		4 to 6	5	3.16
	7 to 9	2	1.27		7 to 9	1	0.63
	10 or more	3	1.90		10 or more	1	0.63
Fail to signal	0	118	74.68	**Speed up to get through light**	0	92	58.23
	1 to 3	28	17.72		1 to 3	47	29.75
	4 to 6	7	4.43		4 to 6	10	6.33
	7 to 9	2	1.27		7 to 9	5	3.16
	10 or more	3	1.90		10 or more	4	2.53

4.1.2. Responses and Behaviors of Distracted Drivers

In this section, distracted driving behaviors, distracted driving technology, and aggressive behaviors of distracted drivers are examined.

4.1.2.1. Frequency of Driving

As shown in Table 12, many self-reported distracted drivers (35%) reported driving a few days a week, while 23% of the respondents reported driving every day. The majority of distracted drivers (50%) drove less than 8,000 miles annually on average. Moreover, more than 56% of them drove less than 100 miles weekly.

Table 12. Frequency of driving information of distracted drivers

Variables	Levels	Frequency	Percentage
Frequency of Driving	Everyday	8	23.52
	Almost Everyday	6	17.64
	Few Days a Week	12	35.29
	Few Days a Month	7	20.58
	Few Days a Year	1	2.94
Average Annual Driving Mileage	Less than 8,000	17	50
	8,001 to 15,000	14	41.17
	15,001 to 30,000	2	5.88
	30,000 or more	1	2.94
Average Weekly Driving Mileage	Less than 100 miles	19	55.88
	100 to 200 miles	8	23.52
	201 to 300 miles	4	11.76
	301 to 400 miles	1	2.94
	400 miles or more	2	5.88

4.1.2.2. Distracted Behaviors

As shown in Table 13, the most common distracted driving behaviors among self-reported distracted drivers are using GPS (82%) talking on the phone (hands-free) (79%) and eating or drinking (79%). Other distractions include talking on a handheld phone, texting and voice to text.

Table 13. Distracted driving behaviors of distracted drivers

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Talk on the phone (hands-free)	Yes	27	79.41	**Read/respond to Emails**	Yes	9	26.47
Talk on the phone (handheld)	Yes	19	55.88	**Take pictures/record video**	Yes	7	20.59
Texting	Yes	14	41.18	**Using GPS**	Yes	28	82.35
Voice to text	Yes	14	41.18	**Eat/Drink**	Yes	27	79.41
Read/update Social Media	Yes	11	32.35	**Taking on/off clothes**	Yes	7	20.59

4.1.2.3. Distracted Technology

When asked specifically about answering calls while driving, most self-reported distracted drivers (50%) responded that they would answer the call immediately using a hands-free cell phone. Only 6% set their phone to automatic messaging, and only 6% of participants reported being willing to ignore it. However, many distracted drivers would answer it in a safer situation (e.g., red light, parking, etc.) and 32% of respondents would ignore a text message while driving.

Table 14 shows that the most of self-reported distracted drivers (73%) have an ability or feature on their phone that restricts using it while driving. However, only 23% of them always use it. The most popular restricted driving apps used by participants were Do Not Disturb While Driving on the phone's setting (24%) and T-Mobile Drive Smart (7%).

Table 14. Distracted driving technology usage among distracted drivers

Variables	Levels	Frequency	Percentage
Restricted driving ability/feature on participant's phone	Yes	25	73.53
	No, my phone does not have such an app	9	26.47
Frequency of using restricted driving app	Yes, Always	8	23.53
	Yes, Almost always	3	8.82
	Yes, Sometimes	3	8.82
	Yes, Rarely	7	20.59
	Yes, Never	4	11.76
	No, my phone does not have such an app	9	26.47
Restricted driving app used by participants	AT&T ICW	2	4.88
	T-Mobile Drive Smart	3	7.32
	Do Not Disturb While Driving on your phone's setting	10	24.39
	Drive Mode	0	0.00
	KyrusFleet	0	0.00
	Sprint Drive app	2	4.88
	tXt Blocker	1	2.44
	Drivesafe.ly		0.00
	Hum by Verizon	1	2.44
	KyrusFleet	1	2.44
	LifeSaver	2	4.88
	Sprint Drive First	1	2.44
	None	18	43.90
Response of participants when their phone ring while driving	My phone is set with automatic messaging while driving	2	5.88
	I will ignore it	2	5.88
	I will stop on the road shoulder and answer it	2	5.88
	I will answer it in a safer situation (e.g., red light, parking, etc.)	7	20.59
	I will answer it immediately if it is an emergency situation (hands-free or handheld)	2	5.88
	I will answer it immediately (hands-free)	17	50.00
	I will answer it immediately (handheld)	2	5.88
	My phone is set with automatic messaging while driving	4	11.76

Response of participants when they receive a text while driving	I will ignore it	11	32.35
	I will stop on the road shoulder and answer it	1	2.94
	I will answer it in a safer situation (e.g., red light, parking, etc.)	14	41.18
	I will answer it immediately if it is an emergency situation (Texting or Voice to Text)	1	2.94
	I will answer it immediately (Voice to Text)	1	2.94
	I will answer it immediately (Texting)	2	5.88

As seen in Table 15, Lane Departure Warning Systems or Lane Keeping Assistant Systems has the most distractions, and automatic emergency braking or crash imminent braking has the least distractions among all five car technologies. On the other hand, Lane Departure Warning Systems or Lane Keeping Assistant Systems cause the most distraction.

Table 15. Distraction due to car technology among distracted drivers

Car Technology	Levels	Frequency	Percentage
Distraction due to Blind Spot Warning	Yes	8	50.00
	My car does not have this technology	16	19.28
Distraction due to Collision Warning Systems	Yes	4	36.36
	My car does not have this technology	15	18.52
Distraction due to Lane Departure Warning Systems or Lane Keeping Assistant Systems	Yes	9	52.94
	My car does not have this technology	15	17.44
Distraction due to Automatic Emergency Braking or Crash Imminent Braking	Yes	6	31.58
	My car does not have this technology	14	17.07
Distraction due to Hands-Off Detection	Yes	5	50.00
	My car does not have this technology	15	16.48

4.1.2.4. Crash and Near-Crash Experience

Table 16 presents the near-crash and crash information of self-reported distracted drivers. 32% of distracted drivers had at least one near-crash experience due to using a cell phone while driving, and 23.5% of distracted drivers had at least one crash due to distraction. The most frequent reason for a crash among distracted drivers was adjusting audio or playing music. Moreover, a rear end crash is the most frequent type of crash among distracted drivers.

Table 16. Crash and near-crashes information among distracted drivers

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Having a near-crash experience due to using a cellphone while driving	0	23	67.65	**Reason for the crash**	No crash	26	76.47
	1 to 3	7	20.59		By Outside, person	1	2.94
	4 to 6	3	8.82		Looked But Did Not See	0	0.00
	7 to 9	0	0.00		By Moving Object in Vehicle (e.g., kids or dogs jumping around)	1	2.94
	10 or more	1	2.94		Texting from a Cell Phone	1	2.94
Having a crash due to distraction	0	26	76.47		Adjusting Audio or playing music	2	5.88
	1	5	14.71		By Outside, animal	1	2.94
	2	2	5.88		Talking on the Phone (handheld)	0	0.00

in the last two years	3	0	0.00		Other Distraction	2	5.88
	4 or more	1	2.94	**Type of crash**	No crash	26	76.47
Year of the crash due to distraction	No crash	26	76.47		Left Turn	1	2.94
	2019	3	8.82		Rear End	3	8.82
	2020	3	8.82		Sideswipe	1	2.94
	2021	2	5.88		Fixed Object	1	2.94
Category of the crash	No Crash	26	76.47		Opposite Direction	1	2.94
	Property Damage Only Crash	8	23.53		Parked Vehicle	0	0.00
	Injury Crash	0	0.00		U-Turn	1	2.94
	Fatal Crash	0	0.00				

4.1.2.5. Aggressive Behaviors

As shown in Table 17, among all the aggressive driving behaviors, driving well over the speed limit and failing to signal were repeated more than other behaviors among distracted drivers.

Table 17. Aggressive driving behavior

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Swear under my breath	0	15	44.12	**Tailgating**	0	27	79.41
	1 to 3	11	32.35		1 to 3	3	8.82
	4 to 6	3	8.82		4 to 6	3	8.82
	7 to 9	3	8.82		7 to 9	0	0.00
	10 or more	2	5.88		10 or more	1	2.94
Drive well over speed limit	0	10	29.41	**Weave in/out traffic**	0	23	67.65
	1 to 3	14	41.18		1 to 3	3	8.82
	4 to 6	3	8.82		4 to 6	5	14.71
	7 to 9	1	2.94		7 to 9	2	5.88
	10 or more	6	17.65		10 or more	1	2.94
Use horn when annoyed	0	21	61.76	**Failing to stop at stop sign**	0	27	79.41
	1 to 3	8	23.53		1 to 3	1	2.94
	4 to 6	2	5.88		4 to 6	4	11.76
	7 to 9	2	5.88		7 to 9	1	2.94
	10 or more	1	2.94		10 or more	1	2.94
Fail to signal	0	22	64.71	**Speed up to get through light**	0	15	44.12
	1 to 3	6	17.65		1 to 3	10	29.41
	4 to 6	3	8.82		4 to 6	6	17.65
	7 to 9	0	0.00		7 to 9	3	8.82
	10 or more	3	8.82		10 or more	0	0.00

4.1.2.6. Spatial Distribution of Distracted Drivers

Respondents were asked about their county of residence. Worcester and Calvert counties have the most distracted drivers, followed by Carroll, Cecil and Allegany counties.

4.1.3. Gender and Age as a Factor in Distraction

As shown in Table 18, females engage more in using hands-free cell phone, texting, voice to text, taking pictures/recording video, using GPS, eating, or drinking while driving than males. Males engage more in reading or updating social media, reading, or responding to emails, and taking on or off clothes. Moreover, those between 16 to 19 years old use hands-free and handheld cell phone, texting, voice to text, reading or updating social media, reading, or responding to emails, taking pictures/recording video, using GPS, eating or drinking while driving more than other age groups. The most common distracted driving behaviors among older drivers (more than 65) are talk on the phone (hands-free), using GPS and eating and drinking.

Table 18. Genders and ages of distracted drivers and their distracted driving behaviors

	Gender		Age				
Types of distraction	**Female**	**Male**	**16 to 19**	**20 to 34**	**35 to 49**	**50 to 64**	**more than 65**
Talk on the phone (hands-free)	66.25	61.5	75	63.2	70.2	52.6	66.66667
Talk on the phone (handheld)	16.25	16.7	50	18.4	17.5	13.2	9.52381
Texting	20	16.7	50	26.3	21.1	7.9	9.52381
Voice to text	23.75	20.5	75	28.9	28.1	10.5	4.761905
Read/update Social Media	12.5	12.8	50	21.1	10.5	5.3	9.52381
Read/respond to Emails	11.25	12.8	25	18.4	10.5	7.9	4.761905
Take pictures/record video	8.75	16.7	25	18.4	15.8	5.3	4.761905
Using GPS	78.75	71.8	100	84.2	75.4	71.1	61.90476
Eat/Drink	57.5	56.4	75	55.3	57.9	52.6	61.90476
Taking on/off clothes	8.75	10.3	50	7.9	10.5	7.9	4.761905

As seen in Table 19, males use cell phone apps that assist with avoiding distraction while driving more than females do (always and almost always). Moreover, those between 50 to 64 and 65 and older use these applications more than other age groups.

Table 19. Genders and ages of distracted drivers and their technology usage behaviors

	Female	**Male**	**16 to 19**	**20 to 34**	**35 to 49**	**50 to 64**	**more than 65**
No, my phone does not have such an app	37.5	37.2	25	21.1	28.1	57.9	57.1
Yes, Always	12.5	14.1	0	23.7	7.0	13.2	14.3
Yes, Almost always	5	11.5	0	13.2	12.3	2.6	0.0
Yes, Sometimes	11.25	17.9	25	21.1	19.3	5.3	4.8
Yes, Rarely	10	10.3	50	10.5	10.5	7.9	4.8
Yes, Never	23.75	9.0	0	10.5	22.8	13.2	19.0

The risk of having a near-crash experience due to using a cell phone while driving was higher in males than females, and those between 16 to 19 among distracted drivers, as shown in Table 20.

Table 20. Genders and ages of distracted drivers and their near-crash experience

	Female	Male	16 to 19	20 to 34	35 to 49	50 to 64	more than 65
0	91.25	84.6	50	89.5	84.2	92.1	95.2
1 to 3	7.5	9.0	25	7.9	10.5	5.3	4.8
4 to 6	1.25	3.8	25	0.0	5.3	0.0	0.0
7 to 9	0	0.0	0	0.0	0.0	0.0	0.0
10 or more	0	2.6	0	2.6	0.0	2.6	0.0

As shown in Table 21, when it comes to all types of car technology, males and those between 20 to 34 were distracted more than other groups.

Table 21. Genders and ages of distracted drivers and their car technology related distraction

	Female	Male	16 to 19	20 to 34	35 to 49	50 to 64	more than 65
Blind Spot Warning	6.3	14.1	0	18.4	10.5	5.2	4.7
Collision Warning Systems	2.5	11.5	0	18.4	3.5	2.6	4.7
Lane Departure Warning Systems or Lane Keeping Assistant	7.5	14.1	0	15.7	12.2	7.8	4.7
Automatic Emergency Braking or Crash Imminent Braking	6.2	17.9	0	18.4	15.7	2.6	9.5
Hands-Off Detection	1.2	11.5	0	13.1	7	0	4.7

4.1.4. Distraction Before the COVID-19 Pandemic

The COVID-19 pandemic caused a significant shift in people's travel behaviors and distraction while driving. Local and state shelter-in-place and public health orders minted millions of new low-mileage drivers overnight, as many people limited their vehicle use to the bare minimum. While some drivers may return to their pre-pandemic habits, emerging social trends, such as increased remote work and household moves to more distant suburban and rural communities, may advance these changes, creating different driving routines and a new normal going forward. Therefore, because the data collected during the pandemic are not comparable to the data of previous years, all the questions were asked of the respondents before and after the pandemic to compare the changes in drivers' behavior before and after the pandemic. In this section, the characteristics of distracted drivers, distracted driving behaviors, distracted driving technology, aggressive behaviors of distracted drivers before the COVID-19 pandemic (from 3/1/2019 to 3/1/2020) is examined.

4.1.4.1. Socio-Demographic information of distracted drivers before the pandemic

The respondents were asked whether they usually got distracted while driving before the pandemic. Some 25.5% of respondents answered that they usually did (see Figure 9). Table 22 shows the socio-demographic information of the distracted drivers.

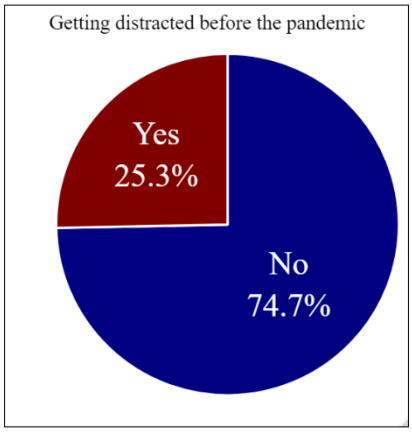


Figure 9. Distraction while driving before the pandemic among participants

As Table 22 shows, distractions while driving occurred more among females than males before the pandemic, the same as during the pandemic. Among different age groups, those between 16 to 19 and 20 to 34 were more distracted. Participants who graduated from high school became more distracted than those with other educational levels. Moreover, those with incomes between $40,000 to $79,999 were the most distracted while driving. Participants who had more children in the household also were more distracted, as were respondents who had their driver's license for one year.

Table 22. Socio-Demographic information of distracted drivers before the pandemic

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Gender	Female	23	28.75	**Ethnicity**	Not Hispanic	37	26.24
	Male	17	21.79		Hispanic	3	17.65
Age	16 to 19	3	75.00	**Race**	African American, Black	9	24.32
	20 to 34	12	31.58		White	27	25.96
	35 to 49	15	26.32		Asian	1	11.11
	50 to 64	7	18.42		Hispanic/Mexican	1	25.00
	65 or more	3	14.29		Multiracial	1	33.33
Income	Less than $40,000	4	14.81		American Indian, Alaskan Native, Native Hawaiian, or other Pacific Islander	1	100.00
	$40,000 to $79,999	12	34.29	**Homeownership**	Owned	23	14.56
	$80,000 to $119,999	8	30.77		Rented	13	8.23
	$120,000 to $159,999	6	17.65		Occupied without payment of rent	4	2.53
	More than $160,000	10	28.57	**Type of Vehicle**	Car	22	23.16
Education	Less than high school graduate	1	0.00		SUV	13	26.53
	High school graduate, including GED	5	41.67		Van	2	33.33
	Some college or Associate Degree (e.g., AA, AS)	6	20.69		Pickup Truck	1	20.00
	Bachelor's Degree (e.g., BA, AB, BS)	9	20.93		Other Truck	1	50.00
	Graduate or professional degree (e.g., MA, MS, MED, Ph.D., MD, DDS)	19	26.76		Car Light Electric Vehicle (Golf Cart)	1	100.00
Number of Adults in the Household	1	6	20.00	**Employment**	Full-time	28	30.11
	2	21	22.58		Part-time	3	15.00
	3	5	27.78		Not Employed	9	20.00
	4	7	50.00	**Number of Household Vehicle**	0	1	100.00
	5	0	0.00		1	12	21.05
	6	0	0.00		2	18	24.66
	7	0	0.00		3	5	33.33
	8	0	0.00		4	2	22.22

	9	0	0.00		5 or more	2	66.67
	10 or more	1	100.00	**Home Type**	Single family attached house	10	6.33
Marital Status	Single, never married	12	26.67		Single family detached house	20	12.66
	Married or domestic partnership	26	26.80		A building with 2 or more apartments or condos	9	5.70
	Separated/Divorced	2	14.29		Dorm room	0	0.00
	Widowed	0	0.00		A mobile home or trailer	1	100.00
Number of Children in the Household	0	17	17.35	**Driver License Type**	Learner's Permit	1	100.00
	1	7	36.84		Permanent License for all types of vehicles class A	6	3.80
	2	12	35.29		Permanent License for all types of vehicles class B	3	50.00
	3	2	40.00		Permanent License for regular vehicles class C	30	22.39
	4	1	100.00	**Years of Having a Driver's license**	Less than one year	0	0.00
	5	1	100.00		1 year	2	50.00
	6	0	0.00		2 years	2	100.00
	7	0	0.00		3 years	0	0.00
	8	0	0.00		4 years	1	16.67
	9	0	0.00		5 years or more	35	25.00
	10 or more	0	0.00				

4.1.4.2. Distracted Behaviors

As shown in Table 23, the most common distracted driving behaviors among distracted drivers before the pandemic were using GPS (100%) talking on the phone (hands-free) (92.5%) and eating or drinking (92.5%). Other distractions include talking on a handheld phone , texting and voice to text.

Table 23. Distracted driving behaviors of distracted drivers

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Talk on the phone (handsfree)	Yes	37	92.50	**Read/respond to Emails**	Yes	11	27.50
Talk on the phone (handheld)	Yes	16	40.00	**Take pictures/record video**	Yes	10	25.00
Texting	Yes	17	42.50	**Using GPS**	Yes	40	100.00
Voice to text	Yes	18	45.00	**Eat/Drink**	Yes	37	92.50
Read/update Social Media	Yes	12	30.00	**Taking on/off clothes**	Yes	6	15.00

4.1.4.3. Distracted Technology

When asked specifically about answering calls while driving, half of the distracted drivers (50%) answered that they would answer the call immediately using a hands-free cell phone. Only 5% set their phone to automatic messaging, and only 7.5% of participants reported willing to ignore it. However, the majority of distracted drivers would answer it in a safer situation (e.g., red light, parking, etc.) and 35% of respondents would ignore a text message while driving. Table 24 shows that the most of distracted drivers (70%) have an ability or feature on their phone that restricts using it while driving. However, only 20% of them always use it. The most popular restricted driving app used by participants were Do Not Disturb While Driving on the phone's setting (35%) and T-Mobile Drive Smart (10%).

Table 24. Distracted driving technology usage among distracted drivers

Variables	Levels	Frequency	Percentage
Restricted driving ability/feature on participant's phone	Yes	12	30.00
	No, my phone does not have such an app	28	70.00
Frequency of using restricted driving app	Yes, Always	8	20.00
	Yes, Almost always	2	5.00
	Yes, Sometimes	5	12.50
	Yes, Rarely	6	15.00
	Yes, Never	7	17.50
	No, my phone does not have such an app	12	30.00
Restricted driving app used by participants	AT&T ICW	2	5.00
	T-Mobile Drive Smart	4	10.00
	Do Not Disturb While Driving on your phone's setting	14	35.00
	Drive Mode	2	5.00
	KyrusFleet	1	2.50
	Sprint Drive app	3	7.50

	tXt Blocker	0	0.00
	Drivesafe.ly	1	2.50
	Hum by Verizon	2	5.00
	KyrusFleet	1	2.50
	LifeSaver	1	2.50
	Sprint Drive First	0	0.00
	None	22	55.00
Response of participants when their phone ring while driving	My phone is set with automatic messaging while driving	2	5.00
	I will ignore it	3	7.50
	I will stop on the road shoulder and answer it	1	2.50
	I will answer it in a safer situation (e.g., red light, parking, etc.)	9	22.50
	I will answer it immediately if it is an emergency situation (hands-free or handheld)	3	7.50
	I will answer it immediately (handsfree)	20	50.00
	I will answer it immediately (handheld)	2	5.00
Response of participants when they receive a text while driving	My phone is set with automatic messaging while driving	5	12.50
	I will ignore it	14	35.00
	I will stop on the road shoulder and answer it	1	2.50
	I will answer it in a safer situation (e.g., red light, parking, etc.)	14	35.00
	I will answer it immediately if it is an emergency situation (Texting or Voice to Text)	2	5.00
	I will answer it immediately (Voice to Text)	1	2.50
	I will answer it immediately (Texting)	3	7.50

As seen in Table 25, Hands-off detection has the most distractions among distracted drivers before the pandemic.

Table 25. Distraction due to car technology among distracted drivers

Variables	Levels	Frequency	Percentage
Distraction due to Blind Spot Warning	Yes	5	12.50
	My car does not have this technology	23	57.50
Distraction due to Collision Warning Systems	Yes	5	12.50
	My car does not have this technology	21	52.50
Distraction due to Lane Departure Warning Systems or Lane Keeping Assistant Systems	Yes	5	12.50
	My car does not have this technology	22	55.00
Distraction due to Automatic Emergency Braking or Crash Imminent Braking	Yes	5	12.50
	My car does not have this technology	19	47.50
Distraction due to Hands-Off Detection	Yes	6	15.00
	My car does not have this technology	22	55.00

4.1.4.4. Crash and Near-Crash Experience

As shown in Table 26, 40% of distracted drivers had at least one near-crash experience due to using a cell phone while driving and more than 22% had at least one crash due to distraction. The most frequent reason for having a crash among distracted drivers was adjusting audio or playing

music. A rear end collision is the most frequent type of crash among distracted drivers before the pandemic.

Table 26. Crash and near-crashes among distracted drivers

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Having a near-crash experience due to using a cellphone while driving	0	18	45.00	**Reason for the crash**	No crash	30	75.00
	1 to 3	16	40.00		By Outside, person	2	5.00
	4 to 6	5	12.50		Looked But Did Not See	1	2.50
	7 to 9	0	0.00		By Moving Object in Vehicle (e.g., kids or dogs jumping around)	1	2.50
	10 or more	1	2.50		Texting from a Cell Phone	0	0.00
Having a crash due to distraction in the last two years	0	30	75.00		Adjusting Audio or playing music	2	5.00
	1	7	17.50		By Outside, animal	0	0.00
	2	2	5.00		Talking on the Phone (handheld)	0	0.00
	3	0	0.00		Other Distraction	2	5.00
	4 or more	1	2.50	**Type of crash**	No crash	30	75.00
Year of the crash due to distraction	No crash	30	75.00		Left Turn	3	7.50
	2019	4	10.00		Rear End	4	10.00
	2020	4	10.00		Sideswipe	2	5.00
	2021	2	5.00		Fixed Object	1	2.50
Category of the crash	No Crash	30	75.00		Opposite Direction	0	0.00
	Property Damage Only Crash	10	25.00		Parked Vehicle	0	0.00
	Injury Crash	0	0.00		U-Turn	0	0.00
	Fatal Crash	0	0.00				

4.1.4.5. Aggressive Behaviors

As shown in Table 27, among all the aggressive behaviors while driving, the percentage of 10 or more times of driving well over the speed limit was more than other behaviors among distracted drivers.

Table 27. Aggressive driving behavior

Variables	Levels	Frequency	Percentage	Variables	Levels	Frequency	Percentage
Swear under my breath	0	16	40.00	**Tailgating**	0	31	77.50
	1 to 3	13	32.50		1 to 3	5	12.50
	4 to 6	6	15.00		4 to 6	2	5.00
	7 to 9	2	5.00		7 to 9	1	2.50
	10 or more	3	**7.50**		10 or more	1	**2.50**
Drive well over speed limit	0	7	17.50	**Weave in/out traffic**	0	30	75.00
	1 to 3	22	55.00		1 to 3	5	12.50
	4 to 6	2	5.00		4 to 6	2	5.00
	7 to 9	4	10.00		7 to 9	1	2.50

	10 or more	5	**12.50**		10 or more	2	**5.00**
Use horn when annoyed	0	20	50.00	**Failing to stop at stop sign**	0	29	72.50
	1 to 3	14	35.00		1 to 3	8	20.00
	4 to 6	3	7.50		4 to 6	2	5.00
	7 to 9	1	2.50		7 to 9	0	0.00
	10 or more	2	**5.00**		10 or more	1	**2.50**
Fail to signal	0	10	25.00	**Speed up to get through light**	0	12	30.00
	1 to 3	14	35.00		1 to 3	18	45.00
	4 to 6	3	7.50		4 to 6	5	12.50
	7 to 9	1	2.50		7 to 9	3	7.50
	10 or more	2	**5.00**		10 or more	2	**5.00**

4.1.4.6. Changes Before and During the Pandemic

As shown in Figure 10, the distracted driving rate decreased more than 3% during the pandemic, from 25.3% to 21.5%. A Chi-square Bonferroni Post Hoc test (p-value<0.0001) revealed self-reported distraction dropped significantly before and during the pandemic.

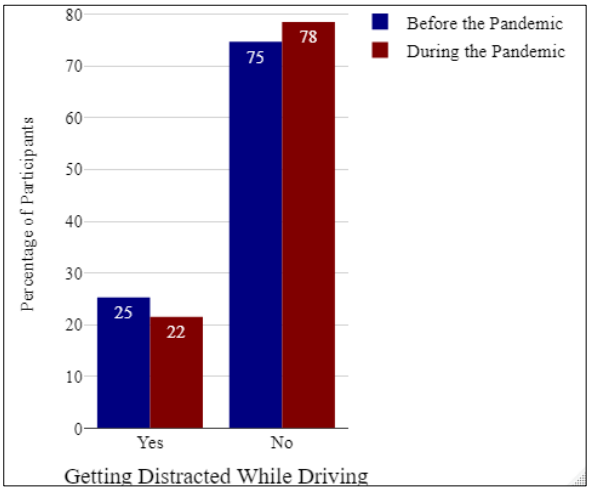


Figure 10. Getting distracted while driving before and during the pandemic

The frequency of driving reported by respondents before and during the COVID-19 pandemic shows that before the pandemic, 55% of participants drove every day; however, after the pandemic that dropped sharply to 11%. Figure 11 (a) shows that during the pandemic, most participants, about 68%, have been driving less than 8,000 miles annually. Also, those who drove an average of 30,000 miles or more annually dropped to less than 3% during the pandemic. Figure 11 (b) shows the weekly driving mileage of participants. Most of the participants, about 70%, have been driving less than 100 miles weekly during the pandemic.

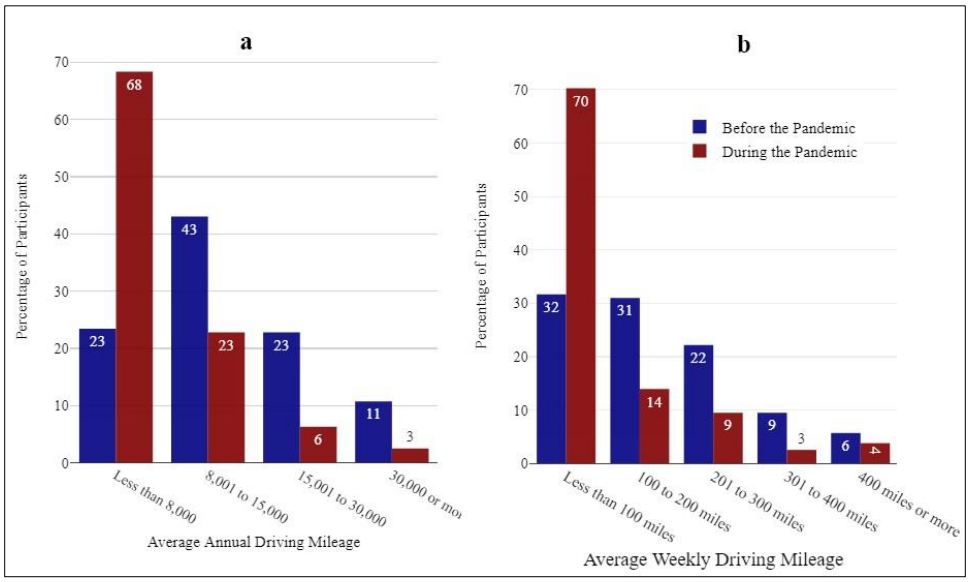
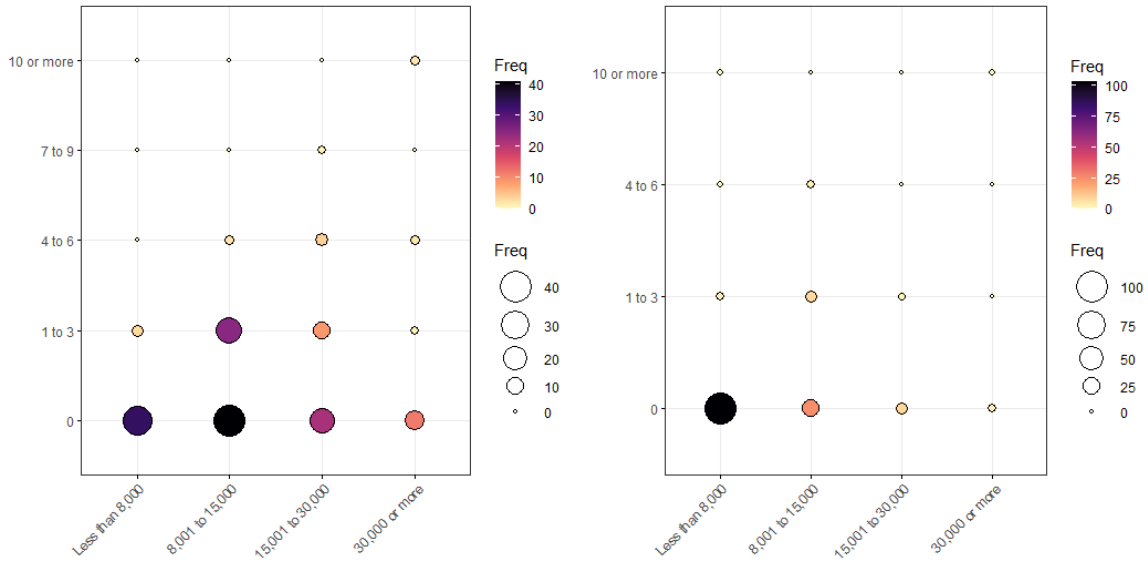


Figure 11. (a) Average annual driving, and (b) Average weekly driving

The findings show that hands-free cell phone use while driving dropped by 5% (from 68% to 63% of users) during the COVID-19 pandemic. The p-value of the Chi-square test (p-value<0.0001) shows that the changes in using a hands-free cell phone before and during the pandemic are statistically significant. Handheld cell phone use remained unchanged at 16% before and during the COVID-19 pandemic.

According to the survey results, almost 12% of participants had at least one crash due to distraction in the past two years (2019-2021). A Chi-square Bonferroni Post Hoc test (p-value<0.0001) revealed having at least one crash due to distraction dropped significantly (23%) from 2019 (before the COVID-19 pandemic) to 2020 (during the COVID-19 pandemic). Similarly, not having a near-crash experience increased 30% during the pandemic. A Chi Square Bonferroni Post Hoc test (p-value<0.0001) revealed a significant difference between not having a near-crash experience due to distraction before and during the COVID-19 pandemic.

Moreover, the results show that aggressive behavior – including swearing under one's breath (8.22%), driving over the speed limit (27.21%), using the horn when annoyed (4.43%), failing to signal (10.12%), tailgating (3.79%), weaving in or out traffic (1.89%), failing to stop at stop sign (5.69%), and speeding up to get through light (17.08%) – decreased during the pandemic.



(a) **(b)**

Figure 12. (a) Number of near-crash experiences while driving in one year versus average annual driving before the pandemic, (b) Number of near-crash experiences while driving in one year versus average annual driving during the pandemic

4.2. Statistical Analysis

The Chi-square test was used to determine the relationship between self-reported distraction while driving and the socio-demographic information of drivers. No statistically significant relationship exists between gender, age, income, race, education, and employment. A strong statistically significant relationship was found between the number of children in the household and getting distracted while driving (p-value=0.01043). As seen in Figure 13, having 2 children in the household can cause more distraction.

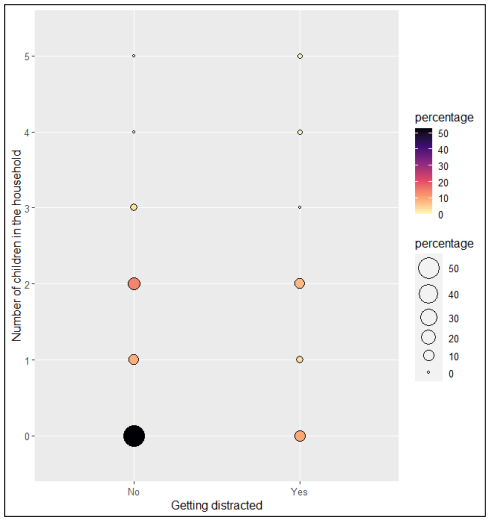


Figure 13. Association between number of children in household and self-reported distraction

The Chi-square test was used to determine the relationship between self-reported distraction and frequency and average mileage of driving of participants. The results of the Chi-square test show that there is a statistically significant relationship between average annual driving mileage and getting distracted while driving (p-value= 0.03497). As seen in Figure 14, those drivers with an average annual driving mileage of less than 15,000 get distracted more than others.

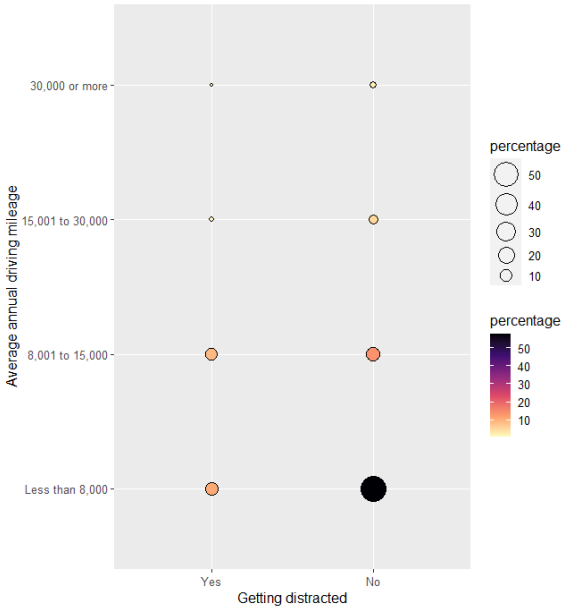


Figure 14. Association between average annual driving mileage and self-reported distraction

The results of the Chi-square test show that a statistically significant relationship was found between talking on the phone (handheld) (p-value= 1.607E-11), texting (p-value=0.000283), voice to text (p-value=0.005398), reading or updating social media (p-value=0.0003092), reading, or responding to emails (p-value=0.00865), eating or drinking (p-value=0.005289), and taking on or off clothes (p-value=0.0307), and self-reported distraction. Moreover, the results of the Chi-square test show that there is a statistically significant relationship between getting distracted due to Blind Spot Warning systems (p-value=0.01316), Lane Departure Warning Systems or Lane Keeping Assistant (p-value=0.003795), Hands-Off Detection (p-value= 0.03913) and self-reporting distraction. The results also indicate that there is a statistically significant relationship between near-crashes due to using a cell phone while driving (p-value=0.0004804) and having a crash due to distraction (p-value=0.0004541) and self-reporting distraction.

4.3. Distracted Driving Models

In this section, two binary logistic regression models are developed to examine the effect of different socio-demographic, travel behavior and distracted behavior on self-reporting distraction and having a near-crash due to using a cell phone. To investigate the effect of socio-demographic and travel behavior of drivers on number of times drivers engage in distracted driving behavior (including using a hands-free, handheld cell phone, texting, etc.) a multinominal regression is developed.

4.3.1. Binary Logistic Regression Model

Researchers developed a binary logistic regression to predict the odds of self-reporting distraction (dependent variable) on distracted driving behavior and the different socio-demographic information of drivers. Table 28 presents the results of the final model after stepwise regression. Using a handheld cell phone, using voice to text while driving and household income are significant. The odd of self-reported distraction is 13.33 times higher (exp (2.59)) among drivers who use handheld cell phone while driving than other drivers. Also, using voice to text while driving increase the odd of self-reported distraction by 6.49 times higher (exp (1.87)) than other drivers. The results indicate that the odds of having self-reporting distraction for drivers with incomes of 40,000 to 79,999 and 80,000 to 119,999, increase by 6.55 (exp (1.88)) and 6.36 (exp (1.85)), respectively, compared to drivers with incomes of less than 40,000.

Table 28. Results of binary logistic regression model for self-reporting distraction

	Estimate	Std. Error	z value	Pr(>|z|)	Signif. codes
(Intercept)	-3.75	0.84	-4.47	0.00	***
handheldYes	2.59	0.56	4.58	0.00	***
voicetotYes	1.87	0.53	3.49	0.00	***
income40,000 to 79,999	1.88	0.91	2.07	0.04	*
income80,000 to 119,999	1.85	0.91	2.04	0.04	*
income120,000 to 159,999	1.36	0.93	1.46	0.14	
incomemore than 160,000	0.89	0.92	0.97	0.33	
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 Null deviance: 167.11 on 157 degrees of freedom Residual deviance: 116.91 on 151 degrees of freedom, AIC: 130.91					

Moreover, a binary logistic regression was developed to predict the odds of having a near-crash experience due to using a cell phone while driving (dependent variable) on distracted driving behavior and the different socio-demographic information of drivers. Table 29 presents the results of the final model after stepwise regression. It was understood that using a handheld cell phone, average annual driving mileage and race of drivers are significant. Using a handheld cell phone while driving increased the odds of near-crashes by 7.61 (exp (2.03)). Moreover, the results indicate that the odds of having a near-crash experience for drivers who drove an average 8,001 to 15,000 annually increase by 8.76 (exp (2.17)) compared to drivers who drove less than 8,000 on average annually. The model also indicates that the odds of having a near-crash experience due to using a cell phone is 12.68 times (exp (2.54)) higher in the Asian population than the African American population.

Table 29. The model for having a near-crash experience due to using a cell phone

	Estimate	Std. Error	z value	Pr(>|z|)	Signif. codes
(Intercept)	-4.13	0.84	-4.91	0.00	***
handheldYes	2.03	0.63	3.24	0.00	**
annual8,001 to 15,000	2.17	0.67	3.22	0.00	**
annual15,001 to 30,000	1.74	1.05	1.65	0.10	.
annual30,000 or more	2.44	1.44	1.69	0.09	.
raceAmerican Indian, Alaskan Native, Native Hawaiian, or other Pacific Islander	17.49	3956.18	0.00	1.00	
raceAsian	2.54	1.16	2.19	0.03	*
raceHispanic/Mexican	-15.81	1712.63	-0.01	0.99	
raceMultiracial	1.84	1.47	1.25	0.21	
raceWhite	0.34	0.72	0.48	0.63	
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 Null deviance: 116.108 on 157 degrees of freedom Residual deviance: 81.036 on 148 degrees of freedom, AIC: 101.04					

4.3.2. Multinomial Regression Model

To investigate the relationship between the number of times that drivers engage in a distractive behavior and socio-demographic and travel behavior of drivers, a multinominal regression is developed. Distractive behaviors are using a hands-free or handheld cell phone, texting, using voice to text, reading, or updating social media, reading or updating emails, taking pictures or recording a video, using GPS, eating or drinking, and taking on or off clothes. The dependent variable is the number of times a driver engages in a distractive behavior (none, one or two, three or four, and five or more). As shown in Table 30, age, number of vehicles in the household, number of years that a driver has held a driver's license, average annual driving mileage, near-crash experience and self-reported distraction are significant.

Table 30. The model for number of times that drivers engage in a distractive behavior

	Coefficients			**Std. Errors**			**p-value**		
	One or two	Three or Four	Five or more	One or two	Three or Four	Five or more	One or two	Three or Four	Five or more
(Intercept)	3.55	-1.58	40.09	1.30	0.82	1.39	0.01	0.05	0.00
age20 to 34	24.48	-15.49	-12.73	0.56	0.59	0.61	0.00	0.00	0.00
age35 to 49	24.53	-14.89	-13.35	0.57	0.52	0.64	0.00	0.00	0.00
age50 to 64	24.31	-15.47	-14.71	0.57	0.57	0.77	0.00	0.00	0.00
age65 or more	24.63	-15.31	**-14.85**	0.67	0.69	1.00	0.00	0.00	0.00
nocar	0.08	0.51	**1.34**	0.40	0.42	0.45	0.84	0.22	0.00
ylicense Less than 1 year	19.71	47.03	-44.94	0.00	0.00	0.00	0.00	0.00	0.00
ylicense2 years	41.46	-7.48	-27.35	0.00	NaN	0.00	0.00	NaN	0.00
ylicense3 years	10.00	56.51	-42.33	0.63	0.63	0.00	0.00	0.00	0.00
ylicense4 years	-28.36	-23.91	-30.33	1.34	NaN	1.50	0.00	NaN	0.00
ylicense5 years or more	-28.17	16.95	-30.39	0.93	0.70	1.05	0.00	0.00	0.00
annual30,000 or more	13.14	10.89	**8.95**	1.55	1.47	2.32	0.00	0.00	0.00
annual8,001 to 15,000	1.33	-0.47	0.40	1.64	1.40	1.57	0.42	0.74	0.80
annualLess than 8,000	0.96	-1.43	-0.54	1.48	1.21	1.38	0.52	0.24	0.70
nearcrash1 to 3	-1.01	0.20	1.66	1.56	1.38	1.34	0.52	0.89	0.22
nearcrash10 or more	25.62	-22.45	**25.39**	1.68	0.00	1.68	0.00	0.00	0.00
nearcrash4 to 6	-1.20	-1.46	-19.32	1.64	1.62	0.00	0.46	0.37	0.00
distractionYes	-0.62	1.49	**1.84**	0.99	0.87	0.92	0.53	0.09	0.05
Residual Deviance: 321.916 AIC: 429.916									
Goodness of fit	Pearson's Chi-squared test, data: d14$i140None and predict (MNL3), X-squared =76.583, df = 9, p-value = 7.689e-13								
R square	CoxSnell- Nagelkerke – McFadden, 0.4515166 - 0.4862866 - 0.2276682								

The results indicate that the relative log odds of engaging in five or more distracted driving behaviors vs. engaging in none decreases by 14.85 when comparing those between 16 to 19 to those age 65 or more. A one-unit increase in the number of vehicles in the household is associated with a 1.34 increase in the relative log odds of engaging in five or more distracted driving behavior vs. engaging in none. The relative log odds of engaging in five or more distracted driving behaviors vs. engaging in none increases by 8.95 when comparing those who drive less than 8,000 miles annually to those who drive more than 30,000 miles annually. The relative log odds of engaging in five or more distracted driving behaviors vs. engaging in none increases by 25.39 when comparing those who have not had a near-crash experience due to using a cell phone while driving to those who have had 10 or more near-crash experiences. The relative log odds of engaging in

five or more distracted driving behaviors vs. engaging in none increases by 1.84 when comparing those who reported getting distracted while driving to those who did not report distraction.

5. DISCUSSION

The result of this study revealed that having at least one crash due to distraction dropped significantly from before the pandemic to during the pandemic. This could be due to less cars on the road and the fact that the average mileage of driving, daily commutes, work-related long-distance trips, and non-work travels decreased during the pandemic. As this study shows in this regard, during the pandemic, only 11% of drivers drove every day but before the pandemic that percentage was 55%, and most participants, about 68%, have been driving less than 8,000 miles annually. Also, compared to before the pandemic, self-reported distraction dropped significantly during the pandemic.

The statewide statistics indicates that during the COVID-19 pandemic (2020), the total number of injured and total crashes due to distraction decreased, however, the fatalities due to distraction increased. The results of this study are aligned with the statewide statistics which indicate that distracted driving crashes dropped in 2020 during the pandemic. Moreover, statewide statistics indicates that young drivers (those between 21 to 29) had the most injury and fatal crashes among all age groups, which is the same as this study's results. Moreover, the results of the study show that females had reported distraction more than males. Also, those with higher income levels (more than $120,000) had reported distraction more than other income groups. Furthermore, those with a higher number of children in the household had reported distraction more than other drivers. The African American population got distracted less than white and Asian populations. From the spatial distribution of distracted drivers, it can be interpreted that Worcester and Calvert counties have the most percentages of self-reported distraction among participants.

From the distracted driving regression models, it can be interpreted that a handheld cell phone is the most distractive behavior. Handheld cell phone use will increase the risk of distraction by a factor of 13 and the risk of a near-crash experience by 7.6. Using voice to text while driving also can increase the distraction by almost 6.5 times. Higher income levels are also associated with higher self-reported distraction. Drivers with incomes of less than $40,000 will have less self-reported distraction. Moreover, average annual driving mileage is associated with having a near-crash experience due to using a cell phone. The risk of having a near-crash experience in drivers with average mileage of 8,001 to 15,000 annually will increase by 8.7 compared to drivers with average mileage of less than 8,000. Similarly, driving more than 30,000 miles will increase the risk of engaging in more distractive behaviors. As the age of drivers decreases, the risk of engaging in more than five distractive behaviors while driving will increase and younger drivers will engage more in distractive behaviors. There is a statistically significant decrease in self-reported distraction before and during the pandemic. Due to decreased vehicle volumes and fewer drivers on the streets, drivers' speed increased during the pandemic. As we progressed through the COVID-19 pandemic, transportation networks and systems began to take on new forms. Reduced car crashes and fatalities are the silver lining of the COVID-19 pandemic. After all, it seems that more individuals working or studying from home results in fewer cars on the road, lowering the risk of crashes.

6. SUMMARY AND CONCLUSION

This project investigated the socio-demographic and target group of distracted drivers as well as the types of devices, technologies, and behaviors that distract drivers the most in Maryland.

For this study, some 158 drivers participated in an online stated preference survey about their socio-demographic information, travel behavior, driving behavior and the types of devices and technologies they use while driving, and near-crash and crashes due to distraction. All the survey questions were designed for both before the COVID-19 pandemic (from 3/1/2019 to 3/1/2020) and during the pandemic (from 3/1/2020 to 3/1/2021).

Different information about the driver's behavior – including engaging in different distraction behaviors, distraction due to car technology, aggressive driving, and their reaction when they receive a phone call or a text while driving – is analyzed through different methods including the Chi-square test of independence, Post Hoc tests following a Chi-square, with the Bonferroni adjustment, Binary Logistic Regression and Multinomial Logistic Regression.

The results of this study are aligned with the statewide statistics which indicate that distracted driving crashes dropped in 2020 during the pandemic. The results of the study also revealed that females and young drivers were the most distracted drivers. Females engage more in using hands-free cell phones, texting, voice to text, taking pictures/recording video, using GPS, and eating or drinking while driving than males do. Males engage more in reading or updating social media, reading, or responding to emails, and taking on or off clothes. Moreover, those between 16 to 19 years old engage in all distracted behaviors while driving more than other age groups do. The risk of having a near-crash experience due to using a cell phone while driving was higher for males than females, and for those between 16 to 19.

The most common behaviors while driving was using GPS and talking on the phone (hands-free). Most drivers have an ability or feature on their phones that restricts using it while driving. However, only 13% of them always use them. The most popular restricted driving app used by participants is Do Not Disturb While Driving on the phone's setting. Among different car technologies, automatic emergency braking or crash imminent braking has the greatest amount of distraction. Among all the aggressive behaviors while driving, driving well over speed limit, and swearing under one's breath were repeated more than other behaviors. Most of the self-reported distracted drivers (50%) would answer the call immediately using a hands-free cell phone. Only 6% set their phone to automatic messaging, and only 6% of participants reported being willing to ignore it. 32% of distracted drivers had at least one near-crash experience due to using a cell phone while driving, and more than 23% had at least one crash due to distraction. The most frequent reason for having a crash among distracted drivers was adjusting audio or playing music. Moreover, a rear end collision is the most frequent type of crash among distracted drivers.

The drivers' daily trips have significantly decreased during the pandemic, to about 44% below pre-pandemic rates, and about 68% of drivers have been driving less than 8,000 miles annually. Also, compared to before the pandemic, self-reported distraction dropped significantly during pandemic. The results of the regression indicated that handheld cell phone can cause the most distraction. It will increase the risk of distraction by factor of 13 and increase the risk of a near-crash experience due to distraction by 7.6. Moreover, as the age of the driver decreases, the risk of engaging in more than five distractive behaviors while driving increases and younger drivers will engage more in distractive behaviors. The results of the study will help the Maryland Highway Safety Office (MHSO) target each group specifically, and effectively raise awareness of and educate drivers about the distractive activities they usually participate in while driving.

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8. APPENDIX A. QUESTIONNAIRE

The Effect of COVID-19 on Mobility and Distracted Driving

Morgan State University researchers are seeking your input on the current COVID-19 pandemic and distracted driving to find solutions to improve the traffic safety of Maryland's roadways. The purpose of this survey is to better understand the effect of COVID-19 on mobility and equity, as well as to find the socio-demographics of distracted drivers and reasons for drivers' distraction. This study is conducted by Dr. Mansoureh Jeihani and Dr. Celeste Chavis at Morgan State University. Any information that is obtained in connection with this study and that can be identified with you will remain confidential. If you have any questions, please do not hesitate to contact us at Mansoureh.Jeihani@morgan.edu or Celeste.Chavis@morgan.edu. Please feel free to share this survey with others. Your participation is of great importance in this study.
Thank you.

1. What is your Gender?
   a. Male
   b. Female

2. What is your Age group?
   a. 15 or less
   b. 16 to 19
   c. 20 to 24
   d. 25 to 29
   e. 30 to 34
   f. 35 to 39
   g. 40 to 44
   h. 45 to 49
   i. 50 to 54
   j. 55 to 59
   k. 60 to 64
   l. 65 or more

3. What is your annual Household Income?
   a. Less than $9,999
   b. $10,000 to $19,999
   c. $20,000 to $29,999
   d. $30,000 to $39,999
   e. $40,000 to $49,999
   f. $50,000 to $59,999
   g. $60,000 to $69,999
   h. $70,000 to $79,999
   i. $80,000 to $89,999
   j. $90,000 to $99,999
   k. $100,000 to $109,999
   l. $110,000 to $119,999
   m. $120,000 to $129,999
   n. $130,000 to $139,999

o. $140,000 to $149,999
p. $150,000 to $159,999
q. $160,000 to $169,999
r. $170,000 to $179,999
s. $180,000 to $189,999
t. $190,000 to $199,999
u. $200,000 or more

4. What is the highest level of education you have completed? If you are currently enrolled in school, please indicate the highest degree you have.
   a. Less than high school graduate
   b. High school graduate, including GED
   c. Some college or Associate's degree (e.g., AA, AS)
   d. Bachelor's Degree (e.g., BA, AB, BS)
   e. Graduate or professional degree (e.g., MA, MS, MED, Ph.D., MD, DDS)

5. How many Adults (people 18 years or older) are in your household including yourself?
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5
   f. 6
   g. 7
   h. 8
   i. 9
   j. 10 or more

6. How many Children (people under the age of 18) are in your household?
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4
   f. 5
   g. 6
   h. 7
   i. 8
   j. 9
   k. 10 or more

7. Are you Hispanic, Latino, or Spanish Origin?
   a. Yes
   b. No

8. What is your Race?

a. White
b. African American, Black
c. Asian
d. American Indian, Alaska Native, Native Hawaiian or other Pacific Islander
e. Multiracial
f. Hispanic/Mexican
g. Other

9. What is your Homeownership Status?
   a. Owned
   b. Rented
   c. Occupied without payment or rent
   d. Other

10. What is your Frequency of Driving?

	Everyday	Almost Everyday	Few Days a Week	Few Days a Month	Few Days a Year	I do not drive
Before the Pandemic (From 3/1/2019 To 3/1/2020)						
During the Pandemic (From 3/1/2020 To 3/1/2021)						
In the Last Two Weeks						

11. What is your Primary Type of Vehicle?
   a. Car
   b. Van
   c. SUV
   d. Pickup Truck
   e. Other Truck
   f. RV
   g. Motorcycle
   h. Light Electric Vehicle (Golf cart)
   i. Other (e.g., I do not have a personal car, Taxi, Uber, etc.)

12. Are you currently employed?
   a. No
   b. Yes, Part-time
   c. Yes, Full-time

13. How many automobiles does your household own?
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

f. 5 or more

14. What is your home type?
    a. Single-family detached house
    b. Single-family attached house
    c. A building with 2 or more apartments or condos
    d. A mobile home or trailer
    e. Boat, RV, Van, etc.
    f. Dorm room
    g. Other

15. What is your marital status?
    a. Single, never married
    b. Married or domestic partnership
    c. Separated/Divorced
    d. Widowed

16. Which County do you live in?
    a. Alabama County
    b. Allegany County
    c. Anne Arundel County
    d. Baltimore County
    e. Baltimore City
    f. Calvert County
    g. Caroline County
    h. Carroll County
    i. Cecil County
    j. Charles County
    k. Dorchester County
    l. Frederick County
    m. Garrett County
    n. Harford County
    o. Howard County
    p. Kent County
    q. Montgomery County
    r. Prince George's County
    s. Queen Anne's County
    t. Somerset County
    u. St. Mary's County
    v. Talbot County
    w. Washington County
    x. Wicomico County
    y. Worcester County
    z. Other

17. Will you take the COVID-19 vaccine?
    a. I already took the vaccine
    b. Yes

c. No

18. What is your zip code of residence? [blank space for the answer]

19. Are you a Car driver or a Transit Rider?
    a. I am a Car Driver (I usually do not drive public transit vehicles, and I may or may not have a personal car)
    b. I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

20. What type of Driver's License do you have? (Please feel free to select more than one option.)
    a. Permanent License for regular vehicles class C
    b. Permanent License for all types of vehicles class B
    c. Permanent License for all types of vehicles class A
    d. Learner's Permit
    e. Do not have a license

21. How many years have you held a Driver's License?
    a. Less than 1 year
    b. 1 year
    c. 2 years
    d. 3 years
    e. 4 years
    f. 5 years or more
    g. Do not have a Driver's license

22. What is the average annual driving mileage on your own car (in miles)?

	Less than 8,000	8,001 to 15,000	15,001 to 30,000	30,000 or more	I do not have a personal car
Before the Pandemic (From 3/1/2019 To 3/1/2020)					
During the Pandemic (From 3/1/2020 To 3/1/2021)					

23. How many miles do you drive per week on average?

	Less than 100 miles	100 to 200 miles	201 to 300 miles	301 to 400 miles	400 mile or more	I do not have a personal car
Before the Pandemic (From 3/1/2019 To 3/1/2020)						
During the Pandemic (From 1/3/2020 To 3/1/2021)						
In the Last Two Weeks						

24. Did you usually get distracted while driving?

	Yes	No	I do not have a personal car
Before the Pandemic (From 3/1/2019 to 3/1/2020)			
During the Pandemic (From 3/1/2020 to 3/1/2021)			
In the Last two Weeks			

25. Did you usually indulge in the following activities while driving **Before the Pandemic (From 3/1/2019 to 3/1/2020)?**

	Yes	No	I do not have a personal car
Talk on the phone (hands-free)			
Talk on the phone (handheld)			
Texting			
Voice to text			
Read/update Social Media			
Read/respond to Emails			
Take pictures/record video			
Using GPS			
Eat/Drink			
Taking on/off clothes			

26. Did you usually indulge in the following activities while driving **During the Pandemic (From 3/1/2020 to 3/1/2021)?**

	Yes	No	I do not have a personal car
Talk on the phone (hands-free)			
Talk on the phone (handheld)			
Texting			
Voice to text			
Read/update Social Media			
Read/respond to Emails			
Take pictures/record video			
Using GPS			
Eat/Drink			
Taking on/off clothes			

27. Did you usually indulge in the following activities while driving **in the Last Two Weeks?**

	Yes	No	I do not have a personal car

Talk on the phone (hands-free)			
Talk on the phone (handheld)			
Texting			
Voice to text			
Read/update Social Media			
Read/respond to Emails			
Take pictures/record video			
Using GPS			
Eat/Drink			
Taking on/off clothes			

28. Does your phone have any app/feature/ability that restricts using it while driving? (e.g., Do not disturb while driving, AT&T ICW, LifeSaver, etc.) If yes, how often is this app engaged?
    a. Yes, Always
    b. Yes, Almost always
    c. Yes, Sometimes
    d. Yes, Rarely
    e. Yes, never
    f. No, my phone does not have such an app
    g. I do not have a personal car

29. Based on your answer to the question above, which one of the following apps do you use on your mobile phone?

	Do Not Disturb While Driving on your phone's setting	LifeSaver	KyrusFleet	Sprint Drive First	Sprint Drive app	AT&T ICW	T-Mobile Drive Smart	Hum by Verizon	Drive Mode	tXt Blocker	Drivesafe.ly	None	I do not have a personal car
Before the Pandemic (From 3/1/2019 To 3/1/2020)													
During the Pandemic (From 3/1/2020 To 3/1/2021)													
In the Last Two Weeks													

30. To prove you are paying attention, please type the word "Distraction" into the box bellow.

31. How many times have you experienced a near-crash experience due to using a cell phone while driving?

	0	1 to 3	4 to 6	7 to 9	10 or more	I do not have a personal car
Before the Pandemic (From 3/1/2019 To 3/1/2020)						
During the Pandemic (From 3/1/2020 To 3/1/2021)						
In the Last Two Weeks						

32. If your phone rings while driving, what is your response?
    a. My phone is set with automatic messaging while driving
    b. I will ignore it
    c. I will stop on the road shoulder and answer it
    d. I will answer in a safer situation, (e.g., red light, parking, etc.)
    e. I will answer it immediately if it is an emergency situation (hands-free or handheld)
    f. I will answer immediately (hands-free)
    g. I will answer immediately (handheld)
    h. I do not have a personal car

33. If you receive a text message while driving, what is your response?
    a. My phone is set with automatic messaging while driving
    b. I will ignore it
    c. I will stop on the road shoulder and answer it
    d. I will answer in a safer situation (e.g., red light, parking, etc.)
    e. I will answer it immediately if it is an emergency situation (Texting or Voice to text)
    f. I will answer it immediately (Texting)
    g. I will answer it immediately (Voice to text)
    h. I do not have a personal car

34. How many times per day did you usually indulge in the following activities while driving **Before the Pandemic (From 3/1/2019 to 3/1/2020)**?

	0	1 to 3	4 to 6	7 to 9	10 or more	I do not have a personal car
Swear under my breath						
Drive over speed limit						
Use horn when annoyed						
Fail to signal						
Tailgating						
Weave in/out traffic						
Failing to stop at stop sign						

Speed up to get through light						

35. How many times per day did you usually indulge in the following activities while driving in **During the Pandemic (From 3/1/2020 to 3/1/2021)**?

	0	1 to 3	4 to 6	7 to 9	10 or more	I do not have a personal car
Swear under my breath						
Drive over speed limit						
Use horn when annoyed						
Fail to signal						
Tailgating						
Weave in/out traffic						
Failing to stop at stop sign						
Speed up to get through light						

36. How many times per day did you usually indulge in the following activities while driving in **in the Last Two Weeks**?

	0	1 to 3	4 to 6	7 to 9	10 or more	I do not have a personal car
Swear under my breath						
Drive over speed limit						
Use horn when annoyed						
Fail to signal						
Tailgating						
Weave in/out traffic						
Failing to stop at stop sign						
Speed up to get through light						

37. Did you usually get distracted due to any of the following Vehicle Technologies while driving **Before the Pandemic (From 3/1/2019 to 3/1/2020)?**

	Yes	No	My car does not have this technology	I do not have a personal car
Blind Spot Warning				
Collision Warning Systems				
Lane Departure Warning Systems or Lane Keeping Assistant Systems				

Automatic Emergency Braking or Crash Imminent Braking				
Hands-Off Detection				

38. Did you usually get distracted due to any of the following Vehicle Technologies while driving **During the Pandemic (3/1/2020 to 3/1/2021)?**

	Yes	No	My car does not have this technology	I do not have a personal car
Blind Spot Warning				
Collision Warning Systems				
Lane Departure Warning Systems or Lane Keeping Assistant Systems				
Automatic Emergency Braking or Crash Imminent Braking				
Hands-Off Detection				

39. Did you usually get distracted due to any of the following Vehicle Technologies while driving **in the Last Two Weeks?**

	Yes	No	My car does not have this technology	I do not have a personal car
Blind Spot Warning				
Collision Warning Systems				
Lane Departure Warning Systems or Lane Keeping Assistant Systems				
Automatic Emergency Braking or Crash Imminent Braking				
Hands-Off Detection				
Please choose "Yes" for this one.				

40. How many times have you experienced a crash due to distraction (such as using a cell phone or any kind of in-vehicle technology) while driving **in the last two years?**
    a. 0
    b. 1
    c. 2
    d. 3
    e. 4 or more

[If the answer to the above question is b, c, d, or e, the following questions will be asked:]

If you had more than one crash during the last two years, please answer all the following questions based on your most recent crash.

41. Which Year did you have a crash?
    a. 2021
    b. 2020
    c. 2019

42. Which Month did you have a crash?
    a. Jan
    b. Feb
    c. Mar
    d. Apr
    e. May
    f. Jun
    g. Jul
    h. Aug
    i. Sep
    j. Oct
    k. Nov
    l. Dec

43. Which Category describes your crash?
    a. Property Damage Only Crash
    b. Injury Crash
    c. Fatal Crash

44. Which Crash Type best describes your crash?
    a. Opposite Direction
    b. Rear End
    c. Left Turn
    d. Sideswipe
    e. Angle
    f. Parked Vehicle
    g. Pedestrian
    h. Bicycle
    i. Railway Train
    j. Fixed Object
    k. Overturned
    l. Run Off Road
    m. Down Hill Runaway or Brakes Failed
    n. Explosion or Fire
    o. U-Turn
    p. Backing
    q. Fell/jumped from the vehicle
    r. Other

45. If you had a crash due to distraction, what was the Reason?
    a. By outside, Person

b. By outside, billboard
c. By outside, animal
d. By Moving Object in Vehicle (e.g., kids or dogs jumping around)
e. Talking on the phone (hands-free)
f. Talking on the phone (handheld)
g. Dialing Cell phone
h. Adjusting Audio or playing music
i. Eating or Drinking
j. Texting from a Cell phone
k. Voice texting
l. Inattentive or Lost in Thought
m. Looked But Did Not See
n. Other Distractions

46. If you had a crash with a Pedestrian due to distraction, where was the Pedestrian?
a. I did not have a crash with a pedestrian due to distraction
b. Shoulder
c. Curb
d. Sidewalk
e. On Road, at Crosswalk
f. On Road, Not at Crosswalk
g. In School Bus Zone
h. In Bikeway
i. At Intersection Marked Crosswalk
j. Driveway Access
k. Median
l. Island
m. Shared Use Path or Trails
n. Other

47. If you had a crash with a pedestrian due to distraction, was it the Pedestrian's Fault?
a. I did not have a crash with a pedestrian due to distraction
b. Yes
c. No
d. Other

48. If you had a crash with a pedestrian due to distraction, what distracted the Pedestrian?
a. I did not have a crash with a pedestrian due to distraction
b. Talking on the Phone (hands-free)
c. Talking on the Phone (handheld)
d. Texting
e. Voice to text
f. Listening to music
g. Using a handheld phone
h. Drinking/Eating
i. Inattentive or Lost in Thought

e. Looked But Did Not See
f. It was not pedestrian's fault
g. Other

49. If you had a crash with a Bicyclist due to distraction, where was the Bicyclist?
    a. I did not have a crash with a Bicyclist due to distraction
    b. Shoulder
    c. Curb
    d. Sidewalk
    e. On Road, at Crosswalk
    f. On Road, Not at Crosswalk
    g. In School Bus Zone
    h. In Bikeway
    i. At Intersection Marked Crosswalk
    j. Driveway Access
    k. Median
    l. Island
    m. Shared Use Path or Trails
    n. Other

50. If you had a crash with a Bicyclist due to distraction, was it the Bicyclist's Fault?
    a. I did not have a crash with a Bicyclist due to distraction
    b. Yes
    c. No
    d. Other

51. If you had a crash with a Bicyclist due to distraction, what distracted the bicyclist?
    a. I did not have a crash with a Bicyclist due to distraction
    b. Talking on the Phone (hands-free)
    c. Talking on the phone (handheld)
    d. Texting
    e. Voice to text
    f. Listening to music
    g. Using a handheld phone
    h. Eating/Drinking
    i. Inattentive or Lost in Thought
    j. Looked But Did Not See
    k. It was not Bicyclist's fault
    l. Other