EVALUATING CALIFORNIA'S HANDHELD CELL PHONE USE BAN

A Thesis

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by

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Department of Public Policy and Administration

Abstract

of

EVALUATING CALIFORNIA'S HANDHELD CELL PHONE USE BAN

by

Amy Kathleen Stewart

Driver inattention has long been an issue for traffic safety advocates. Drivers may only briefly look away to change the radio station, answer a phone call, send a text message, or speak to a passenger; however, taking their eyes off the road decreases driver awareness and increases the likelihood of a collision. One of the main sources of driver inattention is the use of cell phones while driving. In California, lawmakers sought to address the dangers of cell phone use while driving by banning the use of hand-held cell phones while operating a vehicle. California's ban went into effect July 1, 2008, and while there have been multiple changes to the law in the five years since, there has been little evaluation as to whether the law achieved its goal of reducing accidents.

Using accident report data compiled in the Statewide Integrated Traffic Records System, I performed three regression analyses to determine whether California's law prohibiting cell phone use while driving resulted in fewer traffic accidents in the year after the law went into effect compared to the year prior. The first two logistic regression models measure fatal accidents and injury accidents for both years to establish the impact of cell phone use on these types of accidents. The third model measures the impact of the

law on accidents involving cell phone use. The general causal factors identified are the year during which the accident occurred, driver behavior, driver demographics, accident time, accident location, weather conditions, and road conditions.

In evaluating the final regression results for Model 1 (Accident Involving Fatality=1), the key explanatory variable (Cell Phone in Use) was not statistically significant. For Model 2 (Accident with Injury=1), Cell Phone in Use was both statistically significant and had a positive impact on the likelihood of being in an injury accident. Based on the results, a driver was 30.61 percent more likely to be involved in an accident involving an injury versus an accident with no injury or a fatality, while using a cell phone than a driver not using a cell phone, all else held constant. For Model 3 (Cell Phone Use While Driving and Being Involved in Accident=1), the results for the key explanatory variable (FY 2008/2009) were statistically significant and indicated that a driver was 42.79 percent less likely to be involved in an accident involving cell phone use than not involving a cell phone, in the year after the law went into effect compared to the prior year.

These results must come with the caveat that not all factors influencing a driver's behavior may be accounted for and that not all accidents resulting from driver cell phone use may be identified in the data set given the low Pseudo R^2 values for each of the three models (Model 1 - 0.0631; Model 2 - 0.0248; Model 3 - 0.0540). Primarily, I recommended that a better method of data collection be identified to ensure the accuracy of conclusion drawn from data analysis. Possible suggestions include the development of best practices for law enforcement in identifying cell phone use at an accident and making the indication of cell phone use mandatory on the accident report. Secondary recommendations include using the demographic results of this study to inform public awareness campaigns to target those drivers most likely to be involved in an accident involving cell phone use and to inform driver education training.

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INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) (2013) estimates that in 2012 2.36 million people were injured and 33,561 people were killed in motor vehicle related crashes in the United States. NHTSA (2012) estimates that approximately ten percent of the annual fatal crashes result from distracted driving. The use of wireless devices, such as cell phones, by drivers is the suggested to be the most frequently related factor in distraction related events such as crashes or near-crashes (Dingus, *et al.*, 2006).

In California, lawmakers sought to address the dangers of cell phone use while driving by banning the use of hand-held cell phones while operating a vehicle (California Vehicle Code §§23123, 23123.5, 23124). This method uses the deterrent effect of the conviction of an infraction and the payment of a penalty to change driving behavior and decrease the number of automobile crashes. California's ban went into effect July 1, 2008, and while there have been multiple changes to the law in the five years since, there has been little evaluation as to whether the law achieved its goal of reducing accidents.

Using accident report data compiled by the California Highway Patrol, I use a regression analysis to determine whether California's law prohibiting cell phone use while driving resulted in fewer traffic accidents involving cell phone use. I will compare the time period one year prior to the implementation of the law to one year after the implementation of the law. The remainder of this chapter provides a background on the issue of distracted driving, discusses the costs associated with distracted driving, and provides a history of California's legislative attempts at addressing distracted driving. It provides a discussion of current non-legislative remedies for distracted driving and concludes with an outline of the following chapters in this thesis.

Background

Driver inattention has long been an issue for traffic safety advocates. Drivers may only briefly look away to change the radio station, answer a phone call, send a text message, or speak to a passenger; however, taking their eyes off the road briefly decreases driver awareness and increases the likelihood of a collision. In a naturalistic driving study conducted by the Virginia Tech Transportation Institute, 80 percent of all crashes and 65 percent of near crashes resulted from a driver looking away from the road i.e. being inattentive (Dingus *et al.*, 2006).

Although distracted driving encompasses any action that causes a driver to change his or her focus from operating the vehicle, state traffic safety policies focus mainly on the use of cell phones, hand-held or hands-free, to place and receive calls, or send and receive text messages or emails. While there is a large support for cell phone use and texting bans, there is limited proof that these prohibitions are effective in lowering the amount of collisions. Almost all drivers recognize that driving while on the phone or sending a text message is dangerous; however, most drivers will still answer the phone while driving (NHTSA, 2012). This creates a need for policymakers to address a behavior that individuals know is dangerous yet continue to perform.

There are many hypotheses as to why cell phone use to place a call is a dangerous behavior while driving compared to the impacts of conversations with passengers. Strayer, Drews, and Johnston (2003) support the notion of inattention-blindness, or the diversion of attention from driving to the phone conversation. Cell phone conversations also lack the shared experience factor that occurs when drivers speak with passengers. Passengers may actually support and focus the driver by discussing the traffic conditions and helping locate the destination (Drews, Pasupathi, & Strayer, 2008). Further evidence exists that individuals have a limited amount of resources to distribute between the two activities (Just, Timothy, & Cynkar, 2008).

Other studies (Rosenbloom, 2006, Zhao *et al*., 2013) complicate the straightforward nature of these conclusions and show that different distractions influence drivers' ability differently, such as the length of the phone call and the vehicle's speed. Zhao *et al*. (2013) evaluated crash risks and identified that individuals who report higher frequencies of cell phone use while driving already engage in risky driving behaviors, even with no cell phone present. This suggest that it is not the cell phone that causes risky driving behavior, but that a person willing to use a cell phone while driving already participates in dangerous driving behaviors. Further complicating the issue is a recent study identify that that cell phone use during weekday evenings does not increase crashes (Bhargava & Pathania, 2013). Suggested explanations include that cell phone use may make drivers more attentive, cell phone use is a substitute for other risky behaviors, or that some drivers function better than others (Bhargava & Pathania, 2013). The authors of this study note that their results do not suggest that cell phone use is harmless and that further research is necessary to evaluate the real and perceived dangers.

Economic Impact of Distracted Driving

Distracted driving, which includes but is not limited to cell phone use while driving, is both dangerous to the individual and creates significant economic costs for society. Numerous ways exist to measure the economic costs of a traffic accident. Costs can be calculated minimally using insurance data that covers property damage and hospital costs, or they can include calculated factors such as lost workplace and home productivity. Naumann, Dellinger, Zaloshnja, Lawrence, and Miller, (2010) estimate that in 2005, the total medical and lost productivity costs of all motor vehicle related fatal and nonfatal injuries totaled $99 billion. Fifty-eight billion dollars of that cost was the result of fatalities. Focusing not just on the medical and lost productivity costs, Blincoe *et al.* (2002) estimate that the economic cost of motor vehicle related crashes in the United States was $230.6 billion in 2000. The $230.6 billion factors in lost household productivity, lost market productivity, property damage costs, medical costs, and a lifetime economic cost to society for each fatality of over $977,000. Those involved in the crash generally pay these costs; however, a significant percentage of the overall costs are borne by general society. Blincoe *et al*. (2002) estimate that public funds pay for approximately nine percent of motor vehicle crash costs, which in 2000 equated to over $170 billion.

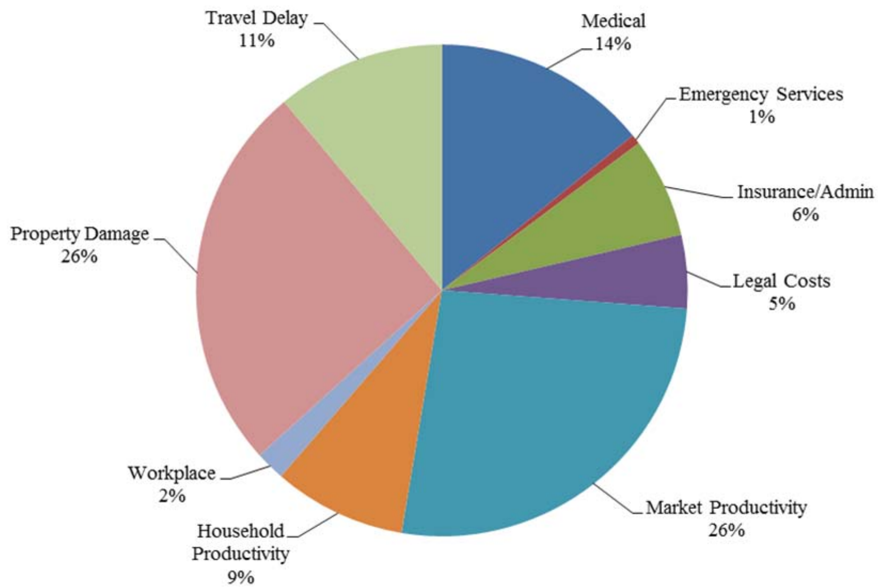

Figure 1: Percent of Total Economic Cost by Factor. Adapted from "The Economic Impact of Motor Vehicle Crashes, 2000" by Blincoe, L., Seay, A., Zaloshnja, E., Miller, T., Romano, E., Luchter, S., & Spicer, R. (2002). Report No. DOT HS 809 446. National Highway Traffic Safety Administration. Washington, DC.

Applying NHTSA's (NHTSA, 2012) estimation that ten percent of all accidents are a result of distracted driving to both Naumann, Dellinger, Zaloshnja, Lawrence, and Miller (2010) and Blincoe *et al.*'s (2002) estimates of the costs to society of traffic accidents provides a range of $9 billion to $23 billion in costs as a result of distracted driving. It is important to note that these costs attempt to aggregate tangible costs related to traffic accidents and do not account for the emotional costs felt by victims, their friends or families.

State Laws

State laws vary on the use of cell phones for calls and text messaging and for certain subsets of the driving population such as novice drivers and school bus drivers.

Some jurisdictions require the use of hands-free devices for drivers, while others place limitations on novice drivers only (Governors Highway Safety Association, 2014). States such as Florida, Kentucky, Louisiana, Mississippi, Nevada, Pennsylvania, and Oklahoma prohibit local governments from enacting any cell phone use restrictions (Governors Highway Safety Association, 2014). Laws further vary on whether or not the enforcement method is primary, when law enforcement may stop a driver solely for the use of a cell phone, or secondary, when the enforcement only occurs when combined with another traffic violation such as speeding (Ibrahim *et al.*, 2011). California bans handheld cell phone use and texting while driving for all drivers but allows for the use of hands-free wireless devices (California Vehicle Code §§23123, 23123.5, 23124).

California's Legislative History

New York passed the first law banning the use of handheld communication devices in 2001. California followed suit with multiple legislative attempts that failed passage, including Assembly Bill (AB) 911 (2001), AB 1911 (2002), AB 45 (2003), AB 1828 (2004), and Senate Bill (SB) 681 (2005), which all proposed similar restrictions. California Assembly/Senate member Joseph Simitian introduced each of these legislative attempts. In 2006, Senator Simitian introduced SB 1613, (Chapter 290, Statutes of 2006) the California Wireless Telephone Automobile Safety Act of 2006, which was signed by Governor Arnold Schwarzenegger in September 2006. This bill, beginning July 1, 2008, prohibited drivers from using a wireless phone while operating a vehicle, unless the phone allowed for hands-free operation. Drivers cited by law enforcement for an infraction receive a base fine of $20 for first offenses and $50 for second or subsequent offenses. The base fine is not inclusive of additional court fees, which raise the total to $162 (Judicial Council of California, 2014). Drivers convicted under this law would not receive a Negligent Operator Treatment System point on their driving record.

Since its enactment, the California Wireless Telephone Automobile Safety Act of 2006 has had multiple changes made. SB 33 (Simitian, Chapter 214, Statutes of 2007) amended the law to prohibit drivers under the age of 18 from using cell phones while driving even with the use of a hands-free device. The argument for this change was to improve traffic safety by reducing the distractions facing provisional drivers, those ages 15 ½ to 17 years old (Imai, 2007). This change was effective beginning July 1, 2008. SB 28 (Simitian, Chapter 270, Statutes of 2008), effective January 1, 2009, adapted the law to address technological and social changes regarding the use of mobile devices to focus on the impact of using the device for activities other than placing phone calls. SB 28 prohibited drivers from using an electronic wireless communications device to write, send, or read a text-based communication, which is defined as manually communicating with any person using text-based communication such as text messaging, instant messaging, and email (Hurd-Parker, 2008).

In 2012, AB 1536 (Miller, Chapter 92, Statutes of 2012) further changed the law by allowing drivers to send text based communications such as text messages and emails through the use of hands-free or voice-operated functions on their mobile device. Another bill from the same legislative session sought to increase the penalties for those who violate the prohibitions against texting and cell phone use while driving. This bill, SB 1310 (Simitian, 2012), was vetoed by Governor Jerry Brown who stated in his veto messages that the ticket amount was enough and that the punitive measure of increasing the fines would likely not lead to a decrease in the behavior (Brown, 2012). In 2013, SB 194 (Galgiani, Chapter 754) made further clarifying changes to the law to address the potential implication the law prohibited novice drivers from texting while driving unless their phones were equipped with hands-free technology.

Other States' Laws

According to the Governors Highway Safety Organization (2014), while no state prohibits all cell phone use, twelve states, Washington DC, Puerto Rico, Guam, and the United States Virgin Islands prohibit hand-held cell phone use while operating a vehicle. These offenses allow for primary enforcement, meaning law enforcement can pull a driver over solely for this offense. Thirty-seven states and Washington, DC prohibit provisional drivers from any cell phone use, hand-held or hands-free. Twenty states and Washington, DC prohibit school bus drivers from all use (Governors Highway Safety Association, 2014). Washington State passed the first texting-while-driving ban in 2007. Puerto Rico, Guam, Washington, DC, the United States Virgin Islands, and 41 states ban text messaging for all drivers (Governors Highway Safety Association, 2014).

Non-Legislative Remedies

In addition to laws prohibiting or limiting the use of cell phones while driving, traffic safety advocates are evaluating alternatives to statute to address the concerns of distracted driving. These alternative methods include distracted driving awareness campaigns and the development of autonomous vehicles.

Distracted Driving Awareness Campaigns

To raise awareness, the California Highway Patrol and the Office of Traffic Safety (OTS) are conducting a one-year campaign to educate drivers on distracted driving and enforce laws prohibiting use (California Highway Patrol, 2013). California instituted a zero-tolerance policy for April 2013, with April designated as Distracted Driving Awareness Month (Fournier, 2013). As part of their campaign against distracted driving, OTS conducted a survey of California drivers over the age of 18 regarding the most serious traffic safety concerns facing drivers in California. OTS interviewed 1,671 drivers at gas stations in 15 counties throughout California and determined that 59.2 percent identified cell phone conversations, hand-held or hands-free, to be the most serious distraction for drivers (OTS, 2010). Fifty-four percent indicated being hit or nearly hit by a driver talking on a cell phone.

OTS's campaign includes multiple media outlets including, television, radio, and the internet to inform drivers of the dangers of distracted driving. Partnering with the United States Department of Transportation, the campaign focuses on the dangers of distracted driving and the consequences. The Faces of Distracted Driving videos featured on OTS's YouTube channel recount stories from families who have lost loved ones due to distractions such as cell phone use.

Autonomous vehicles

Numerous changes in legislation and technological advances attempt to address driver inattention. Vehicle manufacturers now equip most cars with steering wheel buttons to change the radio station or increase the volume. As opposed to attempts to deter unsafe driving behavior through penalizing laws such as California's cell phone ban, which use financial penalties to deter the behavior and rely heavily on enforcement, some government entities and companies, most notably Google, are researching the development of self-driving, or autonomous, vehicle technology to remove the human error effect. Instead of deterring negative behavior, this method acknowledges that drivers will be distracted and uses technological advances to counteract the subsequent danger of the distraction.

In the late 1970s, the Japanese made the first viable attempt at developing autonomous vehicles also known as driverless cars, auto-drive cars, or automated guided vehicle (Forrest & Konca, 2007). Developers and innovators have since made numerous successful and unsuccessful attempts to hone this developing technology. Autonomous vehicles operate independent from human control using radar technology to detect objects in the vehicle's path up to almost one hundred yards away. Developers mount a camera system to recognize traffic signs and signals, which the vehicle's computer then processes. Light detection and ranging technology on top of the vehicle further detect objects surrounding the vehicle and a global position system guides the vehicle to the destination. The autonomous vehicle creates a three dimensional map and uses sensors to perform the functions normally performed by the drive e.g. accelerating, braking, signaling, and turning (Evans, 2012). Many high-end vehicles currently utilize many of the technologies used in autonomous vehicles such as Lane Departure Warning Systems, Rear Parking Assist, and Lane Keeping Assist Systems (Forrest & Konca, 2007).

In September of 2012, California Governor Jerry Brown signed SB 1298 (Chapter 570, Statutes of 2012) authorizing the testing of autonomous vehicles in California so long as they meet certain unspecified criteria. The bill requires the California Department of Motor Vehicles (DMV), no later than January 1, 2015, to adopt regulations to establish requirements for any testing, equipment, or performance standards that DMV concludes are necessary to ensure the safe operation of autonomous vehicles on public roads, with or without the presence of a driver inside the vehicle. These vehicles are not currently commercially available.

Organization of Thesis

Using traffic accident data compiled in the Statewide Integrated Traffic Records System (SWITRS), I will perform a regression analysis to determine whether California's law prohibiting cell phone use while driving resulted in fewer traffic accidents involving cell phone use. I will compare the year prior to the implementation of the law to the year after the law's implementation. Post-implementation time periods will be broken into intervals reflective of subsequent changes to the law. The preceding chapter outlined the issue of cell phone use while driving by looking at the economic costs to society, discussing California's legislative history in addressing cell phone use while driving, and discussing other non-legislative remedies that are currently underway.

The remainder of the thesis is separated into four chapters. Chapter 2 provides a review of the existing academic literature related to the impact of hand-held and hands-free cell phone use on car accidents. I evaluate a selection of research on driver cell phone use from government, traffic safety organizations, government sponsored organizations, and private researchers and institutions, which discusses the impacts of driver awareness and enforcement.

Chapter 3 describes my research methodology including data collection and analysis methods. I first provide an explanation of my dependent variable followed by a discussion of the anticipated broad causal factors. Next, I provide a discussion of the explanatory variables contained within each broad causal factor, and the anticipated outcomes for each. Chapter 4 provides the regression analysis results and an evaluation of the best functional form, additional checks for multicollinearity, heteroskedasticity and the impact of interaction terms. This section will conclude with my final regression results corrected for any identified issues in the proper functional form. Chapter 5 concludes with a discussion of my overall research questions, policy implications, suggestions for improvements, and possibilities for future research.

Chapter 2

LITERATURE REVIEW

The previous section introduced the complex issue of distracted driving as a cause of accidents and laws prohibiting the use of cell phones while driving that intend to eliminate this behavior. In this chapter, I review the literature on driver cell phone use from government traffic safety organizations, government sponsored organizations, and private researchers and institutions. Given the variation of state laws and requirements, this review includes studies on handheld cell phone use, hands-free cell phone use, and text messaging. This review further includes studies looking specifically at cell phone use by novice drivers. I organize this review into categories for driver awareness, observed use and enforcement, and accident rates. These themes represent the broad categories of existing research available on this growing traffic safety concern. Within each theme, I discuss the relevant studies and identify any lessons learned that apply to the research I perform. Appendix A provides a summary table of the studies' findings.

Driver Awareness

One of the primary questions asked when evaluating the effectiveness of laws restricting the use of cell phones while driving is whether the driving public is aware of the dangers of this driving behavior or aware of the laws governing the practice. If they are not aware of either of these, how can the laws be effective? If there is no objective or reasoning behind a law prohibiting a behavior, it may be seen as an unwarranted encroachment on the public's liberty. The following section discusses drivers' knowledge of the dangers of cell phone use while driving and the laws prohibiting it.

Awareness of the Dangers

In a recent study, NHTSA (2012) surveyed six thousand drivers age 18 and older on the general subject of distracted driving. Half of all drivers believe that using a cell phone while driving has no impact on their driving ability and less than two percent recognize that they drift out of their lane when talking on the phone (NHTSA, 2012). This identifies a possible disjoint between what drivers believe about the impact of cell phone use on their driving ability, and the impact identified in driving behavior studies. Contrary to what drivers believe, Virginia Tech Transportation Institute's NHTSA-sponsored naturalistic driving study found that for almost 80 percent of crashes, drivers looked away from the road within a four-second timeframe prior to the accident (Dingus, *et al.*, 2006). Although the 80 percent rate is inclusive of distractions other than cell phones such as checking blind spots, drowsiness or other secondary activities, it underscores the fact that drivers are not aware of the dangers distractions, such as cell phone use, cause. An additional study by Hallett, Lambert, and Regan (2011) conducted in New Zealand, where similar laws are in place, found that a majority of survey respondents did not view cell phone use while driving as a dangerous activity. However, respondents did identify hand-held cell phone use as a more risky behavior than hands-free.

Lesch and Hancock (2003) look specifically at drivers' awareness of the dangers of cell phone by surveying drivers' confidence using cell phones while driving and then testing those drivers using a vehicle equipped with data recording instrumentation on a closed driving range. These tests determined that with the added task of cell phone use, a driver's brake responses slowed and the vehicle stopped 50 percent closer to the intersection (Lesch & Hancock, 2003). Both age and gender were statistically significant and influenced the results. Stop light compliance for female drivers fell 25 percent compared to four percent for male drivers. Younger drivers' (age 25-35) stopping distance to an intersection was 21 percent closer when using a cell phone and older drivers (age 55-65) were 70 percent closer.

Both Lesch and Hancock (2003) and Dingus, *et al.* (2006) suffer from small sample size, a common problem in naturalistic driving studies. Compared to the driving population as a whole, Lesch and Hancock (2003) used a sample size of 36 drivers, while Dingus, *et al.*, (2006) evaluated 241 drivers. Virginia Tech Transportation Institute does acknowledge that this study is a pilot for larger scale research. In both studies, drivers were recruited and aware of the studies' parameters, which may influence their driving behavior. A noticeable difference in the studies is that Lesch and Hancock (2003) observed their drivers on a closed course and controlled for certain behaviors at certain times. Virginia Tech Transportation Institute (Dingus, *et al.*, 2006) conversely gave the drivers no instructions and relied upon non-invasive technology within the vehicle to monitor driving behavior such as video cameras and speedometer monitors. The recordings documented multiple types of driving behavior from speeding, drowsiness, driving under the influence, and other traffic violations. Hallett, Lambert, and Regan (2011) have a larger sample size (n=1,057); however, only individuals with internet access who received online advertisements and emails participated leading to potential selection bias.

Although these studies demonstrate the dangers associated with distractions while driving, specifically cell phone use, knowledge of this danger does not translate to NHTSA’s (2012) survey of drivers. The survey found that a majority of drivers admit continuing to drive after answering incoming calls. The survey also indicates a sharp contrast between beliefs about cell phone use for phone calls and cell phone use for text messaging or sending an email. Only 18 percent of drivers report texting/emailing while driving, with little variation between male and female drivers (NHTSA, 2012). Ninety percent of drivers describe texting/emailing while driving as unsafe (NHTSA, 2012). This may be indicative of drivers performing a risk-reward evaluation of cell phone use while driving. Atchley, Hadlock, and Lane (2012) discuss the idea that knowledge of the risk does necessarily moderate the behavior given that the use of cell phones is socially rewarding. They further suggest that as the behavior becomes more of a part of a person’s personality, the more difficult it is to give up (Atchley, Hadlock, & Lane, 2012).

Awareness of the Laws

While knowledge of the dangers of cell phone use while driving varies, knowledge of the state’s laws regarding use presents another problem for improving traffic safety. Goodwin, *et al.* (2012) researched teenage drivers’ knowledge of laws restricting cell phone use while driving. In December 2006, North Carolina enacted a cell phone use prohibition for those in the graduated driver licensing (GDL) program. GDL programs provide differing restriction levels for novice drivers including limiting driving hours and prohibiting passengers unless adult family members. Goodwin *et al.*

(2012) surveyed North Carolina high school students regarding their awareness of the laws and conducted an observational study of teen drivers outside high schools.

Researchers conducted the surveys and observations prior to the enactment and two years following in North Carolina and in South Carolina, where no prohibition was in effect. The research discovered that prior to the enactment, almost three-quarters of teen drivers were under the impression that law prohibited their use of cell phones while driving. The research further discovered an overall decrease in observed cell phone use by similar percentages in both North Carolina (law in effect) and South Carolina (no law) leading to the conclusion that North Carolina's prohibition was ineffective for teenage drivers (Goodwin, *et al.*, 2012). Hypotheses as to why the prohibition was ineffective include a lack of enforcement and a general change in cell phone use trends from placing calls to sending text messages and emails, which the law did not prohibit.

Although its focus was on teenage drivers, Goodwin *et al.*'s (2012) research is challenging in that it is limited to a small population of the driving public. While the sample sizes for both years and both states is large, the observation times were limited to after school hours and in locations surrounding the school. This begs the question of whether this study is an accurate portrait of teenage driving behavior as to and from school is not the only times in which they drive nor is it known whether this is when a high frequency of calls would be made. Research (Foss *et al.*, 2009) further suggests difficulty in conducting observational studies on teenage drivers given the difficulty identifying a driver's age for both the observers and law enforcement. Identifying cell phone use while driving for any age group is likely similarly difficult.

Driver Awareness Lessons Learned

Studies evaluating driver awareness of the dangers of cell phone use while driving demonstrate that there is variance between what drivers believe and what studies determined to be the impacts of cell phone use while driving. To a lesser degree, studies also imply an amount of misunderstanding about the laws restricting use and to whom they apply. Lessons from these studies apply to the research I conduct for this thesis as they offer insight on why or why not the law restricting cell phone ban in California is effective in reducing traffic accidents and provide information for policymakers.

Observed Use and Enforcement

Jamson (2013) looked at nomadic devices, any portable technology used as a means of navigation, entertainment, or communication, and the laws restricting their use in the European Union. The studied identified that the stringency of the law had no impact on the texting frequencies and suggested the use of enforcement campaigns to alter driving behavior (Jamson, 2013). Given the suggesting impact of enforcement, the following section looks at observed use of cell phones while driving and high-visibility enforcement campaigns

Observed Use

The ability of law enforcement agencies to cite drivers for violations of laws may affect the effectiveness of laws banning cell phone use while driving. Multiple studies (McCartt & Geary, 2004; NHTSA, 2011) suggest a significant correlation between enforcement and the effectiveness of laws restricting cell phone use while driving. McCartt and Geary (2004) conducted observational studies in New York and Connecticut prior to and after the cell phone use ban. Using Connecticut, with no ban in place, for the base for comparison, researchers conducted observations in both New York and Connecticut one month prior to the ban, one month after the ban, four months after the ban, and 15 months after the ban. They then used a logistic regression controlling for the time period and location to evaluate the percentage of drivers using handheld cell phones. The results detailed a decline in observed use in New York immediately after the ban by 1.2 percentage points. However, 15 months after the ban was in place, observed use rates for New York drivers returned to just 0.2 percentage points (95 percent confidence interval) below the pre-law observations rates (McCartt & Geary, 2004).

McCartt and Geary (2004) hypothesize that the return to pre-law use rates is associated with public awareness and enforcement measures and make comparisons to lessons learned from enforcing seatbelt use laws and from changing public behavior regarding driving under the influence of alcohol. Comparing citation rates to locations of observed use provided no significant inverse relationship between citation and observed use (McCartt & Geary, 2004). In some counties, citation rates and post-law use rates both increased, suggesting that enforcement and/or the associated penalty did not create a deterrent. However, there were variations among counties that could not be accounted for making the results interesting, yet inconclusive.

In a follow up to the 2004 study, McCartt, *et al.* (2010) evaluated the long-term effects of laws prohibiting cell phone use while driving in New York, Connecticut, and Washington, DC. Using a Poisson regression, the study found that for Washington, DC, the observed rate of cell phone use was 43 percent lower than the predicted rate, five years after the ban went into effect. In New York and Connecticut, the observed cell phone use rate was 24 percent lower than predicted seven years after their bans went into effect. They hypothesized that the difference in the magnitude of the decreased percentage resulting from Washington, DC's higher rate of issuing cell phone use citations (McCartt, *et al.*, 2010).

High-Visibility Campaigns

Focusing on enforcement, the United States Department of Transportation, through the NHTSA, awarded grants to New York and Connecticut officials to evaluate to effectiveness of high-visibility enforcement campaigns. The campaign, messaged under the banner *Phone in One Hand, Ticket in the Other,* consisted of waves of publicity followed by increased enforcement (NHTSA, 2011). Researchers conducted observations throughout the publicity and enforcement campaign. Law enforcement officials conducted differing methods of enforcement such as using one officer as a spotter versus officers actively searching for drivers on cell phones. Officers provided informational packets on the laws and dangers of cell phone use to all drivers cited during the campaign. Using a binary logistic regression analysis, NHTSA (2011) determined a 57 percent decrease (from 6.8 percent to 2.9 percent) in overall use in the target areas compared to the control areas' 15 percent decrease (6.6 percent to 5.6 percent). NHTSA also determined that certain methods of enforcement, such as the spotter method, were more effective than traditional methods such as stationary checkpoints, and that unmarked vehicles created an advantage (NHTSA, 2011).

One main concern with this study is that it occurred so recently that no follow up observational studies on cell phone use have been conducted. Until follow up is completed, the results must be limited to a specific period of time and not used as an overall measure of success for the laws. This enforcement campaign was only feasible due to a grant by the federal government. It is reasonable to assume that most law enforcement agencies do not have sufficient resources to maintain such high-level enforcement given the scope and nature of their other duties. As such, it is difficult to project whether the decrease in use maintains post-campaign. However, based on McCartt and Geary's (2004) study, it is probable that use rates may increase before any overall decrease is seen.

Enforcement Lessons Learned

These studies detailing the impact of enforcement on laws restricting cell phone use, suggest that law enforcement presence is a key factor in the law's effectiveness. In the research I conduct in this thesis, data was not available indicating or quantifying the presence of law enforcement prior to and after California's law went into effect. This research suggests that further study is necessary to definitively identify the impact.

Accident Rates

Policymakers identify the overarching goal of laws prohibiting cell phone use while driving as preventing traffic collisions and fatalities associated with distracted driving. Studies looking at collisions (Jacobsen, *et al.*, 2012; Highway Loss Data Institute, 2010) and fatal collisions (Nikolaev, *et al.*, 2010) using similar methods and data that I use in this study, come to differing conclusions. The Highway Loss Data

Institute (HLDI) (2010) reviewed insurance collision claims data for 30 states over two years totaling approximately 3.3 million collision claims. After performing a Poisson regression with a logarithmic link function, HLDI found no divergence in trends for states with and without laws prohibiting cell phone use before and after their laws were effective. HLDI did note that in California, the collision claim frequency increased by 7.6 percent with the ban in effect. This leads to the conclusion that the laws were ineffective in reducing traffic collision.

Conversely, Jacobsen, *et al.* (2012) looked specifically at New York State and performing multiple regression analyses, found that the personal injury accident rate had significantly decreased (0.355 per 1,000 licensed drivers) after the ban was in place. They measure this decrease over a five-year time period after New York's law was in place implying that the benefit measured by a decrease in traffic collisions is significant in the long-term as opposed to the short-term. The analysis resulted in high R-squared values (0.959) indicating well-fitted data. Nikolaev *et al.* (2010), a predecessor to Jacobsen *et al.*, (2012), reviewed New York State's fatal accident rates and concluded that 46 of 62 counties had lower fatal accident rates post hand-held cell phone ban. The regression analysis concluded that New York overall demonstrated decrease of 1.88 personal injury accidents per 1,000 drivers.

Sampaio (2010) critiqued Nikolaev *et al.* (2010) arguing that the approach taken does not make the causal link with the ban as it fails to account for any unobservable variable for counties that may impact the estimation. Sampaio (2010) also argued against using the average number of accidents since the accident rate is naturally changing over time. Making changes to the model, Sampaio (2010) used a fixed effects regression model identifying a decrease of 2.932 for the fatal accidents per 1,000 drivers, 3.727 for the personal injury accidents per 1,000 drivers, and a difference-in-differences model to identify a decrease of 1.857 in fatal accidents per 1,000 drivers. With the changes, Sampiao (2010) identified results consistent with Nikolaev *et al.*'s (2010) conclusions.

Jacobsen *et al.* (2012) furthered Nikolaev *et al.*'s (2010) look at New York State on a county-by-county level categorizing areas on a spectrum of urban to rural based on driver density as measured by the number of licensed drivers per mile of roadway. This study concluded that driver density plays a significant role in the effectiveness of laws. Laws prohibiting the use of cell phones while driving are more effective as driver density increases. However, Jacobsen *et al.* (2012) do not speculate on the reasons why density plays an important role in the law's effectiveness.

Using a different approach, Lim and Chi (2013) project non-alcohol related motor vehicle crash rates by evaluating a state's graduated driver licensing policies, seat belt enforcement, speed limit, income, unemployment rate, and population density, among many variables. The study employed a fixed effects model looking at young drivers versus all drivers, over a period of time. Lim and Chi (2013) identified that cell phone use ban on young drivers had an insignificant impact on young driver, but a cell phone use bans for all drivers reduced young drivers' fatal crash involvement by approximately 14 percent for drivers age 15-17, and 12 percent for drivers age 18-20.

As Nikolaev *et al.* (2010) point out, less than one percent of auto accidents report that cell phone use is a factor. This may be partly because data collected on cell phone use at traffic accidents is questionable as it relies on self-reporting or clear evidence by law enforcement (McCartt *et al.*, 2010). It is reasonable to assume that use is likely a larger factor, but individuals are reluctant to volunteer incriminating information given the associated penalties (Eby & Vivoda, 2002). Given the violent nature of auto crashes, there is no way for law enforcement to definitively identify if cell phone use played a roll.

Accident Rate Lessons Learned

Studies on the impact of laws banning cell phone use while driving on accidents vary significantly based on the data set used. Both collision claim frequency and accident rate data sets offer large samples to evaluate; however, given the variance, it is clear that neither data set type may fully address all necessary explanatory variables. Both sets of data rely on accidents being reported to either insurance or law enforcement and for cell phone use to be indicated. Other methods (Lim and Chi, 2013) look to bypass this issue by projecting accident rates. Data source selection plays a large part in the results and conclusions. For the purposes of the research conducted in this paper, there is clearly a need to discuss the limitations associated with any identified outcome.

Summary

Research on laws prohibiting the use of cell phones while driving is developing and changing as time progresses. In some cases, laws ineffective in the short-run prove later to be effective in the long run (McCartt & Geary, 2004; McCartt *et al.*, 2010). Researchers face many challenges in evaluating the efficiency mainly surrounding data collection. Discussion further exists as to what is the best method of identifying success or failure. Measuring the impact on accident rates is additionally problematic as Nikolaev *et al.* (2010) identify that accidents involving cell phone use account for less than one percent of auto accidents. Identifying the presence of cell phone use further does not automatically equate to it being either a causal factor or the causal factor. Continued research and data collection is necessary to establish general consensus on the impact of laws prohibiting the use of cell phones.

These studies clearly identify that the effectiveness of laws prohibiting the use of cell phones while driving is difficult to detect conclusively. The main lesson learned from this review is that there are a variety of non-quantifiable factors that play a role in the effectiveness of a law and that awareness of the limitations they present is key. For example, differing levels of enforcement play a role in the effectiveness of the law; however, quantifying the levels is often problematic, particularly when evaluating existing data versus completing observational studies. Awareness of the limitations of the data set used (accident rate data, insurance claim frequencies, observed use) is also significant when using the results for policymaking. As Sampaio (2010) suggested in his critique of Nikolaev *et al.* (2010), accident rates have a natural ebb and flow to account for when developing a statistical model. This calls for additional care when evaluating the effectiveness of the law so as not to confuse natural declines as proof of a causal relationship.

Chapter 3

METHODOLOGY & DATA

The prior chapter provided a review of the existing literature on the impacts of laws prohibiting cell phone use while driving. In this chapter, I describe the methodology used to answer the question of whether California's law restricting the use of cell phones while driving resulted in reduced traffic accidents involving cell phone use. In the first section discussing my model, I provide an explanation of my dependent variable followed by a discussion of the anticipated broad causal factors. I further provide a discussion of the explanatory variables contained within each broad causal factor, and the anticipated outcomes for each. In the second section, I evaluate the data and each variable, including the variable description and the variable summary statistics.

Model

To evaluate whether laws restricting the use of cell phones while driving were effective in reducing traffic collisions, I perform three logistic regression analyses using traffic collision data collected through SWITRS covering the year before the law prohibiting cell phone use went into effect (July 1, 2007-June 30, 2008), and the year after the law was in effect (July 1, 2008-June 30, 2009). I use a sample of the data as the full data set for this time period includes over 1.5 million entries, many of which provide incomplete information. After identifying those records with compete information, I use a random sample to perform the regression analyses.

The first two logistic regression models measure fatal accidents and injury accidents for both years to establish the impact of cell phone use on these types of accidents. Model 1's dependent variably indicates if the accident resulted in a fatality and Model 2's dependent variable indicates if the accident resulted in an injury. The key explanatory variable for both is a variable indicating whether the driver was using a cell phone at the time of the accident. The third model measures the impact of the law on accidents involving cell phone use, with the dependent variable indicating cell phone use while driving and being involved in an accident, and the key explanatory variable indicating whether the law was in place. My three regression models are as follows:

– *Model 1: Accident Involving Fatality = ƒ(cell phone in use, driver behavior, driver demographic information, accident time, accident location, weather conditions, road conditions).*
– *Model 2: Accident with Injury = ƒ(cell phone in use, driver behavior, driver demographic information, accident time, accident location, weather conditions, road conditions).*
– *Model 3: Cell Phone Use While Driving and Being Involved in Accident = ƒ(Law in Place, driver behavior, driver demographic information, accident time, accident location, weather conditions, road conditions).*

The first two models provide the impact of cell phone use on fatal and injury accidents to identify if there is a statistically significant relationship between cell phone use and accidents. Model 3 then evaluates the impact of the law on drivers' use of cell phones while being involved in an accident. This approach is appropriate because it first provides a baseline by identifying the impact of cell phone use on accidents in general and then identifies the impact of the law on cell phone use.

Dependent Variable Measurement

My three dependent variables used are dummy variables indicating the severity of accident. For Model 1, the dependent variable indicates whether the accident involved a fatality (0=No Fatality, 1=Fatality). For Model 2, the dependent variable indicates whether the accident involved an injury (0=No Injury, No Fatality 1=Injury). For Model 3, the dependent variable indicates whether the accident of any kind involved cell phone use (0=No Cell Phone, 1=Cell Phone).

Causal Factors

The general causal factors identified are the year during which the accident occurred, driver behavior, driver demographics, accident time, accident location, weather conditions, and road conditions. The purpose of these variables is to first identify whether a driver's cell phone use impacts the likelihood of being in a fatal crash or crash involving an injury, and second, to control for factors that lead to an increased probability of a driver being involved in a traffic accident to isolate the impact of the law on driving behavior. Except for the dependent variables, the three models use the same causal factors.

Key Explanatory Variable

The key explanatory variable for Models 1 and 2 is a dummy variable indicating whether a cell phone was in use at the time of the accident (0=No, 1=Yes). The logic and motivation for using this variable is that it directly represents the subject of the study and identifies the influence of cell phone use on the type of accident. The key explanatory variable for Model 3 indicates whether the accident occurred in the year preceding the law (July 1, 2007 – June 30, 2008), or the year after the law was in place (July 1, 2008 – June 30, 2009), such that law in effect = f(Year 2008/2009). I further break Year 2008/2009 into two six-month variables to isolate any impacts from the technical changes made by SB 28 (Simitian, Chapter 270, Statutes of 2008), which took effect January 1, 2009. I use f(Year 2008) for July 1, 2008-December 31, 2008, and f(Year 2009) for January 1, 2009-June 30, 2009. These variables are not included in Models 1 and 2. Given the existing research regarding and the data set used, I anticipated that the law has a small impact on the likelihood of an accident involving cell phone use.

Driver Behavior

Driver behavior factors include whether the driver had been drinking or was legally drunk = f(had been drinking, legally drunk). This category includes a dummy variable indicating if the driver had been drinking but was not legally drunk (0=No, 1=Yes) or was legally drunk (0=No, 1=Yes). For the purposed of this paper, under the influence means a driver's blood alcohol content exceeded the legal limit of 0.08 percent.

Driver Demographics

Driver demographic factors anticipated to cause variation in the dependent variable are proxy variables of age, gender, and race, such that demographics = f(age, gender, race). I identify age with dummy variables for whether the driver was between ages 15-20, followed by ten-year increments beginning with age 21 and ending with a category indicate if the driver was over age seventy-one. The age ranges begin with age 15 as that it the age in California when an individual can qualify for a learner's permit for driving. I exclude in all three models the category for drivers ages 15-20. I identify gender by a dummy variable indicating whether the driver was male. I identify race/ethnicity by dummy variables for whether the driver was Asian, Black, Hispanic, White, or Other Race with White being the excluded category. I generally expect demographics to have a large significance given the existing literature on the use of cellular phones while driving and the impacts of factors such as age and gender. I anticipate age to have a negative impact in that, as a driver ages, he or she is less likely to be using a cell phone while driving. I anticipate that the likelihood of using a cell phone while driving increases if a driver is male and not female. It is not known how race/ethnicity affects the use of cell phones while driving, as the existing literature did not touch on the subject.

Accident Time

I use proxy variables for timeframes in six-hour increments to distinguish between morning (4:00 am-9:59 am), midday (10:00 am-3:59 pm), evening (4:00 pm-9:59 pm), and night (10:00 pm-3:59 am). The time of the accident is also identified by a variable indicating if the accident occurred during a weekday or the weekend. I include an additional set of dummy variables to indicate the month the accident took place. The model for this causal factor is accident time = f(morning, midday, evening, night, weekday, January, February, March, April, May, June, July, August, September, October, November, December). The timeframes are separated in such a way to isolate the impact of peak commute times compared to less-congested driving times. I anticipate time of the accident to have varying impacts depending on which timeframe. I anticipate that the morning and evening timeframes will increase the likelihood of an accident given that peak commute times fall into this category. In addition, I anticipate weekdays to increase the likelihood of an accident, as there are generally more cars on the road as people travel to and from work and school.

Accident Location

The broad cause of accident location includes proxy variables that indicate whether the accident occurred in an intersection and whether the accident occurred in a densely populated area. I identify population density with variables indicating whether the area was rural/unincorporated or incorporated, and if incorporated, the size-range of the population density. I anticipate that an increase population density increases the likelihood of an accident given that generally with a larger population, there are more cars on the road. A location in an intersection is likely to increase the probability of an accident, as intersections are a hub of driver interaction and require significant attention to navigate. The model for this causal factor is that accident location = f(rural/unincorporated, population <50,000, population 50,000-100,000, population 100,000-250,000, population >250,000, intersection).

Weather Conditions

I identify accident conditions by proxy variables indicating the weather at the time of the accident. These conditions include whether it was cloudy, raining, snowing, foggy, windy, or other weather condition, compared to a clear day. Other weather conditions include any weather not captured by clouds, rain, snow, fog, or clear. The model for weather conditions is that weather conditions = f(cloudy, raining, snowing, foggy, windy, other weather, wind). Hazardous weather conditions such as rain, snow, and fog are likely to increase the chance of an accident.

Road Conditions

Road conditions further affect the accident conditions. I quantify road conditions through variables indicating if the road was wet, slippery, or covered in snow or ice at the time of the accident compared to a dry road. The model for road conditions is f(wet, slippery, snow/ice). Hazardous road conditions are likely to increase the probability of an accident. As such, I anticipate that the conditions, in general, have a negative impact, as drivers may be more attentive given the hazards present.

Data

This section provides a more comprehensive look at each variable. The following tables will identify the variable description and the variable summary statistics. This section will also discuss the simple correlation coefficients between all explanatory variables. Table 3 provides this data and is located in Appendix B.

Variable Description

Table 3.1 provides a description of the dependent and explanatory variables. All variables derive from SWITRS raw data. I organize the variables by broad causal factor. The table additionally indicates the measurement of each variable used in the regression. Notable to this study is that all variables used are dummy variables indicating whether a specific condition was present.

Table 3.1

Variable Description

Variable	Description
Dependent Variables	
Model 1	
Fatality Only	Dummy variable indicating whether the accident resulted in a fatality only: No Injury or Fatality = 0, Fatality = 1
Model 2	
Injury Only	Dummy variable indicating whether the accident resulted in an injury only: No Injury or Fatality = 0, Injury = 1
Model 3	
Model 3 – Cell Phone in Use	Dummy variable indicating whether a cell phone was in use at the time of the accident: No = 0, Yes = 1
Key Explanatory Variable	
Model 1	
Cell Phone in Use	Dummy variable indicating whether a cell phone was in use at the time of the accident: No = 0, Yes = 1
Model 2	
Cell Phone in Use	Dummy variable indicating whether a cell phone was in use at the time of the accident: No = 0, Yes = 1
Model 3	
Year 2008/2009	Dummy variable indicating the year the accident took place: FY 2007/08 = 0, FY 2008/09 = 1
Year 2008	Dummy variable indicating whether the accident occurred between July 1, 2008 and December 31, 2008: No = 0, Yes = 1
Year 2009	Dummy variable indicating whether the accident occurred between January 1, 2009 and June 30, 2009: No = 0, Yes = 1
Driver Behavior	
Had Been Drinking	Dummy variable indicating whether the driver had been drinking at the time of the accident but was not legally drunk: No = 0, Yes = 1
Legally Drunk	Dummy variable indicating whether the driver was legally drunk at the time of the accident: No = 0, Yes = 1
Driver Demographic Information	
Gender	
Male	Dummy variable indicating if the driver was male: No = 0, Yes = 1
Race	
Asian	Dummy variable indicating if the driver was Asian: No = 0, Yes = 1
Black	Dummy variable indicating if the driver was Black: No = 0, Yes = 1
Hispanic	Dummy variable indicating if the driver was Hispanic: No = 0, Yes = 1
Other Race	Dummy variable indicating if the driver was a race other than

	Asian, Black, Hispanic, or White: No = 0, Yes = 1
Age	
Age 21-30	Dummy variable indicating if the driver was between the ages of 21-30:No = 0, Yes = 1
Age 31-40	Dummy variable indicating if the driver was between the ages of 31-40: No = 0, Yes = 1
Age 41-50	Dummy variable indicating if the driver was between the ages of 41-50: No = 0, Yes = 1
Age 51-60	Dummy variable indicating if the driver was between the ages of 51-60: No = 0, Yes = 1
Age 61-70	Dummy variable indicating if the driver was between the ages of 61-70: No = 0, Yes = 1
Age 71+	Dummy variable indicating if the driver was over age 70: No = 0, Yes = 1
Accident Time	
Time of Day	
Morning	Dummy variable indicating whether the accident took place between 4:00am – 9:59am: No = 0, Yes = 1
Midday	Dummy variable indicating whether the accident took place between 10:00am – 3:59pm: No = 0, Yes = 1
Evening	Dummy variable indicating whether the accident took place between 4:00pm -9:59pm: No = 0, Yes = 1
Day of Week	
Weekday	Dummy variable indicating whether the accident took place during a weekday (Monday-Friday): No = 0, Yes = 1
Month	
January	Dummy variable indicating whether the accident took place in the month of January: No = 0, Yes = 1
February	Dummy variable indicating whether the accident took place in the month of February: No = 0, Yes = 1
March	Dummy variable indicating whether the accident took place in the month of March: No = 0, Yes = 1
April	Dummy variable indicating whether the accident took place in the month of April: No = 0, Yes = 1
May	Dummy variable indicating whether the accident took place in the month of May: No = 0, Yes = 1
June	Dummy variable indicating whether the accident took place in the month of June: No = 0, Yes = 1
August	Dummy variable indicating whether the accident took place in the month of August: No = 0, Yes = 1
September	Dummy variable indicating whether the accident took place in the month of September: No = 0, Yes = 1
October	Dummy variable indicating whether the accident took place in the month of October: No = 0, Yes = 1
November	Dummy variable indicating whether the accident took place in the month of November: No = 0, Yes = 1
December	Dummy variable indicating whether the accident took place in

	the month of December: No = 0, Yes = 1
Accident Location	
Intersection	Dummy variable indicating whether the accident occurred in an intersection: No = 0, Yes = 1
Population <50,000	Dummy variable indicating if the accident took place in a location with a population density of less than 50,000 people: No = 0, Yes = 1
Population 50,000-100,000	Dummy variable indicating if the accident took place in a location with a population density of between 50,000 – 100,000 people: No = 0, Yes = 1
Population 100,000-250,000	Dummy variable indicating if the accident took place in a location with a population density of between 100,000 – 250,000 people: No = 0, Yes = 1
Population >250,000	Dummy variable indicating if the accident took place in a location with a population density of 250,000 or more people: No = 0, Yes = 1
Weather Conditions	
Cloudy	Dummy variable indicating if was cloudy at the time of the accident: No = 0, Yes = 1
Raining	Dummy variable indicting if it was raining at the time of the accident: No = 0, Yes = 1
Snowing	Dummy variable indicating if it was snowing at the time of the accident: No = 0, Yes = 1
Fog	Dummy variable indicating if it was foggy at the time of the accident: No = 0, Yes = 1
Other Weather	Dummy variable indicating if there were other weather conditions present at the time of the accident: No = 0, Yes = 1
Wind	Dummy variable indicating if it was windy at the time of the accident: No = 0, Yes = 1
Road Conditions	
Wet	Dummy variable indicating if the roads were wet at the time of the accident: No = 0, Yes = 1
Slippery	Dummy variable indicating if the road was slippery at the time of the accident: No = 0, Yes = 1
Snow/Ice	Dummy variable indicating if there was snow or ice on the road at the time of the accident: No = 0, Yes = 1

Summary Statistics

Table 3.2 identifies the summary statistics for each variable -- mean, standard deviation, minimum value, and maximum value. Considering that all variables are dummy variables with values of either 0 or 1, the maximum and minimum statistics may not be entirely useful; however, the mean and standard deviation provide insight into the frequency of a variable.

Table 3.2

Variable Summary Statistics

Variable	Mean	Std. Deviation	Minimum	Maximum
Dependent Variable				
Model 1				
Fatality Only	0.0057002	0.0752854	0	1
Model 2				
Injury Only	0.3964799	0.4891744	0	1
Model 3				
Cell Phone in Use	0.0077669	0.0877887	0	1
Key Explanatory Variable				
Model 1				
Cell Phone in Use	0.0077669	0.0877887	0	1
Model 2				
Cell Phone in Use	0.0077669	0.0877887	0	1
Model 3				
Year 2008/2009	0.4983166	0.5000055	0	1
Year 2008	0.2546418	0.4356669	0	1
Year 2009	0.2436748	0.4293059	0	1
Driver Behavior				
Had Been Drinking	0.0102003	0.1004820	0	1
Legally Drunk	0.0479683	0.2137027	0	1
Driver Demographic Information				
Gender				
Male	0.6053535	0.4887828	0	1
Race				
Asian	0.0868696	0.2816485	0	1
Black	0.0784026	0.2688086	0	1
Hispanic	0.3225774	0.4674703	0	1
White	0.4478149	0.4972775	0	1
Other Race	0.0643355	0.2453537	0	1
Age				

Age 15-20	0.1280376	0.3341372	0	1
Age 21-30	0.2650422	0.4413630	0	1
Age 31-40	0.1977399	0.3983016	0	1
Age 41-50	0.1828728	0.3865686	0	1
Age 51-60	0.1308377	0.3372284	0	1
Age 61-70	0.0590686	0.2357570	0	1
Age 71+	0.0364012	0.1872894	0	1
Accident Time				
Time of Day				
Morning	0.2085736	0.4062957	0	1
Midday	0.3678123	0.4822180	0	1
Evening	0.3363112	0.4724547	0	1
Night	0.0873029	0.2822831	0	1
Day of the Week				
Weekday	0.7712257	0.4200506	0	1
Month				
January	0.0808360	0.2725877	0	1
February	0.0787360	0.2693307	0	1
March	0.0875696	0.2826726	0	1
April	0.0799360	0.2711986	0	1
May	0.0818361	0.2741194	0	1
June	0.0746025	0.2627532	0	1
July	0.0812694	0.2732529	0	1
August	0.0848695	0.2786920	0	1
September	0.0850362	0.2789402	0	1
October	0.0909697	0.2875708	0	1
November	0.0866696	0.2813549	0	1
December	0.0876696	0.2828185	0	1
Accident Location				
Intersection	0.2239741	0.4169119	0	1
Population <50,000	0.1446715	0.3517752	0	1
Population 50,000-100,000	0.1758059	0.3806613	0	1
Population 100,000-250,000	0.1906064	0.3927858	0	1
Population >250,000	0.2418414	0.4282058	0	1
Rural/Unincorporated	0.2470749	0.4313179	0	1
Accident Conditions				
Cloudy	0.1337711	0.3404119	0	1
Raining	0.031101	0.1735937	0	1
Snowing	0.0016334	0.0403828	0	1
Fog	0.0041335	0.0641601	0	1
Other Weather	0.0006667	0.0258121	0	1
Wind	0.000300	0.0173185	0	1
Road Conditions				
Wet	0.0761025	0.2651665	0	1
Slippery	0.0009000	0.0299875	0	1
Snow/Ice	0.0046335	0.0679130	0	1

Summary

In this section, I identified model I use to evaluate the effectiveness of California's law prohibiting the use of cell phones while driving. For Models 1 and 2, the key explanatory variable expected to influence the dependent variable indicates whether a driver was using a cell phone at the time of the accident. The key explanatory variable expected to influence the dependent variable for Model 3 indicates whether the law was in place. The broad causal factors include the driver behavior, driver demographics, accident time, accident location, weather conditions, and road conditions. The two tables presented in this section describe the variables used in this analysis and provide summary statistics. Notable is the fact that all variables used are dummy variables with values of either 0 or 1. I evaluate this subject further in the next chapter of the paper, which details my regression results.

Chapter 4

RESULTS

The previous chapter provides a description of the method and data I use for the regression analyses. This chapter details the regression analyses performed and the results. Specifically, this chapter provides an evaluation of the best functional form, additional checks for multicollinearity, heteroskedasticity, and the impact of interaction terms. This chapter concludes with my final regression results corrected for any identified issues in the proper functional form.

Functional Form

Choosing the appropriate functional form is vital to a successful regression analysis. Functional forms available include, but are not limited to, linear-linear, quadratic, log-linear, linear-semi-log, and logistic. The first four forms are Ordinary Least Squares (OLS) models. Conversely, the logistic model uses maximum likelihood estimation. As my data set contains only dummy variables and no continuous variables, the quadratic, log-linear, and linear-semilog forms are eliminated. Quadratic is inappropriate as it requires an explanatory variable to be squared. Since the square of one is one, this model provides no value. Both the log-linear and linear-semilog forms are also inappropriate, as they require the inclusion of the logarithmic value of either my dependent variable or an explanatory variable. As the logarithmic value of one is zero and the logarithmic value of zero is infinity, neither of these results is useful to my regression equations.

By eliminating the functional forms of quadratic, log-linear, and linear-semilog, I am left with a comparison of the linear-linear model and the logistic model. Below, I provide the uncorrected regression results from performing both of these functions for each of my three models.

Tables 4.1

Uncorrected Regression Results in Possible Functional Forms

*Model 1 – **Accident Involving Fatality=1***

	Linear		Logistic		Excluded
Variable	**Coefficient**	**Std. Error**	**Odds Ratio**	**Std. Error**	**Variable**
Key Explanatory Variable					
Cell Phone in Use	-0.0021979	0.0049525	0.7420882	0.7484758	Not In Use
Driver Behavior					
Had Been Drinking	0.0117229***	0.0043531	2.6077260**	1.1374390	Sober
Legally Drunk	0.0075028***	0.0021621	1.9411000***	0.4902842	Sober
Driver Demographic Information					
Gender					
Male	0.0008732	0.0008967	1.1912280	0.2005126	Female
Race					
Asian	-0.0015671	0.0016197	0.6871001	0.2442833	White
Black	-0.0013610	0.0016969	0.7663081	0.2607206	White
Hispanic	0.0010237	0.0010291	1.1785910	0.2069892	White
Other Race	-0.0011277	0.0018398	0.7804780	0.2925099	White
Age					
Age 21-30	-0.0017238	0.0014828	0.7567021	0.1934938	Age 15-20
Age 31-40	-0.0011585	0.0015637	0.8365847	0.2294666	Age 15-20
Age 41-50	-0.0009281	0.0015903	0.8832570	0.2470805	Age 15-20
Age 51-60	0.00000056	0.0017190	1.0542460	0.3118948	Age 15-20
Age 61-70	0.0041555*	0.0021756	1.8662550*	0.6010168	Age 15-20
Age 71+	0.0041199	0.0026017	1.9488760*	0.7478688	Age 15-20
Accident Time					
Time of Day					
Morning	-0.0088117	0.0018656	0.3442319	0.0950029	Night
Midday	-00.0085869	0.0017493	0.3615547	0.0875412	Night
Evening	-0.0078230	0.0017334	0.4331013	0.0989241	Night
Day of Week					
Weekday	-0.0015349	0.0010559	1.9925250*	0.1334826	Weekend
Month					
January	0.0039665*	0.0021914	1.9925250*	0.8045555	July
February	0.0049253**	0.0022157	2.2928980*	0.9119138	July

March	0.0002821	0.0021175	1.0203520	0.4589816	July
April	0.0019304	0.0021638	1.4803210	0.6264091	July
May	0.0006477	0.0021518	1.1329930	0.4979308	July
June	0.0042153*	0.0022036	2.0395960*	0.8104507	July
August	0.0011159	0.0021303	1.2589580	0.5324698	July
September	0.0031450	0.0021306	1.7613640	0.7064262	July
October	0.0020245	0.0020980	1.4625760	0.6015879	July
November	0.0008096	0.0021276	1.1465610	0.4956611	July
December	0.0016827	0.0021442	1.4121570	0.595195	July
Accident Location					
Intersection	-0.0002022	0.0010526	0.9603308	0.1897373	Not Intersection
Population <50,000	-0.0086378	0.0014515	0.2133078	0.0720059	Rural/ Unincorporated
Population 50,000-100,000	-0.0061536	0.0013662	0.4393114	0.1032919	Rural/ Unincorporated
Population 100,000-250,000	-0.0069534	0.0013362	0.3630044	0.0881429	Rural/ Unincorporated
Population >250,000	-0.0064763	0.0012632	0.4125816	0.0888823	Rural/ Unincorporated
Weather Conditions					
Cloudy	0.0054520	0.0014779	1.0655790	0.2669033	Clear
Raining	-0.0001692	0.0033990	0.9565914	0.5604447	Clear
Snowing	-0.0091149	0.0128492	1	n/a	Clear
Fog	0.0160500**	0.0068675	3.2278670*	2.0255650	Clear
Other Weather	0.0430714***	0.0168257	8.3519810**	8.7510480	Clear
Wind	-0.0047866	0.0250602	1	n/a	No Wind
Road Conditions					
Wet	-0.0011985	0.0023892	0.8629381	0.3277808	Dry
Slippery	-0.0075619	0.0144868	1	n/a	Dry
Snow/Ice	-0.0008495	0.0077207	0.8984596	0.9271887	Dry
Constant	0.0171699	0.0026863	0.0170089	0.0075007	
No. of Observations	29,999		29,915		
R^2	0.0057		n/a		
Adjusted R^2	0.0042		n/a		
Pseudo R^2	n/a		0.0632		
No. of Significant Results	8		9		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

Tables 4.2

Uncorrected Regression Results in Possible Functional Forms

*Model 2 – **Accident with Injury=1***

Variable	Linear		Logistic		Excluded Variable
	Coefficient	**Std. Error**	**Odds Ratio**	**Std. Error**	
Key Explanatory Variable					
Cell Phone in Use	0.0633340**	0.0317291	1.3061210**	0.1753324	Not In Use
Driver Behavior					
Had Been Drinking	-0.0094339	0.0278888	0.9596470	0.1163246	Sober
Legally Drunk	0.0330636**	0.0138518	1.1534050**	0.0684685	Sober
Driver Demographic Information					
Gender					
Male	-0.3203270	0.0574480	0.8710154	0.0215604	Female
Race					
Asian	-0.0375538	0.0103769	0.8487851	0.0384218	White
Black	0.0030923	0.0108713	1.0140600	0.4704720	White
Hispanic	-0.0233097	0.0065933	0.9035377	0.0257790	White
Other Race	-0.0156678	0.0117872	0.9340883	0.4762130	White
Age					
Age 21-30	-0.0022668	0.0095001	0.9856290	0.0408668	Age 15-20
Age 31-40	0.0182053*	0.0100178	1.0820700*	0.4698900	Age 15-20
Age 41-50	0.0272183***	0.0101883	1.1248340***	0.4958270	Age 15-20
Age 51-60	0.0253281**	0.0110129	1.1156010**	0.5313170	Age 15-20
Age 61-70	0.0382976***	0.0139381	1.1791940***	0.0707116	Age 15-20
Age 71+	0.609598	0.0166683	1.2963500	0.0922438	Age 15-20
Accident Time					
Time of Day					
Morning	-0.0327006***	0.0119526	0.8671865***	0.0447447	Night
Midday	-0.0018354	0.0112073	0.9923363	0.0477834	Night
Evening	-0.0114729	0.0111056	0.9522484	0.4545870	Night
Day of Week					
Weekday	-0.0280317	0.0067650	-0.8869497	0.2573550	Weekend
Month					
January	-0.0158780	0.0140399	0.9332500	030567889	July
February	-0.0127860	0.0141955	0.9456357	0.0581712	July
March	0.0143527	0.0135664	1.0635100	0.0620974	July
April	-0.0026511	0.0138624	0.9885578	0.0591915	July
May	0.0286059**	0.0137859	1.1299180**	0.0668566	July
June	-0.0128948	0.0141177	0.9453087	0.0577761	July
August	-0.0025474	0.0136482	0.9891387	0.0582612	July
September	0.0085099	0.0136499	1.0376970	0.0610291	July
October	0.0092585	0.0134414	1.0404010	0.0602609	July
November	-0.0015271	0.0136306	0.9934845	0.0584544	July

December	-0.0235764*	0.0137369	0.9021913*	0.0538008	July
Accident Location					
Intersection	0.1402035	0.0067438	1.7976770	0.0513976	Not Intersection
Population <50,000	-0.0432042	0.0092992	0.8259925	0.0337164	Rural/ Unincorporated
Population 50,000-100,000	-0.0275070***	0.0087531	0.8853813***	0.0338636	Rural/ Unincorporated
Population 100,000-250,000	0.0011753	0.0085604	1.0047550	0.0372230	Rural/ Unincorporated
Population >250,000	0.1124792	0.0080927	1.5997110	0.0552650	Rural/ Unincorporated
Weather Conditions					
Cloudy	-0.0079710	0.0094684	0.9655354	0.0397229	Clear
Raining	0.0281217	0.0217765	1.1304340	0.1066667	Clear
Snowing	-0.1106734	0.0823203	0.5849082	0.2276836	Clear
Fog	0.0362372	0.0439978	1.1715840	0.2220321	Clear
Other Weather	0.2670671**	0.1077968	3.0881500**	1.4678340	Clear
Wind	0.4158121***	0.1605522	6.6479300**	5.4030660	No Wind
Road Conditions					
Wet	0.0101682	0.0153066	0.9563444	0.0640015	Dry
Slippery	0.1224611	0.0928188	1.6835740	0.6592104	Dry
Snow/Ice	-0.0132770	0.0494638	0.9931867	0.2172546	Dry
Constant	0.3962011	0.0172102	0.6547880	0.0485606	
No. of Observations	29,999		29,999		
R^2	0.0333		n/a		
Adjusted R^2	0.0319		n/a		
Pseudo R^2	n/a		0.0248		
No. of Significant Results	12		12		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

Table 4.3

Uncorrected Regression Results in Possible Functional Forms

Model 3 - ***Cell Phone Use While Driving and Being Involved in Accident =1***

Variable	Linear		Logistic		Excluded Variable
	Coefficient	Std. Error	Odds Ratio	Std. Error	
Key Explanatory Variable					
FY 2008/2009	-0.0042298***	0.0014092	0.5737965***	0.1089893	FY 2007/2008
FY 2009	-0.0020363	0.0020264	0.7222474	0.2040782	FY 2008
Driver Behavior					
Had Been Drinking	0.0289302	0.0050736	5.4095060	1.7669240	Sober
Legally Drunk	0.0145024	0.0025200	3.3252950	0.7502707	Sober
Driver Demographic Information					
Gender					
Male	-0.0018816*	0.0010456	0.7827567*	0.1059822	Female

Race					
Asian	-0.0056824***	0.0018885	0.3751255***	0.1304133	White
Black	-0.0013513	0.0019790	0.8566566	0.2102293	White
Hispanic	-0.0032188***	0.0012000	0.6670140***	0.1033184	White
Other Race	-0.0035169	0.0021455	0.6146981	0.1954325	White
Age					
Age 21-30	-0.0014993	0.0017292	0.8694381	0.1658556	Age 15-20
Age 31-40	-0.0028894	0.0018234	0.7442938	0.1568950	Age 15-20
Age 41-50	-0.0055100***	0.0018542	0.5109590***	0.1203766	Age 15-20
Age 51-60	-0.0072237	0.0020042	0.3566791	0.1053607	Age 15-20
Age 61-70	-0.0073501***	0.0025367	0.3525624**	0.1448291	Age 15-20
Age 71+	-0.0074264**	0.0030337	0.3658432**	0.1745518	Age 15-20
Accident Time					
Time of Day					
Morning	-0.0005874	0.0021757	0.8935788	0.2515201	Night
Midday	0.0007821	0.0020400	1.1158670	0.2818467	Night
Evening	0.0021246	0.0020214	1.3233770	0.3148626	Night
Day of Week					
Weekday	0.0016501	0.0012314	1.2321220	0.2032380	Weekend
Month					
January	0.0003560	0.0027447	1.0406180	0.3647777	July
February	-0.0008185	0.0027716	0.8260754	0.3080856	July
March	0.0006107	0.0026663	1.0444910	0.3461724	July
April	0.0000775	0.0027157	0.9898895	0.3413125	July
May	0.0018106	0.0027043	1.2209880	0.3970019	July
June	0.0029093	0.0027680	1.3788800	0.4496112	July
August	-0.0037370	0.0024843	0.5611041	0.2061107	July
September	-0.0002034	0.0024846	0.9840429	0.3138302	July
October	0.0022356	0.0024466	1.2921710	0.3823017	July
November	-0.0016813	0.0024811	0.7834776	0.2652210	July
December	0.0022342	0.0032113	1.3102820	0.3978909	July
Accident Location					
Intersection	0.0024988**	0.0012274	1.3522380**	0.2022922	Not Intersection
Population <50,000	0.0028167*	0.0016926	1.4390560*	0.3122885	Rural/ Unincorporated
Population 50,000-100,000	0.0030465*	0.0015931	1.4677650*	0.3013498	Rural/ Unincorporated
Population 100,000-250,000	0.0000447	0.0015582	1.0045840	0.2227587	Rural/ Unincorporated
Population >250,000	0.0017529	0.001473	1.2797180	0.2566093	Rural/ Unincorporated
Weather Conditions					
Cloudy	-0.0009429	0.0017242	0.8691106	0.2095415	Clear
Raining	-0.0022427	0.0039637	0.6432575	0.4128899	Clear
Snowing	-0.0019913	0.0149839	1	n/a	Clear
Fog	0.0024024	0.0080091	1.4602770	1.4994400	Clear

Other Weather	-0.0060273	0.0196215	1	n/a	Clear
Wind	-0.0092194	0.0292240	1	n/a	No Wind
Road Conditions					
Wet	-0.0017022	0.0027861	1	0.3213358	Dry
Slippery	-0.0073993	0.0168936	1	n/a	Dry
Snow/Ice	-0.0048016	0.0090039	0.0112664	n/a	Dry
Constant	0.0119679	0.0032113	1	0.0044465	
No. of Observations	29,999		29,802		
R^2	0.0056		n/a		
Adjusted R^2	0.0041		n/a		
Pseudo R^2	n/a		0.0538		
No. of Significant Results	10		10		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

OLS versus Logistic Model

It is important to note the difference in results between the two forms. For the linear-linear regression, the results display the coefficient and the associated standard error. The logistic regression results display the odds ratio and standard error. As mentioned previously, the linear-linear regression is an OLS model, which intends to minimize the sum of the squared residuals, the differences between the estimated line produced by the regression and the actual values. As my data set, particularly my dependent variable has only values of one and zero, the resulting coefficients of an OLS based regression may be outside the meaningful range leading to a misinterpretation of results. In other words, the results are unbounded. While this model does return many significant results, the degree to which the results affect the dependent variable may be skewed.

The logistic model corrects for the concerns of using a linear-linear model in an equation with a dummy dependent variable. Unlike OLS models, the logistic model is bounded by the parameters of my dummy dependent variable. While OLS models attempt to fit a straight line between two values, the logistic model fits an “S” curve that works within the bounds of the dependent variable. Instead of returning a coefficient, logistic models provide an odds ratio. The odds ratio identifies the change in the log of the probability of the dependent variable cause by a one-unit increase in the explanatory variable, holding all other variables constant. Both methods returned statistically significant variables for each of my three models; however, the logistic method returned more statistically significant results in addition to being a better fit for the data set. Given these factors, I use a logistic regression model for my corrected results.

Interaction Terms

Having established the preferred functional form, I now evaluate the inclusion of interaction terms in my regression equation. To create interaction terms, one or more explanatory variables are multiplied to create a new variable that identifies that influence of one variable on the other (Studenmund, 2006). For Models 1 and 2, I create interaction terms by multiplying the key explanatory variable (Cell Phone in Use) by each of the other explanatory variables to indentify the impact cell phone has on each. For Model 3, I again create interaction terms using this model’s key explanatory variable (Year 2008/2009) multiplied by each of my other explanatory variables to identify the impact the post-law year had on those variables.

To test whether any of the interaction terms are necessary to include in my regression equation, I included each interaction term in the regression one-by-one and recorded the results at a significance level of 90-percent. For Model 1, no interaction terms yielded significant results. For Model 2, three interaction terms returned significant results for FY 2008/2009*Age 41-50, FY 2008/2009*Morning, and FY 2008/2009*January. In Model 3, three interaction terms returned significant results: Year 2008/2009*Age 41-50, Year 2008/2009*April, and Year 2008/2009*Cloudy. Although the interaction terms for both Model 2 and 3 are statistically significant, I choose to omit them from the final regression results as many of the variables were already significant and they ultimately do not contribute to a better understanding of the three regression equations. The inclusion of the interaction terms in the adjusted results additionally had the interesting effect of making statistically significant variables insignificant and excluding other variables for predicting failure perfectly. The results for all interaction terms are located in Appendix B.

Testing for Multicollinearity

Multicollinearity occurs when the movement in an independent variable can be explained by the movement in another variable, or when one variable is the function of another. For example, I would have multicollinearity if I had a dummy variable for being male and a dummy variable for being female. Results for female would be directly explained by results for being male, and vice versa. While most equations have some degree of multicollinearity, high or severe multicollinearity may indicate problems within the equation and the inability to isolate the effects of the explanatory variables. This is problematic as this means the explanation for the movement in an independent variable is explained by the movement in another variable. In regression analysis, this may lead to inaccurate portrayals of the variables' regression coefficients and prejudice results.

Correlation coefficients are useful in regression analyses as a first step in identifying multicollinearity between variables. Appendix C identifies the correlation coefficients for the explanatory variables used in this study. Correlation coefficients are also referred to as “r” values. The simple correlation coefficients identify the linear relationship between two variables on a scale from -1 to +1. The positive (+) or negative (-) sign indicates the direction of the correlation. A simple correlation coefficient with an absolute value close to 1 indicates a high correlation between the two variables. Values close to 0 indicate a low correlation for the variables. Coefficients with asterisks (*) indicate values that are statistically significant at a 95 percent significance level, which indicates multicollinearity between variables.

In reviewing Appendix C there are variables indicating potential multicollinearity. However, this does not necessarily indicate significant concern for my model. For example, the variable indicating a driver was Hispanic is not likely explained by the variable indicating that the roads at the time of the accident were wet. The only coefficients with moderate relationships include the relationship between FY 2008/2009 and FY 2008 (0.5865), and FY 2008/2009 FY 2009 (0.5695). This high value is explained by the fact that the variables FY 2008 and FY 2009 derive from FY 2008/2009. As such, no adjustments to my model are necessary at this time.

To identify any severe multicollinearity, I test the Variance Influence Factors (VIF) for my explanatory variables. The VIF identifies the extent movement one explanatory variable can be explained by movement of another and is generally considered more a more reliable measure of multicollinearity than the correlation coefficients (Studenmund, 2006). The test of my data excluding these variables reveals none of the variables has a VIF over five, which is indicative of severe multicollinearity (Studenmund, 2006). The mean VIF for each model is as follows: Model 1 – 1.65, Model 2 – 1.62, Model 3 - 1.85. The complete results for the VIF test are located in Appendix D. Had the results indicated severe multicollinearity, it would be necessary for me to drop a redundant variable from my equation.

Heteroskedasticity

Studenmund (2006) defines heteroskedasticity as a violation of the assumption that variance in the standard error is constant. With heteroskedasticity, it is unclear whether the bias in the standard error is positive or negative. Data sets that have a wide disproportion between the lowest and highest value of the dependent variable may be subject to heteroskedasticity. Additionally, heteroskedasticity may be present in equations with bias due to omitted variables or an exogenous variable. Omitted variable bias is simply not including a key explanatory variable from the equation. Exogenous variables are those whose values are determined by factors not included in the equation.

To test for heteroskedasticity, I perform both the Breusch-Pagan/Cook-Weisberg and Szroeter's tests. The Breusch-Pagan/Cook-Weisberg test requires the running of a linear regression that includes the squared values of the residuals (Studenmund, 2006). Squaring the residuals, the differences between the estimated line produced by the OLS regression and the actual values, amplifies any inconsistencies in variance. Results from this test returning a probability of less than 0.10 or with a high chi-squared value indicate heteroskedasticity. My data returned a chi-squared of 14,379.62 for Model 1, 17.26 for

Model 2, and 10,944.25 for Model 3, each with a probability of 0.000 indicating the presence of heteroskedasticity.

Prior to correcting for any heteroskedasticity identified by the Breusch-Pagan/Cook-Weisberg test, I perform Szroeter's test, which tests the null hypothesis that variance in the error term is unrelated to other variables. In Szroeter's rank test, the following number of variables used in my regression result in $p < 0.10$, indicating heteroskedasticity: Model 1 - 40 of 43, Model 2 – 43 of 46, Model 3 – 43 of 47.

To correct for heteroskedasticity, I consider using the Weighted Least Squares (WLS) method or the Heteroskedasticity-Corrected Standard Errors method. To adjust my equations using WLS, I would need to identify the proportionality factor necessary to divide through the equation (Studenmund, 2006). Given the difficulty in identifying the correct proportionality factor, and the implication that it is better suited for a linear regression, rather than a logistic regression, I use the Heteroskedasticity-Corrected Standard Errors method. To do this, I re-run my logistic regression and account for robust standard error. Results of the Breusch-Pagan/Cook-Weisberg and Szroeter's tests are located in Appendix E and F. I provide the adjusted results in the next section.

Adjusted Regression Results

In Tables 4.4-4.6 below, I provide the adjusted regression results correcting for multicollinearity, heteroskedasticity and accounting for robust standard error. The equation excludes those variables that predicted failure perfectly in the initial results, which includes snowing, wind, and slippery for Model 1, and snowing, other weather, slippery, and snow/ice for Model 3. No variables were excluded for Model 2.

Table 4.4

Adjusted Regression Results

*Model 1 – **Accident Involving Fatality=1***

Variable	Odds Ratio	Robust Std. Error	Excluded Variable
Key Explanatory Variable			
Cell Phone in Use	0.7436460	0.7582167	Not in Use
Driver Behavior			
Had Been Drinking	2.6146800**	1.1585470	Sober
Legally Drunk	1.9410970**	0.5260474	Sober
Driver Demographic Information			
Gender			
Male	1.1924940	0.2012264	Female
Race			
Asian	0.6879606	0.2448965	White
Black	0.7683880	0.2583186	White
Hispanic	1.1797960	0.2048839	White
Other Race	0.7794185	0.2934710	White
Age			
Age 21-30	0.7546600	0.1970112	Age 15-20
Age 31-40	0.8358858	0.2349938	Age 15-20
Age 41-50	0.8819085	0.2546682	Age 15-20
Age 51-60	1.0484380	0.3187537	Age 15-20
Age 61-70	1.8603000*	0.6115490	Age 15-20
Age 71+	1.9466660*	0.7433119	Age 15-20
Accident Time			
Time of Day			
Morning	0.3448366***	0.1070026	Night
Midday	0.3624939	0.0992428	Night
Evening	0.4330594***	0.1101190	Night
Day of Week			
Weekday	0.7833095	0.1416499	Weekend
Month			
January	1.9871700*	0.8092093	July
February	2.2878150**	0.9188460	July
March	1.0207230	0.4616924	July
April	1.4814290	0.6287874	July
May	1.1360050	0.4996264	July
June	2.0413560*	0.8173218	July
August	1.2629550	0.5336827	July
September	1.7615190	0.7077000	July
October	1.4629340	0.6038433	July
November	1.1476540	0.4930566	July
December	1.4153820	0.5977212	July

Accident Location			
Intersection	0.9612613	0.1851362	Not Intersection
Population <50,000	0.2131476	0.0707552	Rural/Unincorporated
Population 50,000-100,000	0.4393560	0.1025846	Rural/Unincorporated
Population 100,000-250,000	0.3656770	0.0879739	Rural/Unincorporated
Population >250,000	0.4130187	0.0873479	Rural/Unincorporated
Weather Conditions			
Cloudy	1.0779530	0.2696767	Clear
Raining	0.9726607	0.5606666	Clear
Fog	3.2409440*	2.0134600	Clear
Other Weather	8.4796720**	8.2029360	Clear
Road Conditions			
Wet	0.8560015	0.3297378	Dry
Snow/Ice	0.6159590	0.6523889	Dry
Constant	0.0169160	0.0072317	
No. of Observations	29,999		
Pseudo R^2	0.0631		
No. of Significant Results	11		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

Table 4.5

Adjusted Regression Results

Model 2 – ***Accident with Injury=1***

Variable	**Odd Ratio**	**Robust Std. Error**	**Excluded Variable**
Key Explanatory Variable			
Cell Phone in Use	1.3061210**	0.1754628	Not in Use
Driver Behavior			
Had Been Drinking	0.9596470	0.1164101	Sober
Legally Drunk	1.1534050**	0.0694086	Sober
Driver Demographic Information			
Gender			
Male	0.8710154	0.0215658	Female
Race			
Asian	0.8487851	0.0383749	White
Black	1.0114060	0.0469985	White
Hispanic	0.9035377	0.0257716	White
Other Race	0.9340883	0.0474590	White
Age			
Age 21-30	0.9895629	0.0407503	Age 15-20
Age 31-40	1.0820700*	0.0468187	Age 15-20
Age 41-50	1.1248340***	0.0494879	Age 15-20
Age 51-60	1.1156010	0.0530855	Age 15-20
Age 61-70	1.1791940***	0.0706300	Age 15-20

Age 71+	1.2963500	0.0918300	Age 15-20
Accident Time			
Time of Day			
Morning	0.8671865***	0.0448812	Night
Midday	0.9923363	0.0448812	Night
Evening	0.9522484	0.0456153	Night
Day of Week			
Weekday	0.8869497	0.0257296	Weeknight
Month			
January	0.9332500	0.0568727	July
February	0.9456357	0.0581993	July
March	1.0635100	0.0621652	July
April	0.9885578	0.0592579	July
May	1.1299180**	0.0669734	July
June	0.9453087	0.0578494	July
August	0.9891378	0.0583782	July
September	1.0376970	0.0611692	July
October	1.0404010	0.0603609	July
November	0.9934845	0.0585460	July
December	0.9021913*	0.0538507	July
Accident Location			
Intersection	1.7976770	0.0509005	Not Intersection
Population <50,000	0.8259925	0.0339341	Rural/Unincorporated
Population 50,000-100,000	0.8853813***	0.0340910	Rural/Unincorporated
Population 100,000-250,000	1.0047550	0.0373389	Rural/Unincorporated
Population >250,000	1.5997110	0.0549531	Rural/Unincorporated
Weather Conditions			
Cloudy	0.9655354	0.0398717	Clear
Raining	1.1304340	0.1071448	Clear
Snowing	0.5849082	0.2211447	Clear
Fog	1.1715840	0.2255680	Clear
Other Weather	3.0881550	1.4685730	Clear
Wind	6.6479300**	5.3005160	No Wind
Road Conditions			
Wet	0.9563444**	0.0638101	Dry
Slippery	1.6835740	0.6607585	Dry
Snow/Ice	0.9931867	0.2172100	Dry
Constant	0.6547880	0.0486648	
No. of Observations	29,999		
Pseudo R^2	0.0248		
No. of Significant Results	11		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

Table 4.6

Adjusted Regression Results

Model 3 - ***Cell Phone Use While Driving and Being Involved in Accident =1***

Variable	Odds Ratio	Robust Std. Error	Excluded Variable
Key Explanatory Variable			
FY 2008/2009	0.5720981***	0.1084568	FY 2007/2008
FY 2009	0.7244987	0.2049806	FY 2008
Driver Behavior			
Had Been Drinking	5.4489940	1.7952470	Sober
Legally Drunk	3.3334670	0.7460416	Sober
Driver Demographic Information			
Gender			
Male	0.7816756*	0.1082460	Female
Race			
Asian	0.3769851***	0.1317261	White
Black	0.8611781	0.2056237	White
Hispanic	0.6697086**	0.1070106	White
Other Race	0.6177645	0.1966951	White
Age			
Age 21-30	0.8675121	0.1650680	Age 15-20
Age 31-40	0.7441656	0.1575852	Age 15-20
Age 41-50	0.5092367***	0.1199962	Age 15-20
Age 51-60	0.3563946***	0.1058988	Age 15-20
Age 61-70	0.3521794**	0.1467187	Age 15-20
Age 71+	0.3667361**	0.1755772	Age 15-20
Accident Time			
Time of Day			
Morning	0.8893004	0.2581448	Night
Midday	1.1589400	0.2854541	Night
Evening	1.3233520	0.3203061	Night
Day of Week			
Weekday	1.2336080	0.2071535	Weekend
Month			
January	1.0248940	0.3634399	July
February	0.8128601	0.2994869	July
March	1.0424420	0.3443917	July
April	0.9870333	0.3486314	July
May	1.2219810	0.4047461	July
June	1.3778840	0.4496369	July
August	0.5620059	0.2058358	July
September	0.9835363	0.3120658	July
October	1.2914800	0.3819376	July
November	0.7844283	0.2651959	July

December	1.2943370	0.3874626	July
Accident Location			
Intersection	1.3543600**	0.2012346	Not Intersection
Population <50,000	1.4553030*	0.3104088	Rural/Unincorporated
Population 50,000-100,000	1.4895490*	0.3062879	Rural/Unincorporated
Population 100,000-250,000	1.0201380	0.2239213	Rural/Unincorporated
Population >250,000	1.2995770	0.2562618	Rural/Unincorporated
Weather Conditions			
Cloudy	0.8596255	0.2045174	Clear
Raining	0.6295150	0.3955012	Clear
Fog	1.4640590	1.5198260	Clear
Road Conditions			
Wet	0.8064056	0.3275999	Dry
Constant	0.0111164	0.0041486	
No. of Observations	29,990		
Pseudo R^2	0.0540		
No. of Significant Results	11		

Note: Statistical Significance: * 90%, ** 95%, *** 99% or more

Statistically Significant Variables

In Tables 4.7-4.9 below, I identify the statistically significant variables, their odds ratios, robust standard errors, 90 percent confidence intervals, and calculated the percent change in odds. The percent change in odds indicates the probability of the explanatory variable being present as the causal variable takes a value of one. It is calculated by subtracting 1 from the odds ratio and multiplying by 100. I sort the tables by the largest positive percent change to the largest negative percent change.

Table 4.7

Statistically Significant Variables

Model 1 ***– Accident Involving Fatality =1***

Statistically Significant Variables	Odds Ratio	Robust Std. Error	90% Confidence Interval		% Change in Odds	Excluded Variable
Other Weather	8.4796720	8.2029360	1.7271940	41.631010	747.97%	Clear
Fog	3.2409440	2.0103460	1.1683220	8.9904350	224.09%	Clear
Had Been Drinking	2.6146810	1.1585470	1.2615200	5.4192920	161.46%	Sober

February	2.2878150	0.9188460	1.1817320	4.4291740	128.78%	July
June	2.0413560	0.8173218	1.0565880	3.9439540	104.14%	July
January	1.9871700	0.8092093	1.0170430	3.8826730	98.72%	July
Age 71+	1.9466660	0.7433119	1.0387830	3.6480270	94.67%	Age 15-20
Legally Drunk	1.9410970	0.5260474	1.2429530	3.0313780	94.11%	Sober
Age 61-70	1.8660300	0.6115490	1.0884440	3.1991230	86.60%	Age 15-20
Evening	0.4330594	0.1101190	0.2850371	0.6579512	-56.69%	Night
Morning	0.3448366	0.1070026	0.2069907	0.5744814	-65.52%	Night

Table 4.8

Statistically Significant Variables

Model 2 ***– Accident With Injury =1***

Statistically Significant Variable	**Odds Ratio**	**Robust Std. Error**	**90% Confidence Interval**		**% Change in Odds**	**Excluded Variable**
Wind	6.6479300	5.3005160	1.7911070	24.674670	564.79%	Clear
Other Weather	3.0881550	1.4685730	1.4125030	6.7516350	208.82%	Clear
Cell Phone in Use	1.3061210	0.1754628	1.0471730	1.6291030	30.61%	No Cell Phone
Age 61-70	1.1791940	0.0706300	1.0685580	1.3012860	17.92%	Age 15-20
Legally Drunk	1.1534050	0.0694086	1.0447060	1.2734130	15.34%	Sober
May	1.1299180	0.0669734	1.0249560	1.2456280	12.99%	July
Age 41-50	1.1248340	0.0494879	1.0463090	1.2092520	12.48%	Age 15-20
Age 51-60	1.1156010	0.0530855	1.0316130	1.2064270	11.56%	Age 15-20
Age 31-40	1.0820700	0.4681870	1.0077360	1.1618860	8.21%	Age 15-20
December	0.9021913	0.0538507	0.8178241	0.9952620	-9.78%	July
Population 50,000-100,000	0.8853813	0.0340910	0.8310454	0.9432699	-11.46%	Rural/ Intersection
Morning	0.8671865	0.0448812	0.7964185	0.9442429	-13.28%	Night

Table 4.9

Statistically Significant Variables

Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident =1***

Statistically Significant Variable	**Odds Ratio**	**Robust Std. Error**	**90% Confidence Interval**		**% Change in Odds**	**Excluded Variable**
Population 50,000-100,000	1.4895490	0.3062879	1.0621030	2.0890220	48.95%	Rural/ Intersection
Population > 50,000	1.4553030	0.3104088	1.0246740	2.0669060	45.53%	Rural/ Intersection
Intersection	1.3543600	0.2012346	1.0607030	1.7293160	35.44%	Not Intersection
Male	0.7816756	0.108246	0.6224488	0.9816337	-21.83%	Female

Hispanic	0.6697086	0.1070106	0.5149228	0.8710231	-33.03%	White
FY 2008/2009	0.5720981	0.1084568	0.4188377	0.7814392	-42.79%	FY 2007/2008
Age 41-50	0.5092367	0.1199962	0.3456134	0.7503239	-49.08%	Age 15-20
Asian	0.3769851	0.1317261	0.2121855	0.6697806	-62.30%	White
Age 71+	0.3667361	0.1755772	0.1668606	0.8060343	-63.33%	Age 15-20
Age 51-60	0.3563946	0.1058988	0.2186097	0.5810220	-64.36%	Age 15-20
Age 61-70	0.3521794	0.1467187	0.1774859	0.6988179	-64.78%	Age 15-20

Comparison with Predicted Results and Relevance

Below I analyze the significant variables and describe their relevance based their percent change in odds. I will additionally compare them with their predicted outcomes. I order the analysis by the broad causal factors identified in Chapter 3.

Key Explanatory Variable

The key explanatory variable for Models 1 and 2 is a dummy variable indicating whether a cell phone was in use at the time of the accident. In evaluating the final regression results for Model 1 (Accident Involving Fatality=1), this variable was not statistically significant. For Model 2 (Accident with Injury=1), cell phone use was both statistically significant and had a positive impact on the likelihood of being in an injury accident. Based on the results, a driver was 30.61 percent more likely to be involved in an accident involving an injury versus an accident with no injury or a fatality, while using a cell phone than a driver not using a cell phone, all else held constant. For Model 3 (Cell Phone Use While Driving and Being Involved in Accident=1), the results for the key explanatory variable (FY 2008/2009) were statistically significant and indicated that a driver was 42.79 percent less likely to be involved in an accident involving cell phone use than not involving a cell phone the year after the law went into effect compared to the prior year.

Model 3 demonstrates a decrease in the likelihood of an accident while using a cell phone in FY 2008/2009 than FY 2007/2008. Model 2 identifies that reduced cell phone use decreases the likelihood of an injury accident. Model 1 identifies no statistically significant impact on fatal accidents by cell phone use. Overall, the decrease in Model 3 may indicate that the financial penalty associated with using a cell phone while driving acted as a significant deterrent to drivers who may have otherwise used their cell phones while driving. It also may be indicative of a changing trend in driving behavior, or potentially the increased availability of hands-free devices, the use of which is legal. Unfortunately, data were not available at the time of this study indicating the availability of hands-free devices.

Drive Behavior

For Model 1, a driver who had been drinking at the time of the accident and a driver who was legally drunk were statistically more likely to be involved in a fatal or injury accident than a sober driver. A driver who had been drinking was 161.46 percent more likely to be involved in a fatal accident than a driver who had not been drinking. A driver who was legally drunk was 94.11 percent more likely to be involved in a fatal accident than a driver who had not been drinking. For Model 2, a driver who was under the influence at the time of accident involving and injury was statistically significant. A legally drunk driver was 15.34 percent more likely to be involved in an accident involving and injury than a driver who has not been drinking. For Model 3, both a driver who had been drinking and a driver who was legally drunk were statistically insignificant in predicting cell phone use at the time of an accident, all else held constant.

Driver Demographics

The driver's gender returned statistically significant results for Model 3 indicating a decreased likelihood for male drivers as hypothesized. According to the results, a male driver is 21.83 percent less likely to be involved in an accident while using a cell phone than a female driver. Gender was not statistically significant for Models 1 and 2.

All else held constant, the driver's age was statistically significant for all three models; however, the significant age ranges varied. I omitted the variable Age 15-20 to provide the base for comparison in interpreting these results. For Model 1, a driver between the ages of 61-70 was 86.6 percent more likely to be involved in a fatal accident than a driver age 15-20. A driver age 71 or older was 94.67 percent more likely to be involved in a fatal accident than a driver age 15-20. Model 2 returned four significant age ranges. A driver age 31-40 was 8.21 percent more likely to be involved in an injury accident than a driver age 15-20. A driver age 41-50 was 12.48 percent more likely. A driver age 51-60 was 11.56 percent more likely, and a driver age 61-70 was 17.92 percent more likely to be involved in an injury accident than a driver age 15-20. These results generally indicate that as age increase, there is an increase likelihood of being in either a fatal accident or an accident involving injury.

Model 3 additionally returned four statistically significant age ranges. A driver age 41-50 was 49.08 percent less likely to be using a cell phone during an accident than a driver age 15-20. A driver age 51-60 was 64.36 percent less likely to be using a cell phone during an accident than a driver age 15-20. A driver age 61-70 was 64.78 percent less likely to be using a cell phone during an accident than a driver age 15-20, and a driver age 71 or older was 63.33 percent less likely to be using a cell phone during an accident than a driver age 15-20. The results indicate that generally there is a decreased likelihood of being involved in an accident while using a cell phone. This is in line with my prediction, as younger drivers tend to engage in riskier driving behaviors.

The variables Asian and Hispanic had statistically significant results for Model 3. The variables Black and Other Race were not statistically significant for any model. I omitted the variable White to serves as the base for comparison. I hypothesized a null impact for race, as there was no available research or studies discussing the subject. The Asian and Hispanic variables indicated a decreased likelihood in being involved in an accident while using a cell phone than someone who is White. An Asian driver was 62.30 percent less likely than a driver who is White to be involved in an accident while using a cell phone. A person who is Hispanic was 33.03 percent less likely than a driver who is White to be involved in an accident while using a cell phone, all else held constant. The reasoning behind these results is unclear, especially as California has a diverse population with large proportions of each different race or ethnicity.

Accident Time

The factor of Accident Time yielded statistically significant results for Models 1 and 2. For Model 1, the variable was statistically significant. The variable Night provided the base for comparison. A driver in the Morning was 65.52 percent less likely to be involved in a fatal accident than a driver at Night. A driver in the Evening was 56.69 percent less likely to be involved in a fatal accident than a driver at Night. The variables Morning, Evening, January, February, and June were also statistically significant. For the month variable, I excluded July as the base for comparison. A driver in January, February, and June was 98.72 percent, 128.78 percent, and 104.14 percent, respectively, more likely to be involved in a fatal accident than in July.

Model 2 yielded three statistically significant variables. A driver in the morning was 13.28 percent less likely to be involved in an injury accident than a driver at night. A driver in May was 12.99 percent more likely to be involved in an injury accident than a driver in July. A driver in December was 9.78 percent less likely to be involved in an injury accident than a driver in July. These results vary from my predicted results. I hypothesized that driving on a weekday would increase the likelihood of an accident; however, the results were not statistically significant. I also hypothesized that Morning and Evening would increase the likelihood of an accident as these timeframes include peak commute times with generally more drivers on the road. The results, however, indicate the opposite for fatal accidents.

Accident Location

The factor of Accident Location resulted in no statistically significant variables for Model 1. Model 2 had one statistically significant variable and Model 3 had three. The variable Rural/Unincorporated was omitted and serves as the base for comparison. For Model 2, the results found that a driver in an incorporated area with a population density between 50,000 and 100,000 was 11.46 percent less likely to be involved in an injury accident than a driver in a rural/unincorporated area. For Model 3, a driver in an incorporated area with a population density of less than 50,000 was 45.53 percent more likely to be involved in an accident while using a cell phone than a driver in a rural/unincorporated area. A driver in an incorporated area with a population density of between 50,000-100,000 was 48.95 percent more likely to be involved in an accident while using a cell phone than a driver in a rural/unincorporated area. A driver in an intersection was 35.44 percent more likely to be involved in an accident while using a cell phone than a driver not in an intersection.

The results for Model 3 are as I hypothesized and show that an increase in population density correlates to an increased likelihood of involvement in an accident while using a cell phone. The results for Model 2 may be reflective of the slower traffic speeds due to congestion or development in areas with highly dense populations. Potentially, low-speed collisions cause less injury than high-speed collisions. Drivers are not reaching as high of speeds as those in rural or unincorporated areas. For intersections, the results are as predicted. This is likely due to the multiple directions of traffic and traffic flow of intersections.

Weather Condition

The factor of Weather Condition returned two statistically significant variables for Models 1 and 2. For Model 1, compared to clear weather, the results show a driver is 224.09 percent more likely to be involved in a fatal accident when fog is present. A driver is further 747.97 percent more likely to be involved in a fatal accident when weather other than rain, clouds or snow is present. In Model 2, a driver is 564.79 more likely to be involved in an injury accident when it is windy than when it is not. A driver is also 208.82 percent more likely to be involved in an injury accident when weather other than rain, clouds or snow is present. This aligns with my hypothesis that hazardous weather conditions are likely to increase the probability of an accident.

Road Conditions

I hypothesized that hazardous road conditions are likely to increase the probability of an accident. Only Model 2 returned statistically significant results. A driver is 4.37 percent less likely to be involved in an injury accident when the roads are wet. This is the opposite of my hypothesis. Potentially, this decrease in likelihood results from drivers paying more attention to the road when the conditions are hazardous than when they are clear.

Interpretation of Pseudo R^2

In identifying the overall fit of the model, linear regressions use the R^2 as a gauge to the degree that the regression model explains variance in actual observations of the dependent variable around its mean. The R^2 returns values from 0 to 1, with a value close to 1 indicating a good overall fit. For logistic models, such as this analysis, with dummy dependent variables, the R^2 provides little insight into the goodness of fit. An alternative is the use of the Pseudo R^2. The Pseudo R^2 compares the predicted values of the dependent variable with the actual value and provides the percentage explained correctly (Studenmund, 2006). Similar to the R^2, a Pseudo R^2 with a value close to 1 indicates a good fit. My regressions returned the following Pseudo R^2 values, all which indicate a poor fit: Model 1 – 0.0631, Model 2 – 0.0248, and Model 3 – 0.0540. Even so, that does not diminish the fact that as hypothesized, a larger percentage of the included explanatory variables were statistically significant in their influence and of the direction expected.

In evaluating my model, my interpretation of the low Pseudo R^2 value is that I did not account for all the necessary causal factors. However, this was beyond my control due to my inability to supplement this pre-gathered data set. Other causal factors that potentially impact the law's effectiveness but not contained in the data set include other driving related laws that directly or indirectly impact driving behavior, levels of enforcement, or levels of cell phone use in accidents or near-accidents that would not require an accident report submitted by law enforcement but would better identify the scope of cell phone use by drivers.

This low value may also be representative of the fact that logistic regressions may function better when the ratio of 0 to 1 results for the dependent variable is closer to 50 percent (Studenmund, 2006). The impact of the ratio of positive to negative results, however, may not be as significant for larger data sets, such as the one used in this thesis (Allison, 2012). In my data set of almost 30,000, only a small percentage of the accidents were those involving fatalities, injuries, or cell phone use. Additional research on this subject may require using a sample with equal proportions of accidents involving cell phone use and accidents not involving cell phone use.

To demonstrate the impact of an unbalanced sample on the results, I rerun Mode 3 using a sample from my data set that includes the same number of accidents indicating cell phone use while driving as accidents that did not involve cell phone use. I report the statistically significant variables in Table 4.10 below.

Table 4.10

Statistically Significant Variables

Adjusted Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident =1***

Statistically Significant Variable	Odds Ratio	Robust Std. Error	90% Confidence Interval		% Change in Odds	Excluded Variable
Age 61-70	0.1487137	0.0893062	0.0553817	0.3993336	-85.13%	Age 15-20
Population >250,000	2.7159260	0.8850051	1.5890640	4.6418880	171.59%	Rural
Evening	2.7921180	1.0110770	1.5390560	5.0653940	179.21%	Night
Population 100,000-250,000	2.8181080	1.0607940	1.5172650	5.2342440	181.81%	Rural
Midday	2.6823110	1.0270560	1.4288430	5.0353970	168.23%	Night
Age 51-60	0.3631257	0.1871712	0.1555423	0.8477452	-63.69%	Age 15-20
Male	0.6310865	0.1572095	0.4189261	0.9506930	-36.89%	Female
Hispanic	0.6180660	0.1704915	0.3926300	0.9729403	-38.19%	White
Morning	2.1186340	0.9481815	1.0147350	4.4234310	111.86%	Night

When using a balanced sample, the key explanatory variable of FY 2008/2009 becomes insignificant, indicating the law had no significant impact on the likelihood of being in an accident while using a cell phone in the years after the law went into effect compared to the year prior.

Summary

In this chapter, I provided an evaluation of the best functional form, specifically whether it was more appropriate to use a linear regression or a logistic regression. I provided a table comparing a linear-linear model and a logistic model with the number of statistically significant variables for each. A logistic regression proved appropriate as my equation utilizes a dummy dependent variable. I further evaluated the addition of interaction terms by testing the interaction between my key explanatory variables (Model 1 and 2 – Cell Phone, Model 3 - Year 2008/2009) and all other variables. I completed checks for multicollinearity and heteroskedasticity, correcting for heteroskedasticity by accounting for robust standard error. I concluded this chapter with my adjusted regression results and a discussion of the findings.

Chapter 5

CONCLUSION

In Chapter 1, I introduced the topic of cell phone use while driving and the traffic safety implications of the behavior. This included a discussion of the economic impacts of distracted driving, California's legislative history, and other non-legislative remedies in progress. Chapter 2 provided an evaluation of the current research on the subject from government traffic safety organizations, government sponsored organizations, academic, and private researchers. Chapter 3 detailed the method used to evaluate whether California's cell phone use ban resulted in fewer accidents involving cell phone use. Chapter 4 detailed the results of the three regression analyses identifying a decrease likelihood of being involved in an accident involving a cell phone in the year after the laws implementation compared to the prior year of 42.70 percent. In this final chapter, I conclude with a discussion of my overall research question, suggestions for improvements, and possibilities for future research.

Evaluation of Research Question and Recommendations

The research question I posed in this analysis was whether California's law prohibiting the use of cell phones while driving was effective at reducing the number of traffic collisions involving cell phone use. After reviewing the literature and performing my own analysis, I conclude that the law has a positive impact on traffic safety; however, the results must be taken with caution. The results of the analysis provide many statistically significant variables that may help traffic safety and law enforcement entities in enforcing the law; however, given the low Pseudo R^2, there are a larger number of factors influencing the outcome than those contained in my data set that may impact the results and subsequent recommendations. The factors may include, but are not limited to, variables quantifying the level of law enforcement, the number of vehicles with hands-free devices or voice activated software on the roads, and the use of hands-free Bluetooth devices.

Improved Data Collection

The completeness and appropriateness of the data set is critical to the evaluation of California's ban, as the existing research indicates that the results of studies on the effectiveness of laws prohibiting cell phone use while driving are highly dependent upon the data set used and the time over which the law is evaluated (McCartt *et al*., 2010; Sampaio, 2010; Lim and Chi, 2013). The actual identification of cell phone use as a factor in an accident is difficult and therefore the results may underestimate the full effect of cell phone use on traffic accidents. As such, the primary recommendation of this thesis is to enhance current data collection methods or create a new method of collecting this data.

Identifying or creating a data source that more accurately accounts for the use of cell phones while driving than traffic accident reports will better identify the magnitude of the problem and its impacts to traffic safety. Identifying or creating a data source is not without challenges, however. Relying on self-reporting may again underscore the actual use and observational or field studies may prove costly. Accurate identification and notation of cell phone use ultimately begins with law enforcement reporting. This aligns with the National Safety Council's (NSC) recommendation that NHTSA conduct a feasibility study to identify a method of addressing the underreporting problem for cell phone involved accidents (NSC, n.d). NSC identified in an evaluation of that national Fatality Analysis Reporting System that of crashes with indications of cell phone use, only 52 percent were coded for cell phone use as a factor (NSC, n.d.). I identified similar results upon evaluating California's SWITRS data. Incomplete or improperly collected data such as this, may lead to policy recommendations based on biased data.

Reiterating the importance of accurate data collection at the time of the accident to law enforcement officials may help address this issue. Making the indication of cell phone use mandatory on accident or incident reports may additionally bridge the data collection gap. It is important to note that indicating cell phone use is challenging for law enforcement as individuals generally will not volunteer the information and the officer must determine use based on evidence at the scene and witness testimony. Establishing and enforcing a best practices guide for law enforcement for identifying cell phone use at traffic accidents potentially may create consistency among jurisdictions and reporting. Consistent reporting will help future researchers of this subject in validating their results.

Additionally, high-visibility enforcement campaigns, such as the Distracted Driving Awareness Month campaign conducted by the California Highway Patrol, Office of Traffic Safety, and local law enforcement entities in April 2014 may provide data that will account for the enforcement levels in future studies. However, enforcement campaign such as this, are generally available due to grants by the federal government. It is reasonable to assume that most law enforcement agencies do not have sufficient resources to maintain such high-level enforcement outside the awareness campaign, given the scope and nature of their other duties.

Targeting Demographics

Although the primary recommendation relates to data collection, the demographic results may allow policymakers to begin to better tailoring their public service campaigns and driver education courses, which, based on the results, would be to younger female drivers. These results are interesting because generally it is assumed that young male drivers are the most risky. Interestingly, gender was only a factor in Model 3. In Model 1 (Accident with Fatality) and Model 2 (Accident Involving Injury), gender was not statistically significant. This leads to the conclusion that possibly female drivers are more likely to be involved in less serious traffic collisions versus the more serious fatal and injury accidents that create the most social and economic hardship. These accidents may include only those resulting in property damage, such as minor fender-benders. Awareness campaigns and driver education courses may look to identify the motivations for use by this particular demographic. As previously mentioned, the assumed social benefit of using a cell phone while driving may be the largest factor to address. Research suggests that as the behavior becomes more of a part of a person's personality, the more difficult it is to give up (Atchley, Hadlock, & Lane, 2012).

Focusing on specific genders, however, may create issues for the actual implementation of the law given statutory protections against discrimination based on sex, gender, race, or ethnicity. Even if the results identify female drivers as having an increased likelihood of being in an accident involving cell phone use, it is unlikely that law enforcement would be able to establish a policy of targeting or profiling female drivers.

The results further identify the demographic category of age as significant in that older drivers (age 41 and over) are less likely to be involved in an accident involving cell phone use than younger drivers (age 15-20). Complicating the issues of demographic based policies is the fact that previous studies (Foss et al., 2009) have identified the difficulty in identifying a driver's age in observational studies. Individuals' appearances show signs of age differently, which may be misleading to law enforcement. It is unclear what methods are available to law enforcement to target younger drivers outside of marketing campaigns aimed specifically at that groups. Existing prohibits law enforcement from engaging in racial profiling activities, which includes detaining a suspect based on a broad set of criteria which casts suspicion on an entire class of people (Penal Code §13519.4). The mere fact a driver is young and female does not create just cause to stop or detain them.

A method of addressing younger drivers' use of cell phones while driving that may avoid the legal issues profiling by law enforcement creates includes adding instruction regarding the dangers to driver education courses. Ensuring young drivers are aware of the dangers may help to deter the behavior before a driver gets behind the wheel. However, in a study sponsored by the AAA Foundation for Traffic Safety, researchers suggested the possibility that many younger drivers wait until they are 18 to obtain their licensee to avoid provisional or GDL programs (Tefft, Williams, & Grabowski, 2013). As driver education courses are only required of provisional drivers in California, many younger drivers may be losing the benefit of this training and may be less prepared to operate a vehicle safely. The study suggests other factors that influence a younger driver's decision to obtain their license when eligible such as race or ethnicity, access to a vehicle, costs of obtaining a license, and the ability to access their social network online. The results from this regression showing an increased likelihood for younger drivers (age 15-20) compared to older drivers (age 41 and older) may require California's traffic safety entities to evaluate what impact avoidance or lack of participation in GDL programs has on distracted driving.

Other Recommendations

The results also indicate an increase likelihood (35.44 percent) of an accident involving cell phone use in intersections. As intersections are already a breeding ground for traffic accidents with multiple directions of traffic converging often at different speeds, campaigns and law enforcement may look to reinforce the need for drivers to pay attention in these areas and avoid cell phone use.

Another interesting fact that may assist policymakers is that the time of day the accident occurred was statistically significant for Models 1 (Accident with Fatality) and 2 (Accident Involving Injury), but insignificant for Model 3 (*Cell Phone Use While Driving and Being Involved in Accident)*. The fact that there was no one particular time of day where a driver was more likely to be involved in an accident involving cell phone use may assist law enforcement in timing their targeted campaigns. This informs officers to watch for distracted drivers at all hours, not just peak commute times as I hypothesized in Chapter 3.

Improvements to Study

Possible improvements to the methods used in this research would be to evaluate accident rates involving cell phone over a longer period of time to provide for a better evaluation of the change in driving behavior over time. Additionally, identifying data that accounts for the technological improvements that occur during the same time frame that impact the use of cell phones while driving will help better pinpoint the effects of the law alone on the accident rates. For example, identifying the availability and use of hands-free devices or the number of vehicles that come with hands-free systems built into the vehicle may help identify if any change is a result of the law or better access to alternatives to hand-held cell phone use.

The impact of hands-free devices may or may not prove important, as there is no established consensus on whether the devices actually make cell phone use while driving safer. Methods accounting for the shift from cell phones being used to place calls versus sending text messages or emails may further explain changing trends. Establishing a clear method of identifying or quantifying law enforcement presence may lend further insight into the effectiveness of the law.

Opportunities for Future Research

My research indicates that based on the available the law serves a positive purpose for California motorists and identifies specific statistically significant variables. Identifying a decrease in the likelihood of a driver being involved in an accident while using a cell phone in the year following the effective date of the law, serves to validate the need for the law and reinforce its positive impact on traffic safety. However, many opportunities exist for future research on cell phone use and distracted driving in general. Methods of changing driver behavior outside of laws and regulations such as media campaigns on the dangers and their associate impact on creating a culture shift should be evaluated. This requires those involved in media campaigns to ensure accurate data collection is part of the campaign. The results of this thesis, which identify a decreased likelihood of an accident while using a cell phone as driver age increases, validate existing distracted driving campaigns that focus on teen drivers.

Other areas of potential future research look at technological advances such as autonomous vehicles, which operate independent of the driver. This method of addressing distracted driving does not attempt to remove the distraction but the human error associated with the distractions. There will undoubtedly be multiple opportunities for research on the traffic safety implications of these vehicles as they become commercially available.

Summary

In this thesis, I evaluate the effectiveness of California's law banning the use of cell phones while at reducing traffic accidents. This study provides a valuable primary look at both the laws effectiveness and identifies opportunities for California to improve its processes. My results indicate that a driver is 42.79 percent less likely to be involved in an accident while using a cell phone in the year following the ban than the year prior to the ban. I also identify many factors such as driver age and gender than impact the likelihood of being involved in an accident while using a cell phone. Male drivers were 21.83 percent less likely to be involved in an accident involving cell phone use in the year after the law went into effect than female drivers. Drivers age 41 and over we additionally significantly less likely to be in an accident involving cell phone use in the year after the law was in effect than drivers age 15-20 (Age 41-50 – 49.08 percent; Age 51-60 – 64.36 percent; Age 61-70 – 64.78 percent; Age 71+ - 63.33 percent).

These results must come with the caveat that not all factors influencing a driver's behavior may be accounted for and that not all accidents resulting from driver cell phone use may be identified in the data set given the low Pseudo R^2 values for each of the three models (Model 1-0.0631; Model 2-0.0248; Model 3-0.0540). Primarily, it is recommended that a better method of data collection be identified to ensure the accuracy of conclusion drawn from data analysis. Secondary recommendations include using the demographic results of this study to inform public awareness campaigns to target those drivers most likely to be involved in an accident involving cell phone use, and to inform driver education training.

McCartt & Geary (2004)	New York, Connecticut (2001-2003)	Daytime Observation of Cell Phone Use	Handheld Ban Effective (Short Term, Long Term) -1.2%, -0.2% 95% confidence	Age, Sex, Vehicle Type	Immediate post-ban lowered cell phone use rates were not sustained during the subsequent year. Compliance with bans is further anticipated to be low in the absence of publicized enforcement.
Lesch & Hancock (2004)	Massachusetts (1998)	Correlation Between Confidence and Distraction Effects	Age Older Drivers (Age 55-65) -0.71, $p < 0.05$	Sex, Driving Experience, Cell phone Ownership	Drivers, in general, are relatively unaware of their decreased performance ability when driving and using a cell phone. Older drivers have a lower confidence in performing distracting tasks. Change in stopping distance while using cell phone for high confidence males (5.4ft) was less than low confidence males (8.6ft).

Appendix B

Interaction Terms

Model 1 ***– Accident Involving Fatality=1***

Variable Multiplied by Cell Phone	Odds Ratio	Robust Std. Error	P > Z
Driver Behavior			
Had Been Drinking	1	n/a	n/a
Legally Drunk	1	n/a	n/a
Demographic Information			
Gender			
Male	1	n/a	n/a
Race			
Asian	8898959	0	0.000
Black	1	n/a	n/a
Hispanic	1	n/a	n/a
Other Race	1	n/a	n/a
Age			
Age 21-30	1	n/a	n/a
Age 31-40	1	n/a	n/a
Age 41-50	5852986	6312607	0.000
Age 51-60	1	n/a	n/a
Age 61-70	1	n/a	n/a
Age 71+	1	n/a	n/a
Accident Time			
Time of Day			
Morning	1	n/a	n/a
Midday	1	n/a	n/a
Evening	1	n/a	n/a
Day of Week			
Weekday	219586	226764.2	0.000
Month			
January	1	n/a	n/a
February	1	n/a	n/a
March	1	n/a	n/a
April	1	n/a	n/a
May	0	0	0.00
June	1	n/a	n/a
August	1	n/a	n/a
September	1	n/a	n/a
October	1	n/a	n/a
November	1	n/a	n/a
December	1	n/a	n/a
Accident Location			

Intersection	1	n/a	n/a
Population <50,000	1	n/a	n/a
Population 50,000-100,000	1	n/a	n/a
Population 100,000-250,000	1	n/a	n/a
Population >250,000	1	n/a	n/a
Weather Conditions			
Cloudy	1	n/a	n/a
Raining	1	n/a	n/a
Snowing	1	n/a	n/a
Fog	1	n/a	n/a
Other Weather	1	n/a	n/a
Wind	1	n/a	n/a
Road Conditions			
Wet	1	n/a	n/a
Slippery	1	n/a	n/a
Snow/Ice	1	n/a	n/a

*Statistically Significant at 90%
Note: all variables was included in the regression equation one-by-one

Model 2 ***– Accident with Injury=1***

Variable Multiplied by Cell Phone	**Odds Ratio**	**Robust Std. Error**	**P > Z**
Driver Behavior			
Had Been Drinking	0.4742361	0.3463277	0.307
Legally Drunk	0.6540545	0.048616	0.000
Demographic Information			
Gender			
Male	1.2375140	0.3334205	0.429
Race			
Asian	1.0291090	0.6710551	0.965
Black	0.6779301	0.3143974	0.402
Hispanic	0.9349181	0.2752482	0.819
Other Race	1.9842910	1.269215	0.284
Age			
Age 21-30	0.6519188	0.1874228	0.137
Age 31-40	1.0767480	0.3566640	0.823
Age 41-50	1.9302180*	0.7631318	0.096
Age 51-60	0.4517503	0.2428172	0.139
Age 61-70	0.3985894	0.3591723	0.307
Age 71+	0.9753428	0.8809443	0.978
Accident Time			
Time of Day			
Morning	2.6682370*	1.0545770	0.013
Midday	0.9966065	0.2817545	0.990
Evening	1.0598680	0.2910773	0.832
Day of Week			
Weekday	0.6479366	0.2135529	0.188
Month			
January	2.5021820*	1.2927590	0.076
February	1.6299020	0.8975953	0.375
March	0.9714287	0.4593456	0.951
April	0.4397094	0.2616821	0.167
May	1.0850340	0.4891419	0.856
June	1.5355870	0.7119959	0.355
August	0.6084766	0.3665746	0.410
September	0.7175166	0.3289484	0.469
October	1.1040870	0.4587883	0.812
November	0.6456409	0.3548526	0.426
December	0.9773071	0.4297909	0.958
Accident Location			
Intersection	1.2689100	0.3850813	0.433
Population <50,000	1.0091700	0.3592228	0.980
Population 50,000-100,000	1.1175200	0.3633599	0.733
Population 100,000-250,000	1.4289190	0.5231525	0.330

Population >250,000	1.1261720	0.3492922	0.702
Weather Conditions			
Cloudy	1.4984460	0.6544111	0.354
Raining	1	n/a	n/a
Snowing	1	n/a	n/a
Fog	1	n/a	n/a
Other Weather	1	n/a	n/a
Wind	1	n/a	n/a
Road Conditions			
Wet	0.9295121	0.5950221	0.909
Slippery	1	n/a	n/a
Snow/Ice	1	n/a	n/a

*Statistically Significant at 90%

Note: all variables was included in the regression equation on-by-one

Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident=1***

Variable Multiplied by FY 2008/2009	Odds Ratio	Robust Std. Error	P > Z
Driver Behavior			
Had Been Drinking	1.1852540	0.7738948	0.975
Legally Drunk	1.2240940	0.5097218	0.627
Demographic Information			
Gender			
Male	1.1202320	0.3165494	0.688
Race			
Asian	0.5874966	0.4787317	0.514
Black	0.9489425	0.4843727	0.918
Hispanic	1.0194640	0.3125680	0.950
Other Race	0.4063829	0.3248555	0.260
Age			
Age 21-30	1.2626710	0.3695731	0.426
Age 31-40	0.4634820*	0.1802149	0.048
Age 41-50	1.2428980	0.4912517	0.582
Age 51-60	1.2043020	0.6475881	0.730
Age 61-70	0.2712322	0.2964210	0.233
Age 71+	1.2957770	1.2033930	0.780
Accident Time			
Time of Day			
Morning	1.1383030	0.4406856	0.738
Midday	0.6852826	0.2105802	0.219
Evening	1.2903620	0.3654930	0.368
Day of Week			
Weekday	0.6093764	0.2020514	0.135
Month			
January	1.2512890	0.6962161	0.687
February	2.5352430	1.5251930	0.122
March	1.4909360	0.7883034	0.450
April	0.2729705*	0.2140528	0.098
May	0.4630461	0.2790732	0.201
June	1.3071680	0.6662476	0.599
August	1.3929660	0.8615402	0.592
September	0.9316294	0.4812564	0.891
October	0.5349806	0.2614084	0.200
November	1.4858430	0.8149382	0.470
December	1.5069750	0.6812794	0.364
Accident Location			
Intersection	1.0354240	0.3219807	0.911
Population <50,000	0.8874982	0.3296810	0.748
Population 50,000-100,000	1.5493990	0.5137670	0.187
Population 100,000-250,000	0.8497325	0.3312641	0.676

Population >250,000	0.8968321	0.2948436	0.740
Weather Conditions			
Cloudy	2.1562570*	0.9363786	0.077
Raining	0.7301604	0.8505750	0.787
Snowing	1	1	n/a
Fog	438274.2	468280.5	0.000
Other Weather	1	1	n/a
Wind	1	1	n/a
Road Conditions			
Wet	1.3538000	0.8157869	0.615
Slippery	1	1	n/a
Snow/Ice	1	1	n/a

*Statistically Significant at 90%

Note: all variables was included in the regression equation one-by-one

Appendix C

Correlation Coefficients

Variable	Fatality	Injury	Year 2008/2009	Year 2008	Year 2009	Cell Phone	Had Been Drinking
Fatality	1						
Injury	0.0201*	1					
Year 2008/2009	0.0034	0.0042	1				
Year 2008	-0.0016	0.0004	0.5865*	1			
Year 2009	0.0055	0.0046	0.5695*	-0.3318*	1		
Cell Phone	-0.0017	0.0129*	-0.0297*	-0.0134-	-0.0210*	1	
Had Been Drinking	0.0188*	-0.0029	0.0010	-0.0015	0.0027	0.0326*	1
Legally Drunk	0.0327*	0.0065	-0.0025	0.0031	-0.0060	0.0334*	-0.0228*
Male	0.0122*	-0.0331*	-0.0057	0.0059	-0.0126*	-0.0094	0.2830*
Asian	-0.0092	-0.0170*	-0.0016	-0.0040	0.0022	-0.0152*	-0.0113
Black	-0.0056	0.0222*	-0.0149*	-0.0139*	-0.0032	0.0024	-0.0012
Hispanic	0.0084	-0.0170*	0.0010	0.0019	-0.0008	-0.0050	0.0045
White	0.0030	0.0148*	0.0036	0.0023	0.0018	0.0150*	0.0073
Other Race	-0.0054	-0.0023	0.0090	0.0114*	-0.0010	-0.0062	-0.0090
Age 15-20	0.0054	-0.0116*	0.0038	0.0018	0.0026	0.0161*	0.0058
Age 21-30	-0.0053	-0.0198*	0.0030	-0.0003	0.0038	0.0157*	0.0262*
Age 31-40	-0.0054	0.0002	-0.0107	-0.0032	-0.0093	0.0028	-0.0079
Age 41-50	-0.0049	0.0095	-0.0098	0.0030	-0.0144*	-0.0104	-0.0034
Age 51-60	-0.0005	0.0066	0.0077	-0.0015	0.0105	-0.0163*	-0.0168*
Age 61-70	0.0130*	0.0117*	0.0110	0.0019	0.0169	-0.0109	-0.0114*
Age 71+	0.0089	0.0208*	0.0014	-0.0017	0.0033	-0.0071	-0.0038
Morning	-0.0094	-0.0290*	-0.0103	-0.0076	-0.0043	-0.0127*	-0.0268*
Midday	-0.1180*	0.0188*	0.0030	-0.0090	0.0126*	0.0076	-0.0410*
Evening	-0.0033	-0.001	0.0023	0.0110	-0.0085	0.0126*	0.0120*
Night	0.0393*	0.0113	0.0059	0.0079	-0.0012	0.0103	0.0885*
Weekday	-0.0178*	-0.0297*	-0.0091	0.0034	-0.0140*	0.0030	-0.0332*
January	0.0068	-0.0100	0.0006	-0.1733*	0.1766*	-0.0026	0.0076
February	0.0107	-0.0095	0.0020	-0.1709*	0.1757*	-0.0075	0.0036
March	0.0078	0.0098	0.0012	-0.1811*	0.1851*	-0.0005	0.0002
April	-0.0011	0.0009	0.0003	-0.1723*	0.1751*	-0.0023	-0.0079
May	-0.0048	0.0196*	0.0028	-0.1745*	0.1804*	0.0041	-0.0049

Variable	Fatality	Injury	Year 2008/2009	Year 2008	Year 2009	Cell Phone	Had Been Drinking
June	0.0088	-0.0063	0.0136*	-0.1660*	0.1843*	0.0067	-0.0010
July	-0.0063	-0.0002	-0.0024	0.1636*	-0.1688*	0.0015	0.0074
August	-0.0024	-0.0004	-0.0145*	0.1537*	-0.1729*	-0.0106	-0.0023
September	0.0039	0.0048	-0.0089	0.1603*	-0.1730*	0.0003	-0.0048
October	-0.0009	0.0085	-0.0120*	0.1631*	-0.1796*	0.0090	-0.0079
November	-0.0044	0.0000	0.0055	0.1787*	-0.1749*	-0.0057	-0.0006
December	-0.0016	-0.0161*	0.0128*	0.1881*	-0.0176*	0.0075	0.01808
Intersection	-0.0056	0.1195*	0.0022	-0.0057	0.0083	0.0117*	0.0012
Rural/Unincorporated	0.0429*	-0.0286*	0.0001	0.0083	-0.0083	-0.0084	0.0141*
Population <50,000	-0.0186*	-0.0399*	0.0101	-0.0057	0.0175*	0.0079	0.0082
Population 50,000-100,000	-0.0071	-0.0392*	-0.0055	-0.0014	-0.0049	0.009	-0.0077
Population 100,000-250,000	-0.0119*	-0.0134*	-0.0036	-0.0070	0.0029	-0.0072	-0.0104
Population >250,000	-0.0107	0.1086*	-0.0002	0.0040	-0.0043	0.0006	-0.0048
Cloudy	0.0041	-0.0172*	0.0249*	-0.0386*	0.0682*	-0.0069	0.0118*
Raining	0.0008	0.0032	-0.0019	-0.0210*	0.0191*	-0.0071	-0.004
Snowing	-0.0031	-0.0125*	0.0059	0.0010	0.0059	-0.0036	-0.0041
Fog	0.0158*	-0.0002	0.0127*	0.0100	0.0046	0.0002	0.009
Other Weather	0.0152*	0.0134*	0.0053	0.0086	-0.0026	-0.0023	-0.0026
Wind	-0.0013	-0.0135*	-0.0057	-0.0057	-0.0009	-0.0015	-0.0018
Wet	0.0033	-0.0101	0.0106	-0.0295*	0.0424*	-0.0082	0.0209*
Slippery	-0.0023	0.0052	0.0034	0.0029	0.0011	-0.0027	-0.0030
Snow/Ice	0.0014	-0.0144*	0.0125*	-0.0004	0.0150*	-0.0060	-0.0069

Variable	Legally Drunk	Male	Asian	Black	Hispanic	White	Other Race
Fatality							
Injury							
Year 2008/2009							
Year 2008							
Year 2009							
Cell Phone							
Had Been Drinking							
Legally Drunk	1						
Male	0.0858*	1					
Asian	-0.0377*	-0.0190*	1				
Black	-0.0069	-0.0248*	-0.0900*	1			
Hispanic	0.0590*	0.0703*	-0.2128*	-0.2013*	1		
White	-0.0193*	-0.0486*	-0.2778*	-0.2627	-0.6214*	1	
Other Race	-0.0226*	0.0135*	-0.0809*	-0.0765*	-0.1809*	-0.2361	1
Age 15-20	-0.0029	-0.0072	-0.0279*	-0.0075	0.0344*	-0.0058	-0.0135*
Age 21-30	0.0674*	-0.0213*	-0.0005	0.0002	0.0881*	-0.0858*	0.0063
Age 31-40	0.0053	-0.0034	0.0050	-0.0010	0.0685*	-0.0718*	0.0104
Age 41-50	-0.0170	0.0141*	0.0145*	0.0125*	-0.0326*	0.0169*	-0.0024
Age 51-60	-0.2700*	0.0073	0.0130*	0.0600	-0.0874*	0.0677*	0.0078
Age 61-70	-0.0371*	0.0186*	0.0046	-0.0068	-0.0852*	0.0834*	-0.0046
Age 71+	-0.0345*	0.0047	-0.0189*	-0.0130*	-0.0827*	0.1034*	-0.0161*
Morning	-0.0715*	0.0042	0.0063	-0.0044	0.0213*	-0.0201*	-0.0022
Midday	-0.1240*	-0.0381*	-0.0114*	-0.0026	-0.0246*	0.0376*	-0.0135*
Evening	0.0086	0.0024	0.0084	-0.0144*	-0.0105	0.0085	0.0089
Night	0.3003*	0.0550*	-0.0036	0.0350*	0.2880*	-0.0496*	0.0113
Weekday	-0.1095*	-0.0317*	-0.0025	-0.0074	-0.0224*	0.0202*	0.0128*
January	0.0015	-0.0031	0.0019	0.0040	0.0180	-0.0047	-0.0005
February	-0.0042	-0.0010	0.0008	-0.0015	-0.0018	0.0065	-0.0091
March	0.0022	-0.0044	0.0079	-0.0061	0.0087	-0.0044	-0.0101
April	-0.0058	-0.0137*	0.0034	-0.0023	0.1307	0.0028	0.0009
May	0.0115*	0.0012	-0.0096	0.0048	-0.0041	-0.0018	-0.0039
June	0.0034	-0.0012	0.0061	0.0196*	0.0070	-0.0123*	0.0000
July	-0.0045	0.0083	-0.0103	-0.0055	*0.0019	0.0055	0.0006
August	0.0016	0.0122*	-0.0094	-0.0038	0.0033	0.0137*	-0.0019
September	-0.0036	-0.0010	0.0027	-0.0039	-0.0057	-0.0099	0.0102

Variable	Legally Drunk	Male	Asian	Black	Hispanic	White	Other Race
October	-0.0092	-0.0007	-0.0037	0.0056	0.0090	0.0018	0.0068
November	0.0007	0.0068	0.0047	-0.0087	-0.0007	-0.0003	0.0061
December	0.0065	-0.0034	0.4170	0.0043	-0.0089	0.0027	0.0004
Intersection	-0.0536*	-0.0333*	-0.0297*	0.0120*	0.0300*	-0.0045	-0.0271*
Rural/Unincorporated	0.0396*	0.0315*	-0.0494*	-0.0377*	-0.0099	0.0713*	-0.0277*
Population <50,000	-0.0103	-0.0146*	-0.0155*	-0.0392*	0.0073	0.0315*	-0.0171*
Population 50,000-100,000	-0.0094	-0.0130*	0.0270*	-0.0252*	-0.0456*	0.0354*	0.0117*
Population 100,000-250,000	-0.0073	-0.0160*	0.0052	-0.0029	0.0417*	-0.0346*	-0.0121*
Population >250,000	-0.0164*	0.0066	0.0337*	0.0953*	0.0063	-0.975*	0.0426*
Cloudy	-0.0016	0.0015	0.0092	-0.0064	-0.0102	0.0106	-0.0057
Raining	0.048	0.0052	-0.0021	-0.0023	0.0086	-0.0080	0.0047
Snowing	-0.0014	0.0006	-0.0095	-0.0087	-0.0156*	0.0267*	*0.0039
Fog	0.0001	-0.0001	0.0023	-0.0053	0.0067	-0.0016	-0.0063
Other Weather	-0.0058	-0.0029	-0.0034	-0.0027	0.0015	0.0027	-0.0015
Wind	-0.0039	0.0140*	-0.0053	-0.0051	0.0045	-0.0001	0.0033
Wet	0.0144*	0.0087	-0.0051	-0.0108	-0.0055	0.0133*	0.0011
Slippery	0.0037	0.0015	0.0065	-0.0088	0.0054	-0.0024	-0.0033
Snow/Ice	-0.0061	0.0109	0.1580*	-0.0126*	-0.0145*	0.0353*	-0.0119*

Variable	Age 15-20	Age 21-30	Age 31-40	Age 41-50	Age 51-60	Age 61-70	Age 71+
Fatality							
Injury							
Year 2008/2009							
Year 2008							
Year 2009							
Cell Phone							
Had Been Drinking							
Legally Drunk							
Male							
Asian							
Black							
Hispanic							
White							
Other Race							
Age 15-20	1						
Age 21-30	-0.2301*	1					
Age 31-40	-0.1902*	-0.2981*	1				
Age 41-50	-0.1813*	-0.2841*	-0.2349*	1			
Age 51-60	-0.1487*	-0.2330*	-0.1926*	-0.1835*	1		
Age 61-70	-0.0968*	-0.1505*	-0.1244*	-0.1158*	-0.0972*	1	
Age 71+	-0.0745*	-0.1167*	-0.9650*	-0.0919*	-0.0754	-0.0487*	1
Morning	-0.0460*	-0.0034	0.0245*	0.0309*	0.0042	-0.0082	-0.0231*
Midday	-0.0122*	-0.0670*	-0.0144*	0.0056	0.0390*	0.0452*	0.0714*
Evening	0.0180*	0.0224*	0.0025	-0.0097	-0.0167*	-0.0123*	-0.0246*
Night	0.0568*	0.0818*	-0.0148*	-0.0379*	-0.0447*	-0.0449-	-0.0475*
Weekday	-0.0309*	-0.0282*	0.0018	0.0298*	0.0223*	0.0045	0.0105
January	-0.0064	0.0139*	-0.0011	-0.0100	0.0017	-0.0038	0.0031
February	0.0043	-0.0006	-0.0016	0.0000	-0.0077	0.0039	0.0060
March	0.0009	0.0066	-0.0075	0.0011	0.0039	-0.0036	-0.0061
April	-0.0007	-0.0066	0.0061	-0.0065	-0.0010	0.0111	0.0051
May	0.0086	0.0020	-0.0087	-0.0022	0.0010	0.0046	-0.0048
June	-0.0055	-0.0026	0.0001	-0.0027	0.0072	0.0010	0.0071
July	0.0040	-0.0017	0.0006	-0.0025	0.0036	0.0010	-0.0070
August	0.0007	-0.0062	0.0086	0.0029	-0.0780	0.0039	-0.0017
September	-0.0045	0.0078	0.0065	-0.0026	-0.0056	-0.0074	-0.0007

Variable	Age 15-20	Age 21-30	Age 31-40	Age 41-50	Age 51-60	Age 61-70	Age 71+
October	0.0019	-0.0014	-0.0002	0.0081	-0.0096	-0.0001	0.0010
November	-0.0099	0.0024	-0.0048	0.0081	0.0077	-0.0088	0.0028
December	0.0064	-0.0136*	0.0021	0.0052	0.0070	-0.0012	-0.0055
Intersection	0.0270*	-0.0233*	-0.0176*	-0.0026	-0.0022	0.0116*	0.0390*
Rural/Unincorporated	0.0213*	-0.0151*	-0.0184*	0.0059	0.0088	0.0083	-0.0016
Population <50,000	0.0086	-0.0125*	-0.0041	-0.0058	-0.0019	0.0159*	0.0182*
Population 50,000-100,000	0.0007	-0.0105	-0.0020	-0.0028	0.0018	0.0080	0.0201*
Population 100,000-250,000	0.0170*	-0.0030	0.0028	-0.0006	-0.0033	-0.0165*	-0.0014
Population >250,000	-0.0447*	0.0376*	0.0210*	0.0019	-0.0058	-0.0134*	-0.0300*
Cloudy	-0.0082	0.0030	0.0040	-0.0040	0.0009	0.0066	-0.0027
Raining	0.0032	0.0121*	0.0041	-0.0048	-0.0092	-0.0156*	0.0031
Snowing	0.0018	-0.0093	-0.0014	0.0044	-0.0137*	-0.0031	-0.0079
Fog	0.0033	-0.0010	0.0006	-0.0036	0.0089	-0.0051	-0.0070
Other Weather	-0.0022	-0.0067	-0.0031	0.0112	-0.0062	0.0154*	-0.0050
Wind	-0.0009	0.0027	0.0011	-0.0032	-0.0010	-0.0043	0.0069
Wet	0.0131*	0.0097	0.0021	-0.0096	-0.0070	-0.0165*	0.0026
Slippery	0.0018	0.0097	-0.0037	0.0031	-0.0083	-0.0075	0.0001
Snow/Ice	-0.0041	0.0013	-0.0043	0.0071	0.0012	0.0037	-0.0080

Variable	Morning	Midday	Evening	Night	Weekday	January	February	March
Fatality								
Injury								
Year 2008/2009								
Year 2008								
Year 2009								
Cell Phone								
Had Been Drinking								
Legally Drunk								
Male								
Asian								
Black								
Hispanic								
White								
Other Race								
Age 15-20								
Age 21-30								
Age 31-40								
Age 41-50								
Age 51-60								
Age 61-70								
Age 71+								
Morning	1							
Midday	-0.3916*	1						
Evening	-0.3654*	-0.5430*	1					
Night	-0.1588*	-0.2359*	-0.2202*	1				
Weekday	0.0160*	-0.0286*	0.0212*	-0.1521*	1			
January	0.0160*	-0.0030	-0.0030	-0.0129*	0.0159*	1		
February	0.0187*	0.0044	-0.0203*	-0.0005	0.0031	-0.0867*	1	
March	0.0018	0.0043	-0.0048	-0.0018	-0.0160*	-0.0919	-0.0906*	1
April	-0.0082	0.0110	-0.0019	-0.0036	0.0037	-0.0874*	-0.0862*	-0.0913*
May	-0.0063	0.0030	-0.0015	0.0063	-0.0186*	-0.0885	-0.0873*	-0.0925*
June	-0.0137*	-0.0043	0.0122*	0.0066	-0.0057	-0.0842*	-0.0830*	-0.0880*
July	-0.0224*	0.0142*	-0.0008	0.0091	0.0023	-0.0882*	-0.0869*	-0.0921*
August	-0.0174	-0.0071	0.0118*	0.0173*	-0.0044	-0.0903*	-0.0890*	-0.0943*
September	0.0212*	-0.0130	-0.0038	-0.0020	-0.0109	-0.0904*	-0.0891*	-0.0944*

Variable	Morning	Midday	Evening	Night	Weekday	January	February	March
October	0.0185*	-0.0026	-0.0095	-0.0063	0.0172*	-0.0938*	-0.8925*	-0.0980*
November	-0.0059	-0.0089	0.0177*	-0.0059	-0.0003	-0.9140*	-0.0901*	-0.0954*
December	-0.0034	0.0024	0.0039	-0.0057	0.0134*	-0.0919*	-0.0906*	-0.0960*
Intersection	-0.0294*	0.0323*	0.0041	-0.0197	-0.0144*	0.0088	-0.0024	0.0022
Rural/Unincorporated	0.0025	0.0003	-0.0073	0.0082	-0.0431*	-0.0023	-0.0007	-0.0123*
Population <50,000	-0.0150*	0.0278*	-0.0059	-0.0161	0.0252*	0.0150*	-0.0006	0.0067
Population 50,000-100,000	0.0067	0.0029	0.0067	-0.0259*	0.0245*	-0.0059	0.0119*	-0.0018
Population 100,000-250,000	-0.0074	0.0056	0.0045	-0.0064	0.0020	-0.0001	-0.0042	0.0064
Population >250,000	0.0107	-0.0309*	0.0022	0.0338*	-0.0010	-0.0047	-0.0056	0.0027
Cloudy	0.0909*	-0.0134*	-0.0611*	-0.0057	0.007	0.0775*	0.1091*	-0.0130*
Raining	0.0092	-0.0056	-0.0215*	0.0323*	-0.0094	0.0990*	0.1031*	-0.0236*
Snowing	0.0097	-0.0069	-0.0008	-0.0008	-0.0114*	0.0213*	0.0372*	-0.0008
Fog	0.0795*	-0.0427*	-0.0371*	0.0206*	-0.0020	0.0419*	0.0120*	-0.0126*
Other Weather	0.0058	0.0017	-0.0020	-0.0080	0.0048	-0.2900	0.0020	-0.0034
Wind	0.0006	-0.0092	0.0080	0.0015	0.0003	0.0019	-0.0051	-0.0054
Wet	0.0467*	-0.0200*	-0.0425*	0.0382*	-0.0071	0.1404*	0.1700*	0.0293*
Slippery	0.0065	-0.0021	-0.0072	0.0065	0.0031	0.0074	-0.0005	0.0025
Snow/Ice	0.0278	-0.0073	-0.0122*	-0.0072	-0.0143*	0.0320*	0.0657*	0.0014

Variable	April	May	June	July	August	September	October	November
Fatality								
Injury								
Year 2008/2009								
Year 2008								
Year 2009								
Cell Phone								
Had Been Drinking								
Legally Drunk								
Male								
Asian								
Black								
Hispanic								
White								
Other Race								
Age 15-20								
Age 21-30								
Age 31-40								
Age 41-50								
Age 51-60								
Age 61-70								
Age 71+								
Morning								
Midday								
Evening								
Night								
Weekday								
January								
February								
March								
April	1							
May	-0.0880*	1						
June	-0.0837*	-0.0848*	1					
July	-0.0877*	-0.0888*	-0.0844*	1				
August	-0.0898*	-0.0909*	-0.0865*	-0.0906*	1			
September	-0.0899*	-0.0910*	-0.0866*	-0.0907*	-0.0928*	1		

Variable	April	May	June	July	August	September	October	November
October	-0.0932*	-0.0944*	-0.0898*	-0.0941*	-0.0963*	-0.0964*	1	
November	-0.0908*	-0.0920*	-0.0875*	-0.0916*	-0.0938*	-0.0939*	-0.0974*	1
December	-0.0914*	-0.0925*	-0.0880*	-0.0922*	-0.0944*	-0.0945*	-0.0981*	-0.0955*
Intersection	-0.0039	0.0094	-0.0031	-0.0100	0.0005	0.0008	0.0002	-0.0004
Rural/Unincorporated	-0.0115*	-0.0002	0.0006	0.0245*	0.0078	-0.0037	-0.0084	0.0079
Population <50,000	0.0102	0.0006	0.0037	-0.0242*	-0.0011	-0.0004	-0.0059	-0.0011
Population 50,000-100,000	-0.0015	-0.004	-0.0008	0.0030	0.0011	-0.0005	-0.0018	-0.0053
Population 100,000-250,000	0.0053	0.0059	-0.0076	0.0010	-0.0086	0.0091	-0.0051	-0.0107
Population >250,000	-0.0003	-0.0022	0.0041	-0.0084	0.0001	-0.0039	0.0195*	0.0075
Cloudy	-0.0216*	-0.0137*	-0.0046	-0.0681*	-0.0866*	-0.0489*	-0.0259*	0.0164*
Raining	-0.0408*	-0.0269*	-0.0421*	-0.0491*	-0.0504*	-0.0333*	-0.0166*	0.0103
Snowing	-0.0089	-0.0121*	-0.0115*	-0.0090	-0.0123*	-0.0094	-0.0128*	-0.0095
Fog	-0.0171*	-0.0135*	-0.0143*	-0.0173*	-0.0084	-0.0196*	-0.0150*	0.0263*
Other Weather	0.0019	-0.0077	0.0025	0.0065	-0.0032	-0.0079	0.0188*	-0.0034
Wind	0.0091	0.0019	0.0024	0.0019	-0.0053	-0.0053	0.0079	-0.0053
Wet	-0.0591*	-0.0462*	-0.0671*	-0.0771*	-0.0802*	-0.0600*	-0.0261*	0.0144*
Slippery	-0.0183*	-0.0168*	-0.0194*	-0.0203*	-0.0190*	-0.0190*	-0.0216*	-0.0175*
Snow/Ice	0.0035	-0.0090	-0.0001	0.0114*	-0.0091	0.0028	-0.0056	-0.0013

Variable	December	Intersection	Rural/ Unincorporated	Population <50,000	Population 50,000-100,000	Population 100,000-250,000	Population >250,000
Fatality							
Injury							
Year 2008/2009							
Year 2008							
Year 2009							
Cell Phone							
Had Been Drinking							
Legally Drunk							
Male							
Asian							
Black							
Hispanic							
White							
Other Race							
Age 15-20							
Age 21-30							
Age 31-40							
Age 41-50							
Age 51-60							
Age 61-70							
Age 71+							
Morning							
Midday							
Evening							
Night							
Weekday							
January							
February							
March							
April							
May							
June							
July							
August							
September							

Variable	December	Intersection	Rural/ Unincorporated	Population <50,000	Population 50,000-100,000	Population 100,000-250,000	Population >250,000
October							
November							
December	1						
Intersection	-0.0023	1					
Rural/Unincorporated	-0.0010	-0.0912*	1				
Population <50,000	-0.0025	0.0755*	-0.2356*	1			
Population 50,000-100,000	0.0058	0.0153*	-0.2646*	-0.1899*	1		
Population 100,000-250,000	0.0083	0.0206*	-0.2780*	-0.1996*	-0.2241*	1	
Population >250,000	-0.0096	-0.0026	-0.3235*	-0.2323*	-0.2608*	-0.2741*	1
Cloudy	0.0821*	-0.0307*	0.0417*	-0.0152*	-0.0099	-0.0124*	-0.0093
Raining	0.0708*	-0.0009	-0.0087	0.0077	0.0000	0.0006	0.0028
Snowing	0.0283*	-0.0099	0.0496*	0.0021	-0.0187*	-0.0133*	-0.0228*
Fog	0.0370*	0.0053	0.0450*	0.0001	-0.0134*	-0.0114*	-0.0230*
Other Weather	-0.0034	-0.0015	0.0181*	-0.0033	0.0016	-0.0125*	-0.0055
Wind	0.0014	-0.0047	-0.0055	0.0148*	-0.0029	-0.0084	0.0037
Wet	0.1208*	-0.0152*	0.0315*	-0.0008	0.0005	-0.0196*	-0.0135*
Slippery	0.0535*	-0.0028	0.0137*	0.0003	-0.0022	-0.0032	-0.0092
Snow/Ice	-0.0535*	-0.0202*	0.0963*	-0.0085	-0.0302*	-0.0269	-0.0385*

Variable	Cloudy	Raining	Snowing	Fog	Other Weather	Wind	Wet	Slippery	Snow/ Ice
Fatality									
Injury									
Year 2008/2009									
Year 2008									
Year 2009									
Cell Phone									
Had Been Drinking									
Legally Drunk									
Male									
Asian									
Black									
Hispanic									
White									
Other Race									
Age 15-20									
Age 21-30									
Age 31-40									
Age 41-50									
Age 51-60									
Age 61-70									
Age 71+									
Morning									
Midday									
Evening									
Night									
Weekday									
January									
February									
March									
April									
May									
June									
July									
August									
September									

Variable	Cloudy	Raining	Snowing	Fog	Other Weather	Wind	Wet	Slippery	Snow/ Ice
October									
November									
December									
Intersection									
Rural/Unincorporated									
Population <50,000									
Population 50,000-100,000									
Population 100,000-250,000									
Population >250,000									
Cloudy	1								
Raining	-0.0704*	1							
Snowing	-0.0159*	-0.0072	1						
Fog	-0.0253*	-0.0115*	-0.0026	1					
Other Weather	-0.0102	-0.0046	-0.001	0.0017	1				
Wind	-0.0068	-0.0031	-0.0007	-0.0011	-0.0004	1			
Wet	0.3296*	0.6061*	-0.0085	0.0697*	0.0072	-0.0050	1		
Slippery	0.0111	0.0018	0.0263*	0.0154*	0.0173*	-0.0012	-0.0086	1	
Snow Ice	0.0511*	0.0076	0.5442*	-0.0044	-0.0008	-0.0005	-0.0196*	-0.0020	1

Appendix D

Variable Inflation Factor Test Results

Model ***1 – Accident Involving Fatality=1***

Variable	VIF	1/VIF
Midday	3.78	0.264401
Evening	3.56	0.280511
Morning	3.05	0.32745
Age 21-30	2.28	0.43924
Wet	2.13	0.468767
Age 31-40	2.06	0.48504
Age 41-50	2.01	0.497843
December	1.95	0.511633
October	1.93	0.516859
November	1.9	0.525061
March	1.9	0.525115
January	1.9	0.527245
February	1.89	0.5283
September	1.88	0.532685
August	1.87	0.533765
Raining	1.85	0.540391
May	1.85	0.540752
April	1.83	0.546384
Age 51-60	1.79	0.559882
June	1.78	0.561208
Population > 250,000	1.56	0.643077
Population 100,000-250,000	1.46	0.683055
Snow/Ice	1.46	0.684337
Population 50,000-100,000	1.44	0.695587
Snowing	1.43	0.698784
Age 61-70	1.4	0.715177
Population < 50,000	1.39	0.721653
Cloudy	1.35	0.743338
Age 71+	1.26	0.792394
Hispanic	1.23	0.812889
Legally Drunk	1.13	0.881287
Asian	1.11	0.904059
Black	1.11	0.904276
Other Race	1.08	0.9233
Weekday	1.05	0.95635
Fog	1.03	0.969078
Intersection	1.02	0.976894
Male	1.02	0.979414

Had Been Drinking	1.02	0.983367
Cell Phone	1	0.995312
Slippery	1	0.996928
Other Weather	1	0.99745
Wind	1	0.998846
Mean VIF	1.65	

Model 2 ***– Accident with Injury=1***

Variable	VIF	1/VIF
Midday	3.78	0.264392
Evening	3.57	0.280504
Morning	3.06	0.326694
Age 21-30	2.28	0.439191
Wet	2.13	0.468668
Age 31-40	2.06	0.484983
Age 41-50	2.02	0.496075
December	1.95	0.511627
October	1.93	0.516818
November	1.9	0.525036
March	1.9	0.525043
January	1.9	0.525168
February	1.89	0.528289
September	1.88	0.532685
August	1.87	0.533748
Raining	1.85	0.540331
May	1.85	0.540711
April	1.83	0.546368
Age 51-60	1.79	0.559817
June	1.78	0.561176
Population <250,000	1.56	0.643009
Population 100,000-250,000	1.46	0.683025
Snow/Ice	1.46	0.684331
Population 50,000-100,000	1.44	0.695541
Snowing	1.43	0.698784
Cell Phone	1.41	0.709677
Age 61-70	1.4	0.715087
Population <50,000	1.39	0.721622
Cloudy	1.35	0.743314
Age 71+	1.26	0.792364
Hispanic	1.23	0.812861
Cell Phone*Morning	1.2	0.833042
Cell Phone*Age 41-50	1.17	0.856598
Legally Drunk	1.14	0.88103
Asian	1.11	0.904021
Black	1.11	0.904081
Cell Phone*January	1.1	0.90831

Other	1.08	0.923257
Weekday	1.05	0.956165
Fog	1.03	0.968755
Intersection	1.02	0.976838
Male	1.02	0.979168
Had Been Drinking	1.02	0.983299
Slippery	1	0.996926
Other Weather	1	0.997449
Wind	1	0.998846
Mean VIF	1.62	

Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident=1***

Variable	VIF	1/VIF
Midday	3.78	0.264368
Evening	3.56	0.280515
FY 2009	3.28	0.304643
Morning	3.05	0.327409
Age 31-40	3.03	0.33022
April	2.88	0.34673
Cloudy	2.47	0.405079
FY 2008/2009*Cloudy	2.33	0.429937
FY 2008/2009*April	2.3	0.43431
FY 2008/2009	2.3	0.435127
Age 21-30	2.28	0.439185
March	2.25	0.443674
January	2.23	0.448658
February	2.21	0.452657
FY 2008/2009*Age 31-40	2.2	0.454559
May	2.18	0.457954
Wet	2.13	0.468682
June	2.1	0.476385
Age 41-50	2.01	0.497919
December	1.96	0.511448
October	1.94	0.516782
November	1.91	0.524788
September	1.88	0.532643
August	1.87	0.5337
Raining	1.85	0.540293
Age 51-60	1.79	0.560057
Population <250,000	1.55	0.643087
Population 100,000-250,000	1.46	0.683021
Snow/Ice	1.46	0.684085
Population 50,000-100,000	1.44	0.695596
Snowing	1.43	0.698677
Age 61-70	1.4	0.715307
Population <50,000	1.39	0.721571
Age 71+	1.26	0.792464
Hispanic	1.23	0.812878
Legally Drunk	1.13	0.88215
Black	1.11	0.903995

Asian	1.11	0.904209
Other	1.08	0.923215
Weekday	1.05	0.956253
Fog	1.03	0.968856
Intersection	1.02	0.976957
Male	1.02	0.979457
Had Been Drinking	1.02	0.984155
Slippery	1	0.996891
Other Weather	1	0.997288
Wind	1	0.998791
Mean VIF	1.85	

Appendix E

Breusch-Pagan/Cook-Weisberg Test Results

Model 1 ***– Accident Involving Fatality=1***

H_0: constant Variance
Variables: all right hand variables
$chi^2(1)$ = 14,379.62
Probability > chi^2 = 0.0000

Model 2 ***– Accident with Injury=1***

H_0: constant Variance
Variables: all right hand variables
$chi^2(1)$ = 17.26
Probability > chi^2 = 0.0000

Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident=1***

H_0: constant Variance
Variables: all right hand variables
$chi^2(1)$ = 10,944.25
Probability > chi^2 = 0.0000

Appendix F

Szroeter's Test Results

Model 1 ***– Accident Involving Fatality=1***

H_0: variance constant, H_a: variance monotonic in variable

Variable	chi^2	df	p-value
Cell Phone	7.11	1	0.0076
Had Been Drinking	886.03	1	0.0000
Legally Drunk	2739.49	1	0.0000
Male	379.75	1	0.0000
Asian	220.47	1	0.0000
Black	76.85	1	0.0000
Hispanic	169.59	1	0.0000
Other Race	77.08	1	0.0000
Age 21-30	73.64	1	0.0000
Age 31-40	73.39	1	0.0000
Age 41-50	61.03	1	0.0000
Age 51-60	0.69	1	0.4051
Age 61-70	416.39	1	0.0000
Age 71+	209.5	1	0.0000
Morning	231.84	1	0.0000
Midday	358.84	1	0.0000
Evening	26.17	1	0.0000
Weekday	811.82	1	0.0000
January	121.76	1	0.0000
February	287.77	1	0.0000
March	154.76	1	0.0000
April	3.21	1	0.0730
May	59.98	1	0.0000
June	204.12	1	0.0000
August	15.61	1	0.0001
September	39.33	1	0.0000
October	1.43	1	0.2318
November	56.86	1	0.0000
December	5.56	1	0.0184
Intersection	76.76	1	0.0000
Population < 50,000	888.82	1	0.0000
Population 50,000-100,000	125.64	1	0.0000

Population 100,000-250,000	361.76	1	0.0000
Population > 250,000	294.35	1	0.0000
Cloudy	41.71	1	0.0000
Raining	1.53	1	0.2165
Snowing	24.26	1	0.0000
Fog	618.55	1	0.0000
Other Weather	531	1	0.0000
Wind	4.48	1	0.0343
Wet	28.05	1	0.0000
Snow/Ice	5.39	1	0.0202
Slippery	13.31	1	0.0003

Model 2 ***– Accident with Injury=1***

H_0: variance constant, H_a: variance monotonic in variable

Variable	chi2	df	p-value
Cell Phone	0.01	1	0.9314
Had Been Drinking	0.02	1	0.9001
Legally Drunk	1.73	1	0.1890
Male	3.13	1	0.0770
Asian	1.17	1	0.2799
Black	0.41	1	0.5234
Hispanic	1.78	1	0.1818
Other Race	0.13	1	0.7188
Age 21-30	0.82	1	0.3643
Age 31-40	0.02	1	0.8971
Age 41-50	0.38	1	0.5355
Age 51-60	0.59	1	0.4441
Age 61-70	0.35	1	0.5557
Age 71+	0.39	1	0.5328
Morning	4.1	1	0.0428
Midday	0.48	1	0.4897
Evening	0.3	1	0.5845
Weekday	1.52	1	0.2183
January	0.42	1	0.5155
February	0.56	1	0.4556
March	0.16	1	0.6882
April	0	1	0.9497
May	0.81	1	0.3679
June	0.16	1	0.6894
August	0.03	1	0.8608
September	0.23	1	0.6285
October	0.11	1	0.7361
November	0	1	0.9458
December	0.68	1	0.4110
Intersection	3.57	1	0.0589
Population < 50,000	1.84	1	0.1746
Population 50,000-100,000	0.82	1	0.3648
Population 100,000-250,000	0.04	1	0.8503
Population > 250,000	2.38	1	0.1227
Cloudy	1.31	1	0.2528

Raining	0.62	1	0.4294
Snowing	1.68	1	0.1951
Fog	0.07	1	0.7969
Other Weather	0.02	1	0.8978
Wind	0.44	1	0.5090
Wet	0.23	1	0.6321
Snow/Ice	0.7	1	0.4020
Slippery	0.04	1	0.8336
Cell Phone*Age 41-50	0.08	1	0.7761
Cell Phone*Morning	0.01	1	0.9374
Cell Phone*January	0.11	1	0.7351

Model 3 ***– Cell Phone Use While Driving and Being Involved in Accident=1***

H_0: variance constant, H_a: variance monotonic in variable

Variable	**chi^2**	**df**	**p-value**
FY 2008/2009	1659.11	1	0.0000
FY 2009	831.97	1	0.0000
Had Been Drinking	1879.14	1	0.0000
Legally Drunk	2063.16	1	0.0000
Male	164.02	1	0.0000
Age 21-30	451.51	1	0.0000
Age 31-40	15.51	1	0.0001
Age 41-50	202.93	1	0.0000
Age 51-60	500.15	1	0.0000
Age 61-70	220.52	1	0.0000
Age 71+	92.19	1	0.0000
Asian	432.64	1	0.0000
Black	11.25	1	0.0008
Hispanic	45.2	1	0.0000
Other Race	71.46	1	0.0000
Morning	305.21	1	0.0000
Midday	108.24	1	0.0000
Evening	296.14	1	0.0000
Weekday	15.81	1	0.0001
Population < 50,000	111.98	1	0.0000
Population 50,000-100,000	154.25	1	0.0000
Population 100,000-250,000	94.86	1	0.0000
Population > 250,000	0.57	1	0.4496
Intersection	253.69	1	0.0000
Cloudy	85.66	1	0.0000
Raining	94.91	1	0.0000
Snowing	24.26	1	0.0000
Fog	0.2	1	0.6563
Other Weather	9.93	1	0.0016
Wind	4.49	1	0.0341
Wet	122.93	1	0.0000
Snow/Ice	69.19	1	0.0000
Slippery	13.36	1	0.0003
January	12.96	1	0.0003
February	103.69	1	0.0000
March	0.34	1	0.5615
April	10.11	1	0.0015
May	29.35	1	0.0000
June	86.41	1	0.0000
August	210.84	1	0.0000
September	0.15	1	0.7004

October	154.51	1	0.0000
November	58.9	1	0.0000
December	100.42	1	0.0000
FY 2008/2009*Age 31-40	478.35	1	0.0000
FY 2008/2009*April	382.43	1	0.0000
FY 2008/2009*Cloudy	50.19	1	0.0000

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