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SAFETY IMPLICATIONS OF DRIVER CELL PHONE USAGE AMONG COLLEGE STUDENTS

by

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Dedication

This thesis are dedicated to my dearest dad and mom,
Khiok Kuang Lim & Kim Kam Lim.
Without your love and support, I would not have made this thesis possible.
I love you all.

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ABSTRACT

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This research effort investigates the use of cell phone while driving and the associated crash risk for the college age drivers. A questionnaire was developed and distributed to University of Memphis students to ascertain information in three key areas: (1) Driving hours, (2) Types of cell phone usage – talking, texting, and other wireless functions, and (3) Safety issues – incidences of crash or 'close call'* using cell phones. The questionnaire was available online on the University of Memphis webpage (http://cifts.memphis.edu/cellphone.html) from February 12, 2009 until April 10, 2009, resulting in responses from 2445 students. Data was analyzed using: (1) Descriptive Statistics, (2) Frequency Figures, and (3) Mann-Whitney U Test. Results indicate that texting, emailing, and taking pictures while driving are related to higher incidences of close call occurrence, and thus cell phone usage is affecting students' driving safety.

*Close call: Defined as an incident where driver engages in high risk traffic movement but avoids collision, i.e. drifting into adjacent lane, having to "slam on brakes," etc.

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Section 1: Introduction

On September 12th 2008, cellular phone texting contributed to one of the worst train accidents of Southern California when 25 people were killed and 138 were injured. According to the National Transportation Safety Board, evidence showed text messaging as the cause of the deadly distraction for the train operator. Cellular phone usage, especially texting, has fueled recent debates on road safety issues.

The National Highway Traffic Safety Administration (NHTSA) published findings indicating that use of cell phones while driving increased from 4% in 2002 to 6% in 2007. The National Occupant Protection Use Survey (NOPUS) also reported that hand-held phone use increased among drivers between the ages of 16 and 24, from 5% in 2002 to 8% in 2004 and to 10% in 2005 (Glassbrenner, 2005).

A research report released by NHTSA and Virginia Tech Transportation Institute (VTTI) on April 20th 2006 stated driver inattention is the leading factor in most crashes and near-crashes. Nearly 80% of crashes and 65% of near-crashes (close calls) involved some form of driver inattention within 3 seconds before the event, and this inattention was frequently due to cell phone usage. (Box & Martin, 2006). A recent report by NHTSA has confirmed that cell phone and texting is the primary distraction while driving (NHTSA, 2009).

Mobile phone-related car crashes are responsible for 1 in 20 highway deaths in the US, according to a Harvard Center for Risk Analysis (HCRA) report (Cohen & Graham, 2003). These statistics offer a damning indictment of individuals who use mobile phones while driving, with one figure claiming that phone-related auto accidents account for 2,600 deaths in the US per year (Cohen & Graham, 2003).

Despite recent statistics, as of April, 2010, only 23 out of 50 states have completely banned cell phone usage while driving. So what happened to the rest of the nation? The Harvard Center for Risk Analysis claims laws to prevent drivers from using cell phones are costly but on the other hand, authors J. Cohen and J. Graham argued a national ban on the use of cellular phones while driving would save $43 billion per year in reduced medical costs, reduced property damage and based on an estimate of what people would be willing to pay to avoid suffering and death. A nation-wide ban on cell phones will not happen without incurring a significant cost, especially when the savings are roughly equal to the economic value of the banned calls, also around $43 billion annually, with an error range between $17 billion and $151 billion (Cohen & Graham, 2003).

Nevertheless, the issues of distracted driving have finally getting considerable attention. On September 21st, 2010, a Distracted Driving Summit was held in Washington. D.C. to launch new cell phone policy, reinforce existing policy, and also to build awareness about the dangers of distracted driving. The 2010 Drive Safely Work Week Toolkit was presented, developed in partnership with DOT and the Network of Employers for Traffic Safety (NETS), which included the fact/tip sheets, communications tools, and downloadable graphics that organizations can use to accomplish above mentioned objectives (Distraction.gov, 2010).

Numerous studies have been conducted on cellular phone usage while driving and more recently with emphasis on the impact of texting. The current research will include a survey of students from the University of Memphis, who are good subjects for assessing the impact of cell phone usage on the driving task, due to the fact that college students are more likely to use cell phones while driving (Cramer, Mayer, & Ryan, 2007).

Findings of this survey will evaluate the statement: Engaging in the following cell phone tasks while driving will invoke crash or near crash scenarios among college students:

1. Talking While Driving
2. Texting While Driving
3. Emailing While Driving
4. Taking Pictures While Driving

This research will provide greater insight into the prevalence of crashes/close calls due to the cell phone usage for college-age students, as well as, the cell phone functions most frequently associated with these events.

Section 2: Literature Review

The purpose of this research is to determine college students' cell phone usage patterns while operating a vehicle, including frequency of close call incidents and car crashes. This literature review will outline studies that have been conducted to date regarding cell phone usage patterns of drivers and the associated risks. Approximately 79% of all teens (17 million) have a mobile device – a 36% increase since 2005 (CTIA, 2008). Hand-held cell phone usage continues to be higher among the 16-24 year age group. In addition, higher levels of education were also found to be associated with higher levels of cell phone usage and texting while driving (American Automobile Association, 2008).

There is a body of growing evidence that using a cell phone either hands-free or hand-held while driving is an unsafe driving behavior in both urban and rural environments (White, Hyde, Walsh, & Watson, 2010). Car accidents due to driver inattention have increased but there is a lack of data to indicate the type of distractions that caused these increases, although experts suggest evidence has begun to show that cellular phones can elevate crash risks. Association between cellular phone usage and crashes is quite difficult to establish but according to Eby, Kostyniuk, and Vivoda (2003), “simulator and on-the-road studies show that both dialing the phone and engaging in complex conversations can disrupt tasks that are important for safe driving”

Reports have stated using a cell phone while driving a vehicle quadruples the risk of a collision and increases the risk of a fatality occurring in an accident nine fold (Cramer et al., 2007). Most vehicle drivers involved in car accidents or traffic stops are unlikely to admit to cellular phone usage while driving and only a handful of states actually contain specific boxes on police reports for indicating cellular phone use. The lack of hard data can contribute to slow legislation in creating laws against cellular phone usage while driving (Seo & Torabi, 2004). Author Dennis Utter adds that potential liability issues causes drivers to be less likely to report cellular phone usage to investigating police officers (Utter, 2001). There are no definite methods to judge if cellular phones were used prior to or during car accidents even if a cellular phone was found in a vehicle and it is even more difficult to determine if this was the cause of the accident.

2.1 Growth of Cell Phone Capabilities and Its Subscribers

Cellular phones were commercially introduced to the United States in 1983 and were still uncommon during the 1990's but rapidly grew at an extraordinary rate after the millennium due to popularity and affordability. According to Hancock, Lesch, and Simmons (2003), the increase of cellular phone ownership has also increased cellular phone usage during driving. People who drive for an extensive period of time compared to drivers who drive a shorter period of time are more likely to engage in cell phone tasks while driving and the more skilled the drivers think themselves to be, the more likely they are to have a cell phone in their car (Poysti, Rajalin, & Summala, 2005).

Presently, the majority of all Americans carry a cellular phone. The number of cell phone users in the United States skyrocketed from 500,000 in 1985 to 137,000,000 in November 2002 (Huang, Stutts, & Hunter, 2003).

According to Cellular Telecommunications and Internet Association, there were over 194 million cell phone users in the United State as of June 2005 (CTIA, 2009). As of June 2008, there were 262.7 million wireless subscribers in the country (CTIA, 2009).

The original function of cell phones was restricted to voice calls. However, cell phones are now equipped with tremendous technologies such as Short Message Service (SMS), java applications, mobile Internet, and Global Position System (GPS) functions as well. The most commonly used data application on mobile phones is SMS text messaging. For a comparison, there was an approximate 35% increase in cell phone subscribers in the year 2008 compared to the year 2003 (CTIA, 2009). However, the growth of text messaging had risen 950% in 2008 compared to year 2003 (Annualized Yearly SMS in 2003 is 57.2 billion messages and in 2008 is 600.5 billion messages) (CTIA, 2009).

Driver education courses are known to focus on traffic laws and the importance of driving safely on the road. Currently with all the increased cell phone usage, driver safety programs now have another topic to expand on in class. "Eighty five percent of American drivers use their phone while they drive and compared to driving alone, manually dialing a cellular phone can have a deleterious effect on vehicle control, including such activities as lane keeping and speed maintenance" (Hancock, Lesch, & Simmons, 2003, p. 502).

Statistics for on the road cell phone usage from the National Occupant Protection Use Survey (NOPUS) are displayed in the Table 2.1 for the years

2000, 2002, 2004, 2005 and 2007. As is demonstrated by Table 2.1, the percentage of hand-held users had risen to 11% in 2007 compared to year 2000.

Table 2.1 Percentage and Estimation of Hand-Held Phones While Driving During Daylight Hours

Years	Percentage of hand-held phones while driving during daylight hours	Estimated number of hand-held phones while driving during daylight hours
2000	3%	600,000
2002	4%	650,000
2004	8%	800,000
2005	10%	974,000
2007	11%	1,005,000

(Source: Glassbrenner, 2005; NHTSA, 2008; Seo & Torabi, 2004; Utter, 2001)

In 2008, the American Automobile Association (AAA) reported that over half of U.S. drivers have reported having used a cell phone while driving in the past 30 days, and one in seven admits to text messaging while driving (American Automobile Association, 2008). According to Michael Austin, texting is on the rise, up from 9.8 billion messages a month in December 2005 to 110.4 billion in December 2008 (Austin, 2009). Texting while driving is especially dangerous for young adults, “Hosking et al. (2006) found that, “… young novice drivers spent up to 400% more time looking away from the road when texting than when not texting,” (Hosking, Young, & Regan, 2006. p. 22).

2.2 Risk Associated with Driver Cell Phone Use

One report compared 100 randomly selected U.S. drivers involved in a car crash over the last two years with another 100 who were not involved. This research showed a risk ratio of 5.6:1 for drivers who talk more than 50 minutes per month on cellular phones. (Violanti & Marshall, 1996). Driver inattention is estimated to be a factor in between 20 to 50 % of all police-reported crashes. Analysis of data from 699 drivers with cell phones who were involved in collisions showed that when a driver used a cell phone while driving, the risk of a collision was between 3 and 6.5 times higher than when the phone was not in use. This increased risk was similar to the risk of driving with a blood-alcohol level above the legal limit. (Redelmeier & Tibshirani, 1997). In a simulator-based study, researchers used a driving simulator to compare the driving performance of drivers using hands-free and hand-held cell phones to drivers not using cell phones and drivers who were given alcoholic beverages until their blood alcohol concentration (BAC) reached 0.08 g/dL, the threshold for driving while intoxicated in all U.S. states (Strayer, 2003). The author found that the reaction times of drivers using cell phones were slowed by 8.4% relative to drivers who neither had consumed alcohol nor were using phones, and that drivers using cell phones were actually more likely to have a rear-end crash than were drivers who had consumed alcohol after controlling for the difficulty and duration of the simulated driving task (Strayer, 2003).

Additional evidence comes from the Koushki, Ali, and Al-Saleh (1999) study of mobile phone use in Kuwait. According to their research, the difference between no calls and 1 call per trip is over a factor of 3 for injuries and 4 for crashes involving damage; the likelihood of both types of crashes continues to increase as call frequency increases (Koushki et al., 1999). The research from Poysti et al. (2005) reported that the drivers who used their phones while driving more than 15 minutes a day were at a greater risk than those who used their phones only sometimes or less than 5 minutes per day (Poysti et al., 2005). Troy Green, the national spokesman for AAA stated that, “For every two seconds a driver’s eyes are off the road, a motorist is twice as likely to be involved in a crash.” (Miller, 2009 para. 2).

2.3 Distracted Driving

According to Distraction.gov (2010), distracted driving is any non-driving activity a person engages in that has the potential to distract him or her from the primary task of driving and increase the risk of crashing. There are three main types of distraction:

1. Visual – taking your eyes off the road
2. Manual – taking your hands off the wheel
3. Cognitive – taking your mind off what you’re doing

While all distraction can endanger drivers’ safety, texting is the most alarming because it involves all three types of distraction. In addition, other distracting activities that can be included according to Distration.gov (2010):

1. Using a cell phone
2. Eating and drinking

3. Talking to passengers
4. Grooming
5. Reading, including maps
6. Using a PDA or navigation system
7. Watching a video
8. Changing the radio station, CD, or Mp3 player.

In 1996, driver distraction in all its various forms contributed to between 20 and 30% of all car crashes and in 1999, driver distractions contributed to 11% of fatal crashes involving 4,462 fatalities (NHTSA, 2001). The American Automobile Association (AAA) recorded “Unknown Driver Attention Status” for 41.5% of crashes and “Unknown Distraction” (subclass of Unknown Driver Attention Status) for 8.6% (American Automobile Association, 2008). According to NHTSA (2009), “There is clearly inadequate reporting of crashes that may be related to cellular telephone use while driving” (NTHSA, 2009). The US Department of Transportation estimated that 25% of the 6.3 million crashes each year involve some degree of driver distraction or inattention (Seo & Torabi, 2004). Drivers who were talking on a cell phone at the time of a crash were more likely to have committed a driving violation and more likely to be at fault (Huang et al., 2003). There are two factors in car crashes to be considered: (1) eyes-off-of-the-road and (2) mind-off-of-the-road. Driving vehicles and simultaneously performing tasks that are visually demanding, such as reading long strings of text and manually demanding tasks that require visual guidance, such as entering a long string of text can often lead to car crashes (Green, 2000).

Drivers not engaged in cell phone tasks have been shown to be less likely to brake harder and more likely to make a mirror glance when changing lanes. Drivers using cell phones make fewer saccadic eye movements and spend less time checking instruments and mirrors (Nunes & Recarte, 2002). Cell phone usage reduces driver awareness and may increase the likelihood of a crash in work zone activity areas (Muttart, Fisher, Knodler, & Pollatsek, 2007).

According to Strayer and Johnston's (2001) report, people who were engaged in cell phone usage while driving missed twice as many simulated traffic signals and had significantly slower response time to simulated traffic signals when compared to drivers not engaged in cell phone tasks. Drivers talking on cell phones are more likely to swerve into the next lane (46%), tailgate (23%), have close calls (18%), and run red lights (10%). Furthermore, cell-phone users have more violations for speeding, impaired driving, seat belt non-use, and nonmoving violations (Wilson, Fang, Wiggins, & Cooper, 2003). The comparison of results showed that, relative to non-cell-phone users, cell phone drivers were more likely to report engaging in a variety of risky driving activities, as well as having one or more tickets and being involved in one or more crashes since they first began driving (Wilson et al., 2003).

Additionally, Schattler, Pellerito, McAvoy, and Datta (2006) determined that distractions caused by answering a cell and engaging in conversation using a hand-held cell phone significantly degraded driving performance (Schattler et al., 2006).

Hand-held cell phones are reported to be an important factor in driver distraction (Williams, 2007). Williams' claim can be backed by NHTSA findings where interviewed drivers reported using cell phones while driving, spending an average of 4.5 minutes per call (Royal, 2002). In 2008, almost 20% of all crashes in the year involved some type of distraction (NHTSA, 2009). NHTSA also added that nearly 6,000 people died in 2008 in crashes involving a distracted driver, and more than half a million were injured. A more recent publication by NHTSA in 2009 revealed that the primary distraction while driving is cell phone use and texting while driving (NHTSA, 2009).

2.4 Hands-Free versus Hand-Held

Dialing a hand-held device was found to have been a contributing factor in 3.58% of crashes and near-crashes, and talking/listening on hand-held devices was a contributing factor in 3.56% of crashes and near-crashes (Klauer, 2006). Hands-free device cell phones are becoming more popular with drivers. According to Huang et al. (2003), the vast majority of hands-free phone users believed that using a hands-free phone while driving was safer than using a hand-held phone. But studies showed driver performance was still significantly disrupted even when a hands-free cell phone was used. Phone conversations impose cognitive demands on drivers, distracting their attention from the driving task. According to the AAA (2008), many Americans are driving with the false sense of security that hands-free devices are somehow safer, which could be a deadly mistake. Hands-free cell phones are just as distracting as the hand held versions because they create the "inattention blindness" - a phenomenon in which motorists can look directly at road conditions but not really see them because they are distracted by cell phone conversations (Schattler et al., 2006).

In Seo and Torabi’s 2004 survey, more college students reported that accidents occurred while using hands-free models (14%) than hand held cell phones (4%) leading them to conclude that there were no differences in unsafe driving behaviors between drivers who used hands-free and hand-held cell phones. Surveys showed the estimates of the reaction time decrements associated with hand-held phones and hand-free phones are virtually identical (Caird, 2005). Thus, the increase in the use of hands-free phones is not expected to reduce the number of crashes that are the result of drivers not paying attention to their driving.

2.5 Reaction Times

Driver performance studies - using either driving simulators or on-road vehicles - concurred that using a cell phone slowed reaction times and degraded tracking abilities. (Huang et al., 2003). Simulation showed that drivers not engaged in cell phone tasks were able to reduce their speed earlier in response to a slowing lead vehicle than were drivers engaged in cell phone tasks. According to Rogers and Monsell (1995), task switching, where one alternates back and forth between activities, indicates performance (reaction time) is impaired when the competing and target activities share features (Rogers & Monsell, 1995). Presumably, if one is alternating between driving and typing text messages, it might prove to be costly in terms of overall amount of time devoted to the target task.

Several studies showed phone usage delayed driver reactions to the deceleration of the car ahead in on-road conditions (Lamble, Kauranen, Laakso, & Summala, 1999), phone usage seriously impaired crucial stopping decisions (Hancock et al., 2003), and that looking up telephone numbers while holding the phone in one hand resulted in a serious deterioration in driving performance in terms of lane control (de Waard, Brookhuis, & Hernandez-Gress, 2001). A simulation that involved 84 studies of the impact of cell phone usage on driving performance concluded that the most impacted driving performance was drivers' speed of reaction to critical events and that it increases the driver's required reaction time by approximately 0.23 seconds (Caird, 2005). According to Caird, Willness, Steel, and Scialfa (2008) as well as Horrey and Wickens (2006), the costs associated with cell phone use while driving were seen in reaction time tasks, with smaller costs in performance on lane keeping and tracking tasks (Caird et al., 2008) and (Horrey & Wickens, 2006). In addition to that, Strayer and Drews (2004) stated that hand-held cell phone use while driving increases braking time by 18%, increases following distances by 12% and increases the time for speed resumption after braking by 17% (Strayer & Drews, 2004).

2.6 Young Adult Drivers

According to a study in 2007, motor vehicle crashes are the leading cause of death and disability for young Americans, especially drivers aged 16 to 19 years old who have a fatality rate 4 times that of drivers aged 25 to 69 years old (Cramer et al., 2007). Increased usage of cell phones on the road threatens the safety of young drivers, who represent 14% of licensed drivers but 26% of drivers involved in fatal crashes, indicating younger drivers may be disproportionately threatened (Seo & Torabi, 2004). Younger drivers were overwhelmingly more likely to be texting, talking longer, and placing and receiving cell phone calls than the older drivers (American Automobile Association, 2008). This fact is also supported by Nemme and White in their 2010 publication (Nemme & White, 2010). Nemme and White (2010) also added that cell phone use, and particularly texting while driving, represents an increased safety risk for this age group.

"Young drivers show marked reductions in dual-task processing and accuracy in visual search when talking on a cell phone while performing driving tasks in a simulator" (Cramer et al., 2007). Talking on a cell phone while driving is clearly distracting to young drivers' attention; particularly texting, which may significantly increase crash risk. Nearly 50% of drivers aged 18 to 24 years admitted texting while driving at least occasionally, as compared to less than 5% of those aged 45 and older (American Automobile Association, 2008). Out of 1,185 college students, 64% reported that they had experienced accidents or near-accidents and 21% of those accidents involved at least 1 driver using a cell phone (Seo & Torabi, 2004). According to Michael Austin, in a simulation of different age groups of drivers that were texting while driving, young driver reaction time was delayed for more than four seconds before reacting to a situation (Autin, 2009).

Researchers also found that the youngest age group (18 - 24 years old) experience hazards while using a phone eight times more than the oldest group (64+ years old) (Poysti et al., 2005).

The American Automobile Association (AAA) encouraged all states to enact laws banning teens from using any wireless device while driving. AAA declared texting while driving posed an even greater safety concern than cell phone usage due to the time involved looking away from the road, and should be made illegal for drivers of all ages (American Automobile Association, 2008). CTIA suggests that education is a more effective approach to enhance drivers' awareness and responsibility (CTIA, 2010).

2.7 Cell Phone Use Banned In US

The dangers associated with cell phone usage while driving have been noticed by legislators and some states are making efforts to address this by a complete or partial ban on cell phones while driving. This is indeed a first step to reducing the cell phone as a main distraction while driving. In fact, since 1999, every state has considered such legislation (Nikolaev, Robbins, & Jacobson, 2010). In 2001, New York became the first state to enact such a law. Since then, more and more states have joined New York.

Throughout the years, more and more states have been working on laws to enhance safety issues associated with cell phones. Table 2.2 shows the state legislative activity that has been ongoing for the last 10 years to address the risks of cell phone usage while driving.

Table 2.2: Summary of State Legislative Activity

Year	Number of states that considered legislation	Number of bills introduced	Number of states that enacted laws
2001	43	140	8
2007	44	130	12
2008	33	131	7
2009	25	222	17
2010	43	270+	25

Source as of Oct 20th, 2010 (Distraction.gov, 2010).

Table 2.3 represents the most recent types of cell phone usage banning in the United States by different states. However, Fowles, Loeb, and Clarke (2010) argued that the bans do not include the use of hands-free devices as of yet, in spite of research indicating that these devices are likely to have similar adverse effects on safety to that of hand-held devices (Fowles et al., 2010). The State of Tennessee has banned texting for all drivers. Iowa, Kentucky, Michigan, Wisconsin and Wyoming were effectively banning texting near the last quarter of 2010, according to IIHS (Insurance Institute for Highway Safety, 2010). Text messaging is banned for all drivers in 30 states and the District of Columbia. In addition, younger drivers are banned from texting in 8 states and school bus drivers are banned from texting in 2 states. Nevertheless, IHHS added that as of Feb 1st, 2011, the remaining 12 states have no cell phone laws or restrictions, including the state of Florida, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Ohio, Pennsylvania, South Carolina, South Dakota, and Vermont (Insurance Institute for Highway Safety, 2011).

Table 2.3: Type of Banning of Cellular Usage in United States

States	Younger Drivers Banned From Texting	All Banned From Texting	Hand-held Phone Banned
Alabama	Yes		
Alaska		Yes	
Arkansas		Yes	
California		Yes	Yes
Colorado		Yes	
Connecticut		Yes	Yes
Delaware	Yes		
District of Columbia		Yes	Yes
Illinois		Yes	
Indiana	Yes		
Iowa		Yes	
Kansas	Yes		
Kentucky		Yes	
Louisiana		Yes	
Maine	Yes		
Maryland		Yes	
Michigan		Yes	
Minnesota		Yes	
Mississippi	Yes		
Missouri	Yes		
Nebraska	Yes		
New Hampshire		Yes	
New Jersey		Yes	
New York			Yes
North Carolina		Yes	
Oregon		Yes	Yes
Rhode Island		Yes	
Tennessee		Yes	
Texas	Yes		
Utah		Yes	
Virginia		Yes	
Washington		Yes	Yes
West Virginia	Yes		
Wisconsin		Yes	
Wyoming		Yes	

Source as of Feb 1st, 2011 (Insurance Institute for Highway Safety, 2010).

As of 2009, more than 250 bills prohibiting or restricting cell phone use while driving are pending in 42 state legislatures, despite disagreement over the risks cell phones pose and the effectiveness of enforcement (Nikolaev et al., 2010). Also, President Barrack Obama has signed an executive order stating that no federal employees are allowed to be sending text messages while driving government vehicles or when driving their own vehicles and using cell phones that are sponsored by the government (Rictel, 2009).

According to Nikolaev et al. (2010), the state of New York experienced lower fatal automobile accident rates and lower personal injury automobile accident rates after the banning of cell phone usage (Nikolaev et al., 2010). Interestingly, Fowles, Loeb and Clarke (2010) analyzed the cell phone effect on motor vehicle fatality rates regarding whether the cell phone is life-taking (accidents occurred due to the use of cell phones that may lead to death) or life-saving (witnesses that placed emergency calls to prevent a death due to vehicle accidents) and concluded that the life-taking effect is higher than the life-saving effect. They also urged policy makers to encourage their legislatures to prohibit the use of cell phones by drivers (Fowles et al., 2010).

2.8 Summary and Statement of Purpose

Cell phone use while driving is a common yet preventable driving risk. Numerous studies have shown that cell phone usage while driving has increased driver distractions and risks for crashes or near crash scenarios. Most drivers have the false sense of security that hands-free cell phone devices are safer than hand-held cell phones which can lead to unsafe driving performances. Young adult drivers are proven to use cellular phones more often and longer than any other group of drivers, which makes them more vulnerable to the risks associated with cell phone use while driving. The rapid increase of cell phone subscribers has lead to a higher number of vehicle crashes and near crashes that has caused state governments to take a closer look at their cellular phone laws. Cell phone usage while driving, especially texting, has become a significant factor contributing to driver safety issues. This research will add to the existing information regarding cell phone usage while driving and the associated risks, and will focus specifically on usage patterns of college students since this age group is most likely to engage in cell phone tasks while driving.

However, as the number of drivers who use cell phones while driving continues to grow, the interest in linking hand-held cell phone use while driving and road safety increases as well. As more technologies, including cameras, music, text messaging, and Internet browsing become available from mobile devices, they may pose an even greater risk for driver distraction.

Section 3: Methodology

The main focus of this research is to determine whether college students are facing a high risk of car crashes because of the usage of cell phones. Exploring the driving hours and investigating the usage of cell phones in different areas is the key to determining the risk of being involved in car accidents for this age group. A questionnaire was developed to ascertain information regarding three key areas:

- Driving hours
- Type of cell phone usage – talking, texting, and taking pictures
- Safety issues – incidences of crash while using cell phones

The focus of the driving hours category was to obtain information regarding the number of driving hours per week. In terms of type of cell phone usages, questions were designed to determine the type and frequency of functions used while driving. For the final category pertaining to safety issues, questions were constructed to collect information regarding the frequency of collision scenarios while using cell phones.

3. 1 Pilot Study

A pilot study was conducted to explore the current trend of college students in two categories of the study – type of cell phone usage and safety issues. A survey was developed with 9 questions in total – 8 questions for cell phone usage and 1 question for safety issues. Refer to “Pilot Survey” in Appendix for the complete questionnaire.

3.1.1 Questions for Type of Cell Phone Usage

Eight questions were developed to determine frequently used cell phone functions by college students while driving during a typical week. One of the reasons that cell phone usage was measured in a week is due to class schedules in this university. Students might be coming to campus 2 days a week, or 3 days a week or 5 days a week. Therefore, a weekly measurement will be able to predict more meaningful data. Making and answering calls are the basic functions of cell phones and this question was asked to measure students talk frequency while driving. Secondly, sending and reading text messages while driving was measured as well since this is the most important data that is needed in this research – to find out the behavior of students dealing with texting while driving. The remaining questions involved other functions of the cell phone such as incorporating a hands free device to talk while driving, browsing address books on cell phones before making a call, and taking pictures with the cell phone built-in camera.

3.1.2 Question for Safety Issues

One question was developed to address safety implications. This question was used to find out whether any of the respondents had ever been involved in a traffic accident involving the use of a cell phone either by the respondent or another driver. This was the intended key question to establish the relationship between the cell phone’s distraction and related crash rates.

3.1.3 Preliminary Survey Conclusion

The questionnaires were distributed in a class with 27 students to collect preliminary responses and to aid in development of a revised questionnaire for the expanded study.

The preliminary survey provided a promising result in terms of student interest in the study, and showed that all students reported talking on the phone while driving. Further, 66% of the students reported reading and sending Short Message Service (SMS) while driving and 6 out of 27 students reported taking pictures with their phones while driving. One student reported being involved in a crash because of cell phone usage.

3.2 Final Survey

Following the completion of the pilot survey, several questions were added for the final questionnaire to investigate email usage and "close call" scenarios – i.e. a driver reports almost being involved in a crash scenario as a result of using a cell phone while driving. The pilot study did not reveal a high crash rate because of the cell phone usage. Therefore, "close call" scenarios are needed to explore the safety category. Besides recording 'yes' or 'no' to the "close call" and crash rate, a question regarding the frequency of these events was added to the final survey. Email is another new addition to the functionality of cell phones. Therefore, a question related to email was added to the category of cell phone usage. Moreover, the pilot study revealed different minimum and maximum values for each cell phone usage type – i.e. minimum number for sending SMS is

0 while maximum number for sending SMS is 160. In order to obtain more meaningful statistics, a question regarding driving hours was added for a better characterization and comparison of the final survey data. The final version of the survey consisted of 15 questions, with 1 question for driving hours, 10 for type of usage, and 4 focused on safety issues. A copy of “Final Survey” is appended in Appendix.

3.2.1 Question for Driving Hours

As mentioned earlier concerning driving hours, more clearly defined relationships can be established by determining the number of driving hours that students are commuting in a vehicle per week. Relationships can be established by looking at driving hours versus cell phone talking hours or even number of text messages sent or read. This question was added to make analysis of the rest of the cell phone functionality questions much more meaningful.

3.2.2 Questions for Type of Cell Phone Usage

In addition to the questions used in the pilot study, questions regarding composing and reading emails were added to the final survey. With driving hours being added to the final survey, this survey was able to draw more information related to the behavior of college students using cell phone functionality while driving including talking on the phones; reading, composing and sending short text messages or emails; and also the rest of the cell phone functions that were mentioned in pilot study, which includes browsing address books, using hands free devices, or taking pictures with cell phones while driving. With a variety of different usages of cell phone functions while driving posted on the final survey, more refined data can be collected identifying particular functions that may cause safety issues for college students while performing the driving task.

3.2.3 Questions for Safety Issues

A new question was developed to find the number of “close call” incidents that students encountered while driving and performing any of the previously defined cell phone usages. For the purpose of this research, “close call” is defined as a situation where a student has successfully prevented a traffic accident; ie., drift into lane, stop short, or having to “slam on brakes”, etc. With the addition of this question, more detailed safety information was collected for the relationship between safety issues and cell phone usage for college students since the “close call” rate was anticipated to be higher than crash frequency. However, the time frame over which the respondents were asked to report for this question was changed from typical ‘one week’ time frame in previous questions on the survey. It was anticipated that the rate of “close call” occurrences would still be fairly infrequent, thus, measuring the “close call” situations in a week may not appropriately reflect occurrences. Therefore, a 30-day time period was used instead of a week for the reporting period on the survey.

3.2.4 Final Survey Conclusion

The questionnaire was posted on the web and announced through an email from The Office of the Provost at the University of Memphis on February 12, 2009 to all the students in the University of Memphis. Responses from the survey were collected from February 12, 2009 until April 10, 2009. Two thousand four hundred sixty nine students submitted responses. Twenty four responses were removed from the database because of incomplete or impossible responses – such as driving more than 150 hours in 7 days; texting 5,000 messages in 7 days and so forth.

Nevertheless, the dataset still contained extreme outliers that are hard to justify and are considered outside of acceptable range. For instance, there are several responders that have reported more than 76 driving hours, students who have claimed texting (both sending and reading SMS) combining to totals of 2,000 texts per week. In order to obtain a more meaningful dataset, a box plot analysis was performed. Based on the result of the box plot, further judgment was used to identify extreme outliers to be trimmed from the database. 192 responses were removed from the dataset bringing the new total to 2,253 for the new dataset.

Descriptive statistics and Mann-Whitney U test were performed using Statistical Package for the Social Sciences (SPSS) on the results of the survey in Section 4. The results will be reported as the following breakdown:

1. Descriptive statistics and frequency column of 2,553 responders,

2. Descriptive statistics, Mann-Whitney U test and frequency columns of 2,052 responders without crashes, and
3. Descriptive statistics, Mann-Whitney U test and frequency column of 201 responders with crashes.

3.3 Analysis Methodology

3.3.1 Descriptive Statistics

The central tendency and variability of the data set were examined via descriptive statistics. In terms of central tendency, mean and median of all observed variables were determined. Using the mean (X) as a method to describe central tendency the following formula was used:

$$X = \frac{\sum yi}{n}$$

Where $\sum yi$ is the sum of all measurements (i denotes any one measurement in a series), and n is the number of measurements made. Based on the equation, the mean for each variable is the sum of all possible scores divided by the total number of scores. Because the computation of mean is sensitive to extreme scores (or outliners), the medians were also examined. Whereas means represent the average scores, medians represent the central point of the variables. The median is identified as the value that is in the middle of the dataset. Because the derivation of median does not involve arithmetic procedures, it is not sensitive to extreme scores, which were commonly observed in the current data set.

Standard deviation and variance are used to estimate the dispersion in the datasets. To compute standard deviation (s), the following formula is applied:

$$s = \sqrt{\frac{\sum(yi - X)^2}{n-1}}$$

To determine the variance (s^2), the following equation is applied:

$$s^2 = \frac{\sum(yi - X)^2}{n-1}$$

Standard deviation is sensitive to extreme scores, but is useful in describing the average discrepancy for each variable about the mean of the dataset.

3.3.2 Mann-Whitney U Test

The Mann-Whitney U test is a non-parametric hypothesis test that is used as an alternative to the parametric t-test. The test is equivalent to the Wilcoxon Rank Sum test. Two independent samples are used to determine whether or not one population is stochastically larger than the other.

This non-parametric test is chosen because the data that has been collected are not normally distributed, are highly skewed, and are not continuous.

As an attribute of a non-parametric test, Mann Whitney U does not require any assumptions regarding the underlying distribution. However, there are three assumptions regarding use of this test including random and independent samples, along with an ordinal measurement scale.

To calculate the value of Mann-Whitney U test, the following formula is applied:

$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - \sum_{i = n_1 + 1}^{n_2} R_i$$

Where: U is Mann-Whitney U test, n_1 is the sample size one, n_2 is the sample size two and R_i is the rank of the sample size.

Two tables are presented in the results section for the Mann-Whitney U test. The first table includes the mean rank and sum of ranks. In order to produce sum of ranks, sample data are sorted in ascending order, without regard to which sample the data comes from. If two or more observations are identical, the ranks would be averaged and all tied observations assigned this averaged rank. Once the rank is assigned, the sum of ranks can be computed by adding the rank of all observations for each sample. With the sum of ranks computed, the mean rank can be obtained by dividing sum of ranks by the total number in that group.

The second table shows the Mann-Whitney U results. The U value is approximated by the Z statistic, which has an asymptotic distribution, when the sample size is large (which is true in this case). The Z distribution has a mean of 0 and standard deviation of 1. The significance of the Mann- Whitney U test will be based on one-tailed test with a significance level of 95% ($p < .05$). In other words, for any Z value that is beyond 1.65, the null hypothesis of identical distributions would be rejected.

Section 4: Results

The following tables present the results of the final survey. Responses from the survey were collected from February 12, 2009 until April 10, 2009. Two thousand two hundred fifty three appropriate responses were used to generate the results. A copy of the questionnaire is included in the Appendix section. Section 4.1 represents the overall results for descriptive statistics for 2,253 college students, 2,052 responders that are not involve in any crashes and 201 students who were involved in crashes due to the usage of the cell phone while driving. Section 4.2 displays the frequency column of the three respective break down as demonstrate in Section 4.1. Lastly, Section 4.3 presents the analysis of Mann-Whitney T test by dividing the students into 2 groups – students involved in crashes and students without crashes.

4.1 Descriptive Statistics

Table 4.1.1 presents the abbreviations that are used in Table 4.1.2, Table 4.1.3, and Table 4.1.4. These abbreviations represent the 15 questions and responses that are being presented in the Descriptive Statistics Tables (Table 4.1.2, Table 4.1.3, and Table 4.1.4).

Table 4.1.1: Explanation of the Abbreviations Used in Descriptive Statistics Table and Ranks Table

Abbreviation	Description
dh	Number of hours a student drives in a week
c	Number of calls a student makes while driving in a week
a	Number of calls a student answers while driving in a week
hf	Has student ever used a hands free device to talk on phone while driving (0 = No, 1 = Yes)
ab	Has student ever browsed the address book to locate a contact number while driving (0 = No, 1 = Yes)
rms	Number of text messages a student types and sends while driving in a week
sms	Number of text messages a student reads while driving in a week
rml	Number of emails a student composes and sends while driving in a week
sml	Number of emails a student reads while driving in a week
p	Has student ever taken pictures with a cell phone while driving (0 = No, 1 = Yes)
pf	Number of pictures a student photographs while driving in a week
cc	Has student ever been involved in a close call situation involving the use of a cell phone either by the student or another driver (0 = No, 1 = Yes)
ccf	Number of close call situations involving a cell phone used a student faced in the last 30 days
ac	Has student ever been involved in traffic accident involving the use of a cell phone either by the student or another driver (0 = No, 1 = Yes)
acf	Number of crashes involving cell phone usage a student has faced

Table 4.1.2 presents descriptive analysis of the overall results. The 15 responses that are gathered from 2253 students were analyzed with SPSS 13.5. The descriptive statistics that were gathered include range, minimum, maximum, mean, median, standard deviation and variance. Range reported as 1 indicates a

yes or no response (0= No, 1 = Yes). Table 4.1.3 represents descriptive statistics for students who were not involved in crashes while Table 4.1.4 presents the remaining 201 students who were reported to have suffered crashes.

Table 4.1.2: Overall Descriptive Statistics for Different Cell Phone Usages (obtained from SPSS 13.5)

N = 2253	Range	Minimum	Maximum	Mean	Median	Standard deviation	Variance
dh	23	0	23	8.18	7	4.88	23.80
c	50	0	50	8.44	5	9.07	82.26
a	50	0	50	7.28	5	8.07	65.18
hf	1	0	1	0.16	0	0.37	0.36
ab	1	0	1	0.43	0	0.50	0.25
rms	200	0	200	13.49	2	27.11	734.95
sms	200	0	200	18.83	4	27.61	762.33
rml	100	0	100	0.58	0	4.2	17.72
sml	100	0	100	1.15	0	5.37	28.89
p	1	0	1	0.12	0	0.32	0.10
pf	35	0	35	0.24	0	1.28	1.64
cc	1	0	1	0.62	1	0.49	0.24
ccf	30	0	30	1.23	0	2.31	5.32
ac	1	0	1	0.09	0	0.29	0.08
acf	10	0	10	0.10	0	0.42	0.18

Table 4.1.3: Students Not Involved In Crashes Descriptive Statistics for Different Cell Phone Usages (obtained from SPSS 13.5)

N = 2052	Range	Minimum	Maximum	Mean	Median	Standard deviation	Variance
dh	23	0	23	8.22	7	4.89	23.90
c	50	0	50	8.38	5	9.00	80.39
a	50	0	50	7.22	5	7.93	62.89
hf	1	0	1	0.16	0	0.37	0.14
ab	1	0	1	0.42	0	0.50	0.24
rms	200	0	200	13.21	2	27.02	729.84
sms	200	0	200	14.52	4	27.39	750.44
rml	100	0	100	0.57	0	4.3	18.77
sml	100	0	100	1.06	0	5.12	26.24
p	1	0	1	0.11	0	0.31	0.10
pf	35	0	35	0.23	0	1.31	1.72
cc	1	0	1	0.60	1	0.49	0.24
ccf	30	0	30	1.13	0	2.19	4.81

Note: All 2051 responders has ac = no

Table 4.1.4: Students Involved in Crashes Descriptive Statistics for Different Cell Phone Usages (obtained from SPSS 13.5)

N = 201	Range	Minimum	Maximum	Mean	Median	Standard deviation	Variance
dh	23	0	23	7.80	7	4.77	22.71
c	50	0	50	9.06	6	10.07	101.42
a	50	0	50	7.92	5	9.41	88.55
hf	1	0	1	0.13	0	0.34	0.12
ab	1	0	1	0.47	0	0.50	0.25
rms	150	0	150	16.37	1.4	27.96	781.91
sms	150	0	150	18.00	5	29.61	876.92
rml	20	0	100	0.64	0	2.65	7.01
sml	75	0	100	2.01	0	7.37	54.28
p	1	0	1	0.19	0	0.39	0.15
pf	5	0	35	0.37	0	0.91	0.83
cc	1	0	1	0.83	1	0.38	0.15
ccf	20	0	30	2.23	1	3.08	9.47
acf	10	0	10	1.09	1	0.94	0.89

Note: All 201 responders has ac = yes

4.2 Frequency Tables

The following sections present results regarding response frequencies based upon the three categories of questions. The questions were grouped according to those addressing driving hours, type of cell phone usage, and safety issues. Each individual figure is then spilt into three different responders as mentioned: overall responders, responders without crashes and responders involved in crashes.

4.2.1 Driving Hours

Two thousand two hundred twenty four out of 2,253 (about 99%) of respondents indicated that they are driving to the campus. The mean number of driving hours per week is 8.2 hours, with a median of 7 hours per week and a standard deviation of 4.9 hours per week. Figure 4.2.1.1 shows the frequency of responses to the number of driving hours per week question. Respondents were required to estimate the number of their driving hours each week. As shown by Figure 4.2.1.1, the most frequently reported number of driving hours is 10 hours per week with 330 responses. About 37% of those surveyed reported driving between 5 and 8 hours per week. 23% of the respondents are driving more than 10 hours per week.

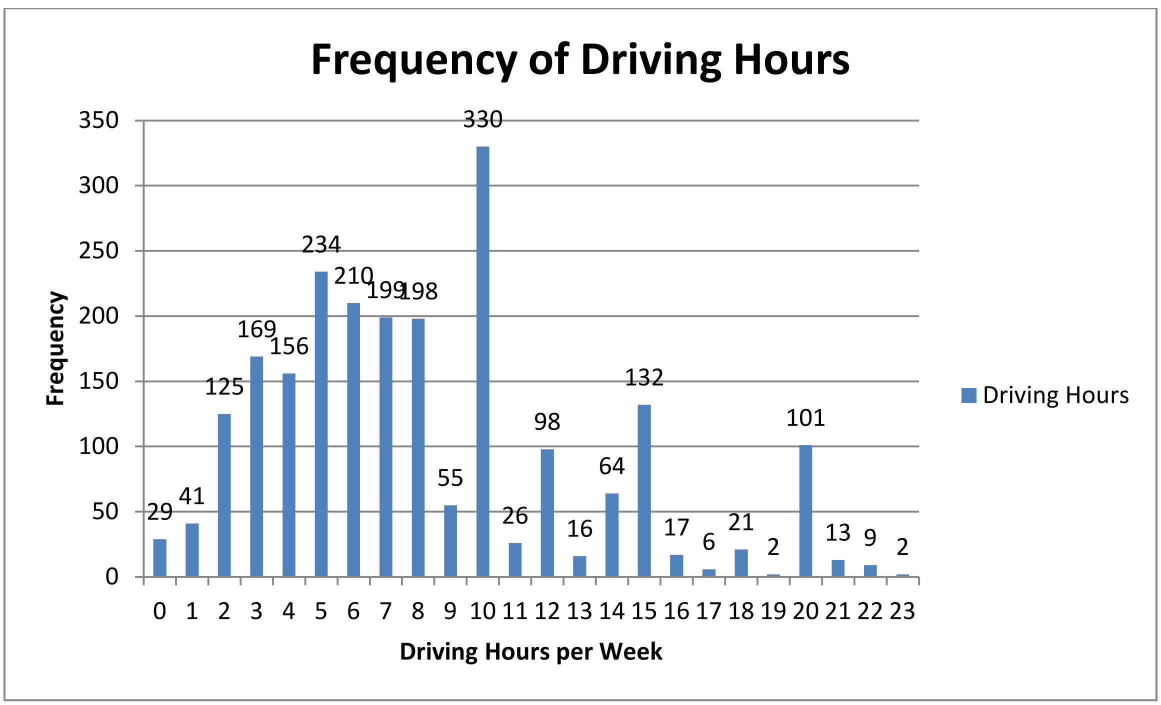

Figure 4.2.1.1: Frequency of Driving Hours per Week

Figure 4.2.1.2 shows the frequency of responses to the number of driving hours per week question and for respondents that were not involved in any crashes. 99% of these respondents reported that they are driving to the campus. The mean, median and standard deviation number of driving hours per week is reported to be the same as the overall result. Figure 4.2.1.2 has a similar result as Figure 4.2.1.1, with the most frequently reported number of driving hours (1o hours per week) with 296 responses.

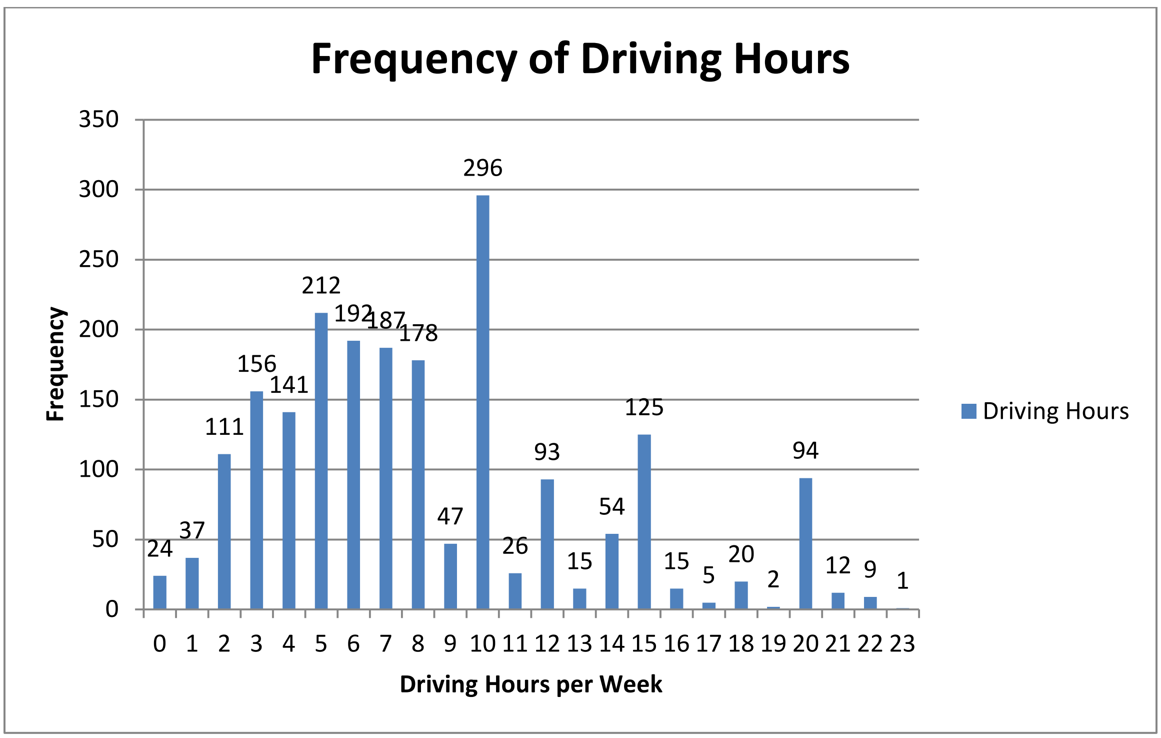

Figure 4.2.1.2: Frequency of Driving Hours per Week (Not Involved in Crashes)

Figure 4.2.1.3 shows the frequency of responses to the number of driving hours per week question for respondents who were reported being involved in crashes because of cellphone usages. However, 5 of these students were also reported they did not drive to campus (students who were carpooling). The mean, median and standard deviation is lower compared to the other two groups, with values of 7.8, 7.0, and 4.8, respectively, per hours per week. Figure 4.2.1.3 still indicates 10 hours per week is being reported as the most frequent number of driving hours with 34 respondents (about 17%) in this case. Most students are driving between 2 to 10 hours per week similar to both Figure 4.2.1.1 and Figure 4.2.1.2.

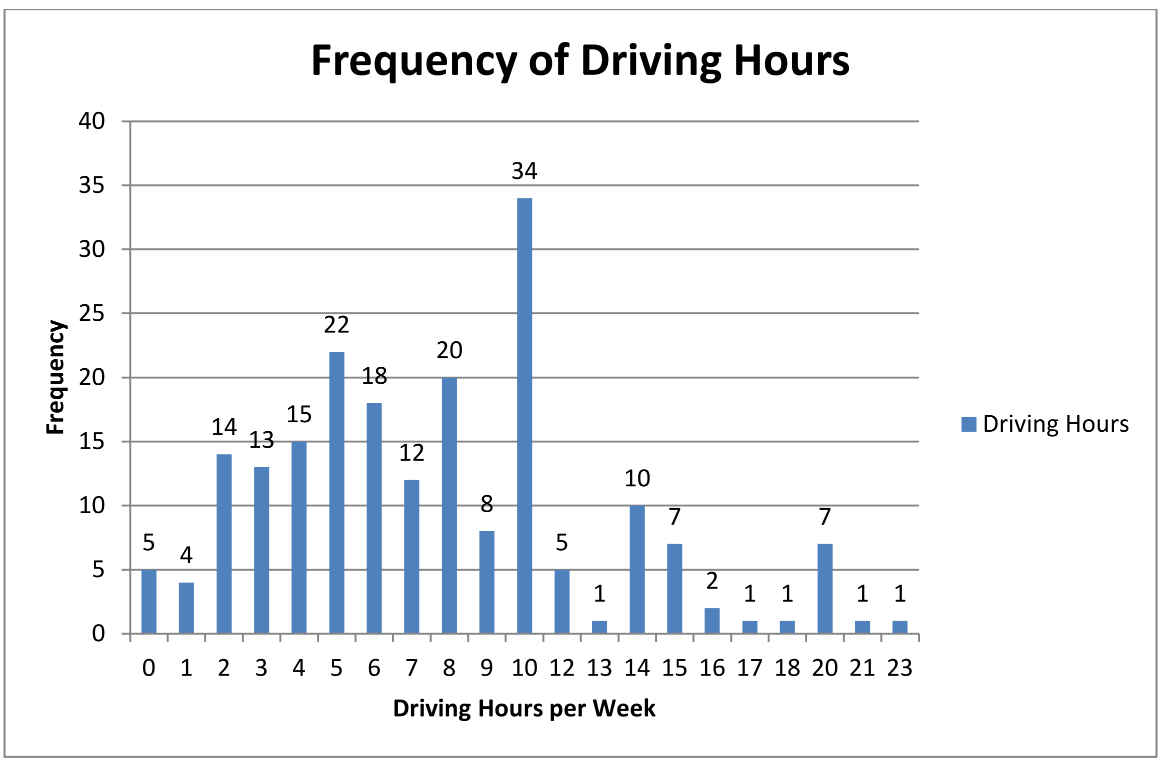

Figure 4.2.1.3: Frequency of Driving Hours per Week (Involved in Crashes)

4.2.2 Type of Cell Phone Usage

In terms of frequency of cell phone use, analysis of survey responses indicates the mean number of calls while driving per week is 8.4, with a median of 5.0, and a standard deviation of 9.1. For answering calls while driving per week, the survey results show a mean of 7.28, with a median of 5.0, and standard deviation of 8.1. 2,023 out of 2,253 responses (about 90%) indicate drivers are making calls while driving while 2,135 out of 2,253 responses (about 95%) indicate drivers are answering calls. Figure 4.2.2.1 provides additional data regarding the frequency of making and answering calls while driving. The results show the most frequent number reported for making calls and answering calls is 5 calls per week. In this case, 270 responses (about 12%) indicated students surveyed were making calls and 309 responses (about 14%) indicated students were answering calls.

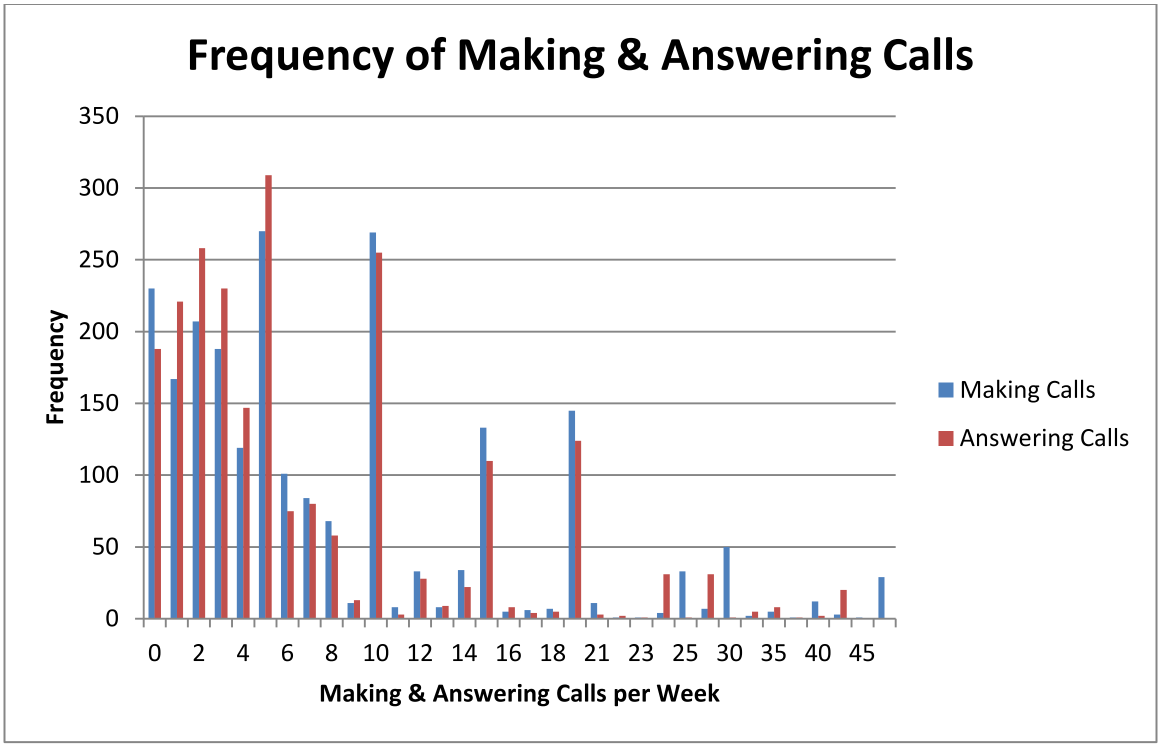

Figure 4.2.2.1: Frequency of Calling and Answering Calls while Driving per Week

Figure 4.2.2.2 and Figure 4.2.2.3 breaks down respondents from Figure 4.2.2.1 into two scenarios, students involved in crashes and students that were not involved in any crashes. For students that were not involved in crashes, the mean number of calls while driving per week is 8.4, with a median of 5.0, and a standard deviation of 9.0. For answering calls while driving per week, the survey results show a mean of 7.2, with a median of 5.0, and standard deviation of 7.9. The most frequent reported number of making and answering calls in Figure 4.2.2.2 is 5 calls per week and the second most reported is 10 calls per week.

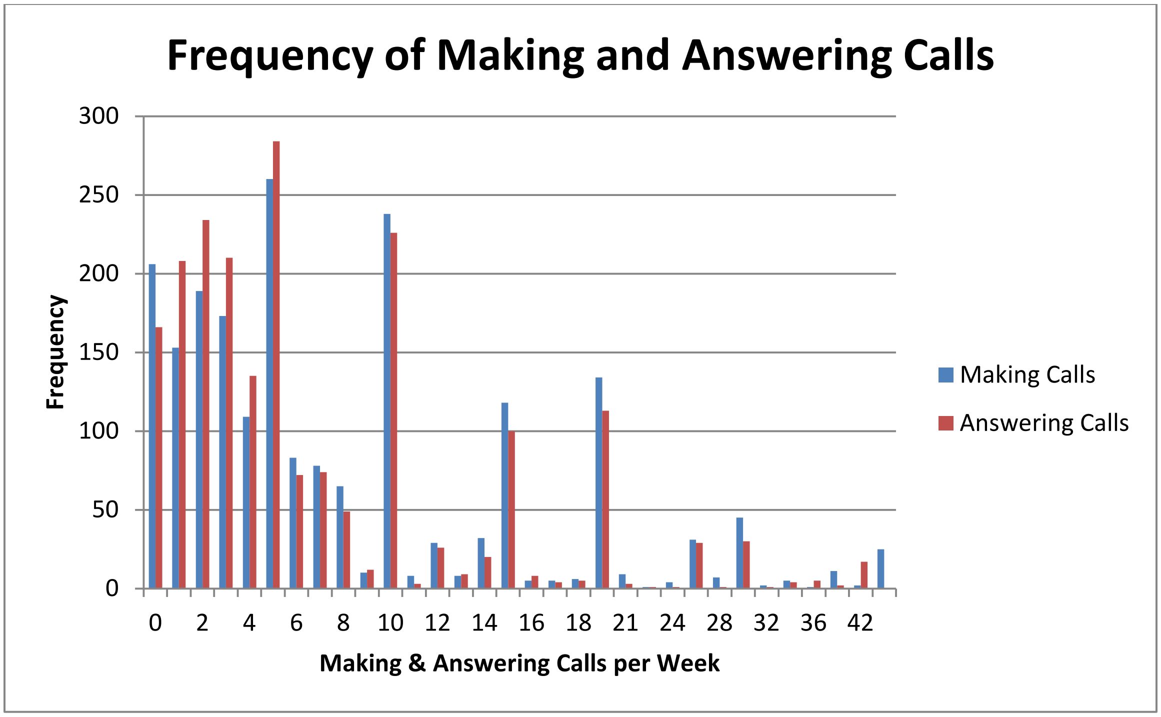

Figure 4.2.2.2 Frequency of Calling and Answering Calls while Driving per Week (Not Involved in Crashes)

The mean, median and standard deviation determined for Figure 4.2.2.3 for making calls is 9.1, 6.0 and 10.1 while answering calls is 8.0, 5.0, and 9.4. Figure 4.2.2.3 shows a different pattern compared to Figure 4.2.2.1 and Figure 4.2.2.2. Observation reveals that students that were involved in crashes have been making more calls than answering calls. Calculations revealed that students make 1.14 times more calls compared to answering calls in this category. Also, the most reported is 10 calls per week, compared to 5 calls in Figure 4.2.2.1 and Figure 4.2.2.2.

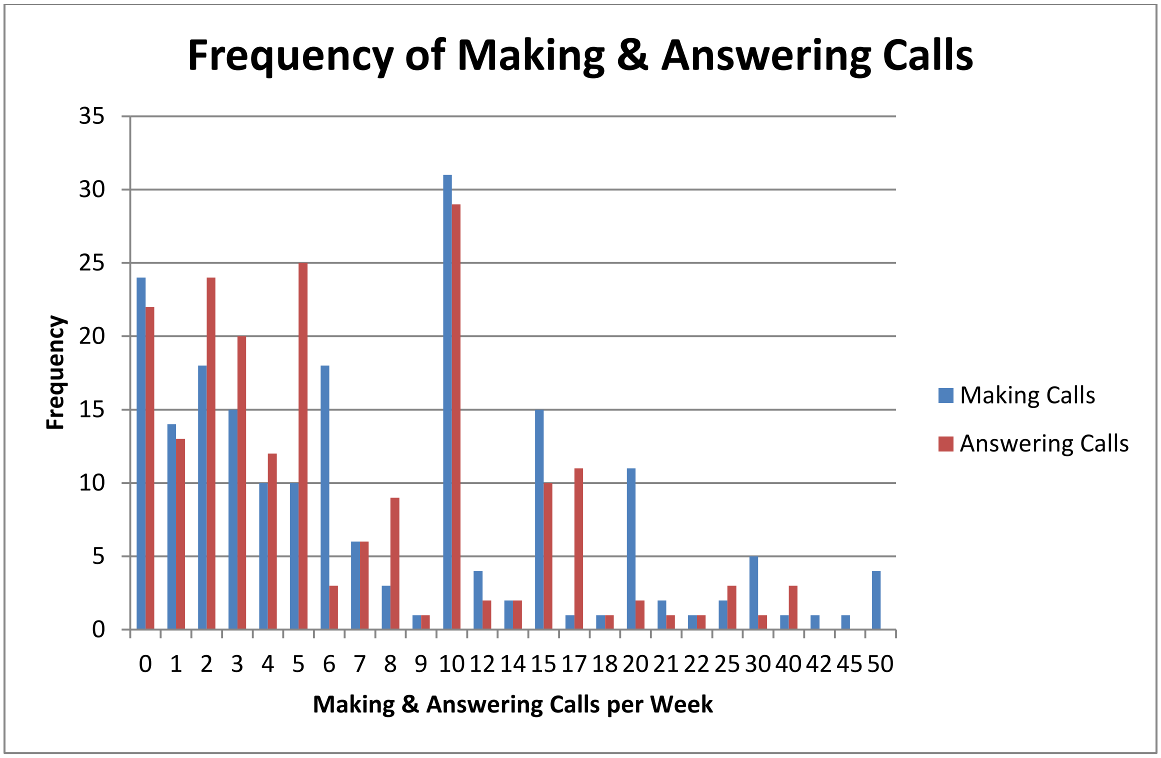

Figure 4.2.2.3 Frequency of Calling and Answering Calls while Driving per Week (Involved in Crashes)

Out of 2,253 responses collected, 364 college students (about 16%) are using hands free devices while driving which leaves the remaining 1889 users who are not using hands free devices or are not using cell phones while driving. Approximately 960 college students (about 43%) are using address books while driving. Figure 4.2.2.4 shows responses about usage of hands free devices and address book functions while driving.

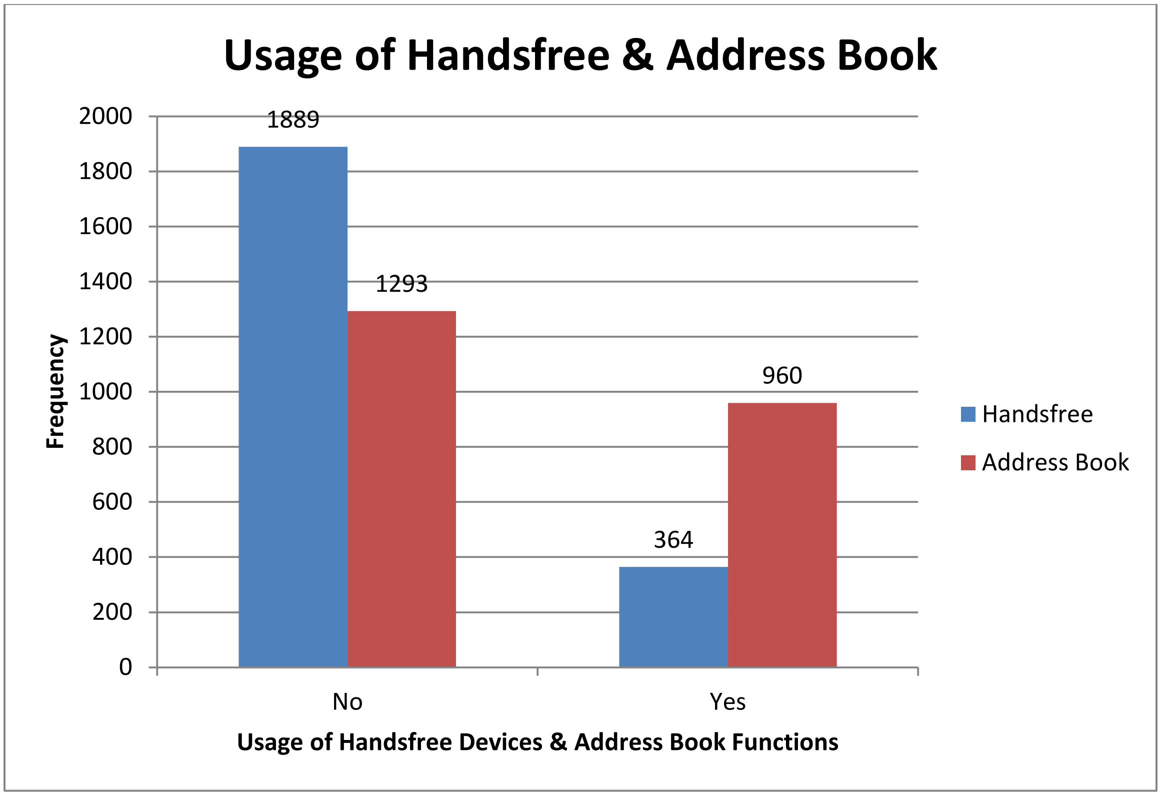

Figure 4.2.2.4: Number of Users Using Hands Free and Address Book while Driving

Figure 4.2.2.5 and Figure 4.2.2.6 break down the respondents to students not involved in crashes and students involved in crashes. The three figures share similar trends with higher percentage of respondents saying no to usage of hands free devices and address book functions. However, Figure 4.2.2.6 shows a higher usage of address book (about 47%) as opposed to Figure 4.2.2.4 and Figure 4.2.2.5.

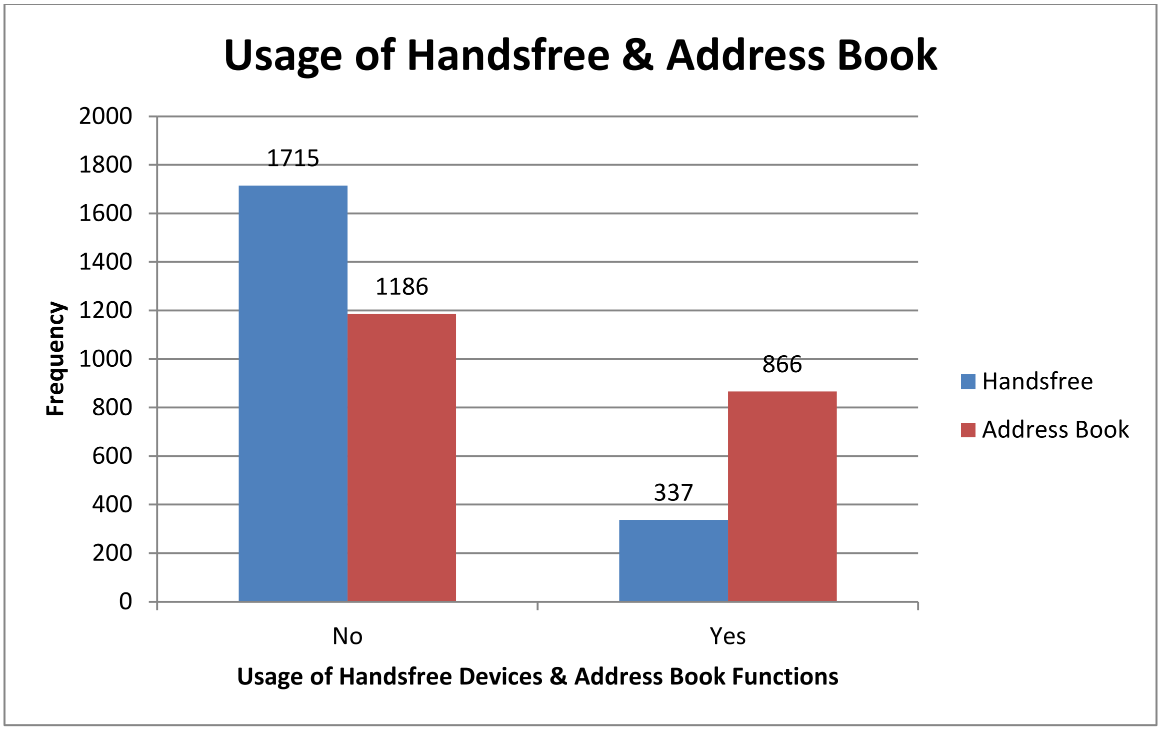

Figure 4.2.2.5: Number of Users Using Hands Free and Address Book while Driving (Not Involved in Crashes)

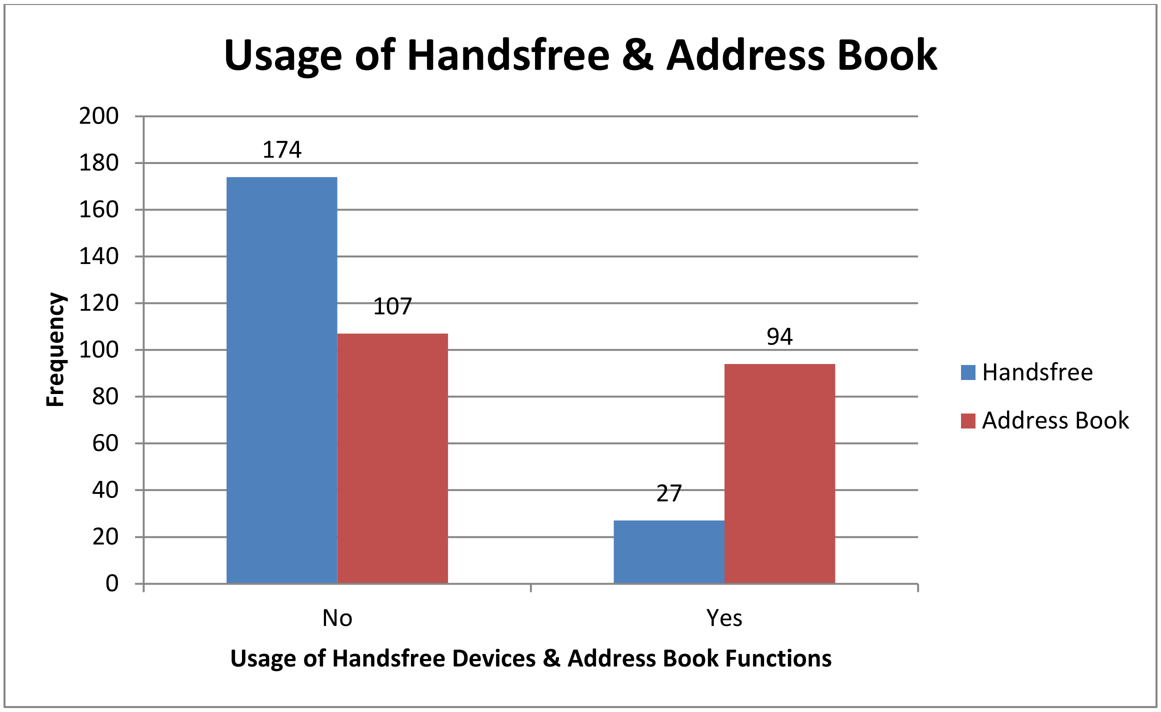

Figure 4.2.2.6: Number of Users Using Hands Free and Address Book while Driving (Involved in Crashes)

One thousand four hundred thirty out of 2,253 (about 63%) responses indicate drivers are reading SMS while driving and 1,965 out of 2,253 (about 77%) drivers are sending SMS while driving. The mean, median and standard deviation for reading SMS while driving are 13.5, 2.0 and 27.1, respectively. The mean, median and standard deviation for sending SMS while driving are 18.8, 4.0 and 27.6, respectively. Figure 4.2.2.7 shows the frequency of reading and sending SMS while driving per week. According to Figure 4.2.2.7, 189 respondents are reading 1 SMS per week while driving. This number is the most frequent number of messages being read in a week. Figure 4.2.2.7 also shows that 203 respondents are sending 1 SMS per week while driving. This number is also the most frequent number of messages being sent in a week. Interestingly, the second most frequent number of messages being read and sent in a week is 10 messages per week while driving. 144 respondents are shown reading 10 messages per week while driving while 171 respondents are shown sending 10 messages per week while driving.

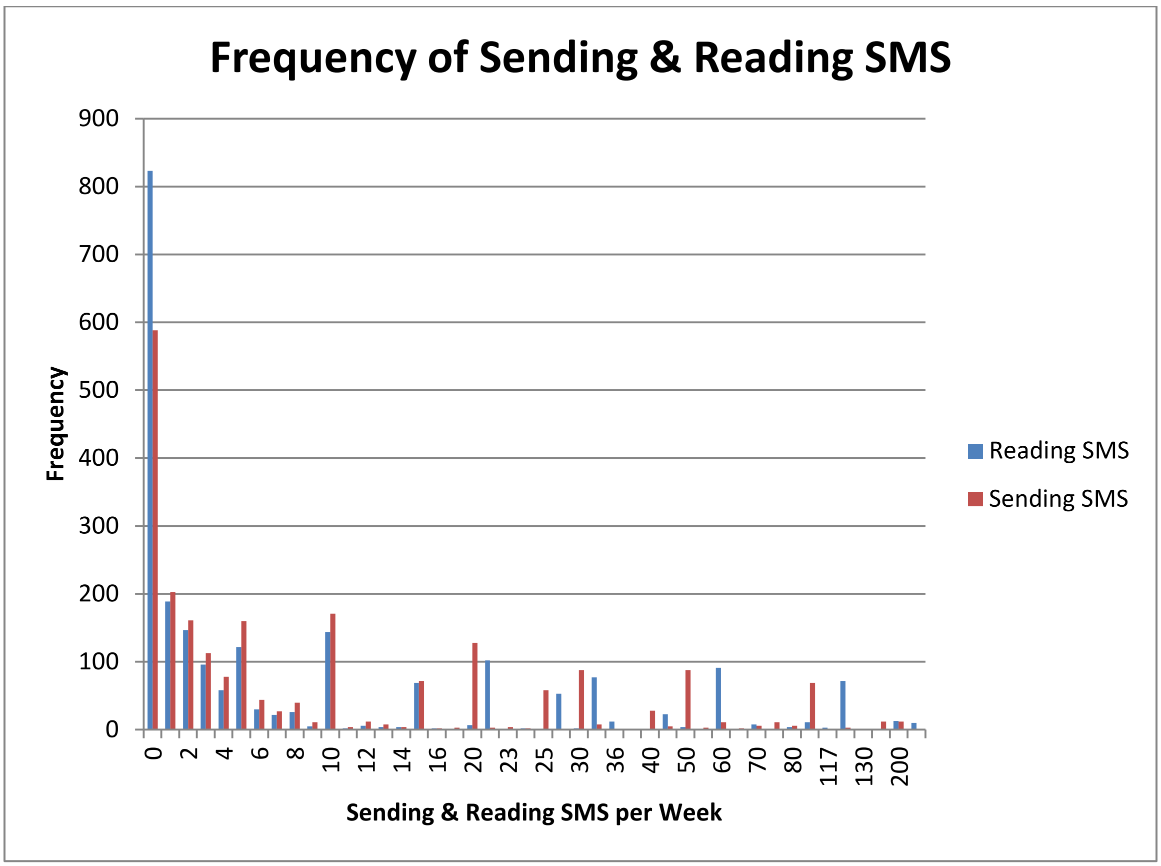

Figure 4.2.2.7: Frequency of Sending and Reading SMS while Driving per Week

Figure 4.2.2.8 shows the frequency of reading and sending SMS while driving per week for students who are not involved in crashes. According to Figure 4.2.2.8, 176 respondents are reading 1 SMS per week while driving. This number is the most frequent number of messages being read in a week. Figure 4.2.2.7 also shows that 189 respondents are sending 1 SMS per week while driving. Figure 4.2.2.8 has a similar trend to Figure 4.2.2.7.

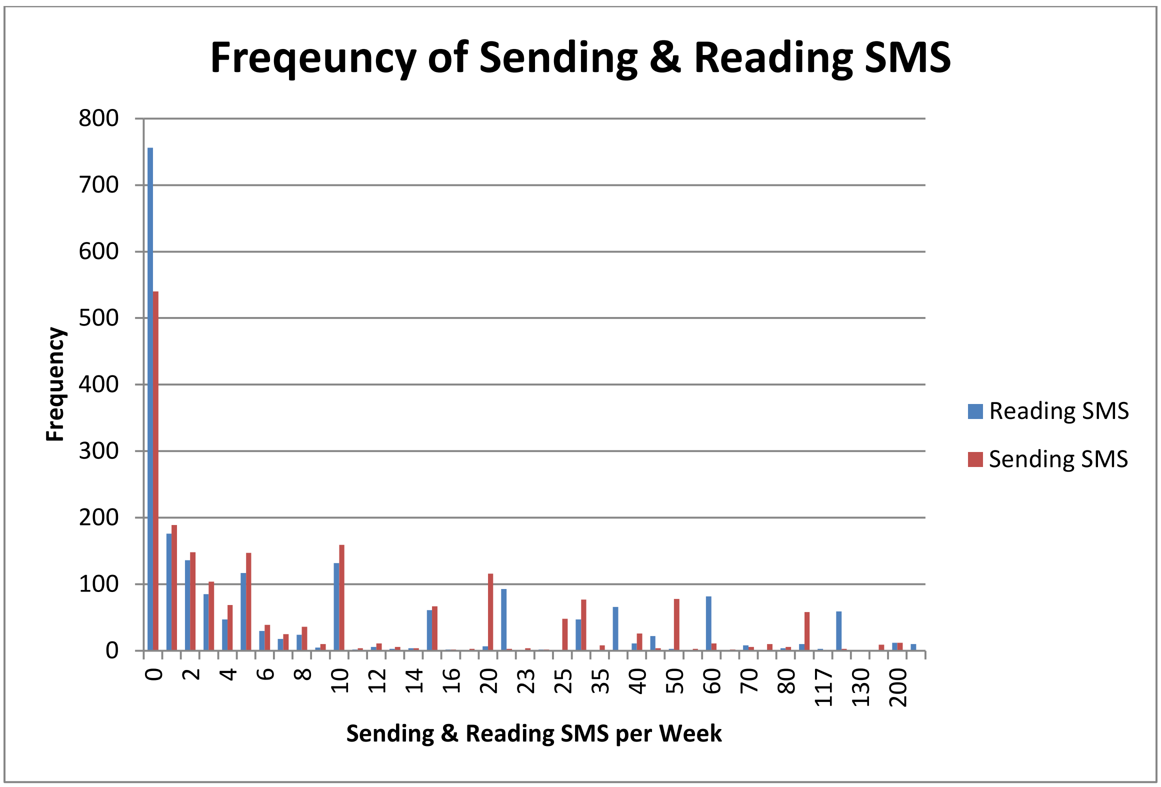

Figure 4.3.2.8: Frequency of Sending and Reading SMS while Driving per Week (Not Involved in Crashes)

Figure 4.2.2.9 shows the frequency of reading and sending SMS while driving per week for students who are involved in crashes. 67% of respondents admitted to reading SMS while driving and 74% of students admitted to sending SMS while driving. Figure 4.2.2.9 has a different trend that suggests a higher probability of students distracted while driving. The most frequent reported number for reading SMS is 1 and 100 messages per week. While the most reported number for sending SMS is 1, 2, and 5 (reported 13 times) per week, follows by 10 and 20 (reported 12 times) per week and 30 and 100 per week being reported as 11 appearances.

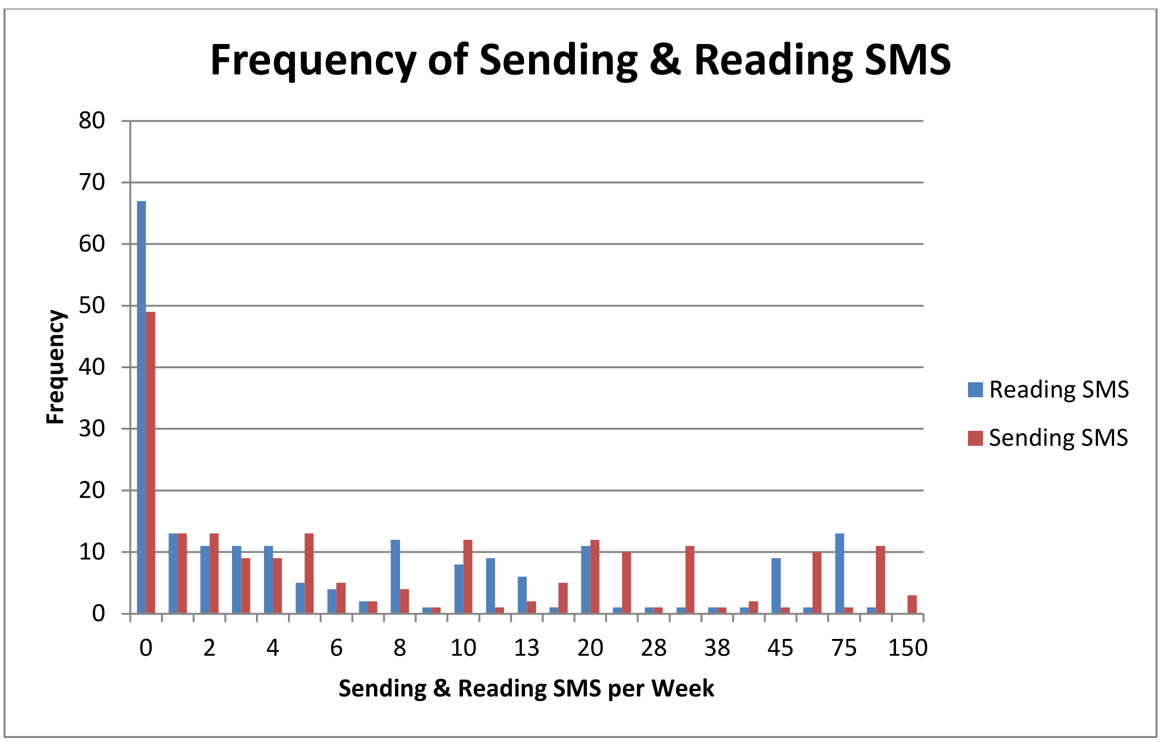

Figure 4.2.2.9: Frequency of Sending and Reading SMS while Driving per Week (Involved in Crashes)

One hundred sixty four out of 2253 responding drivers (about 7%) are reading emails while driving and 301 out of 2,253 (about 13%) are sending emails while driving. Figure 4.5 shows the different frequencies reported for reading emails and sending emails while driving in a week. As shown in Figure 4.2.2.10, 114 out of 164 respondents (about 70%) who claimed to send emails while driving are sending up to 5 emails per week while driving. In addition, 194 out of 301 college students (about 64%) who claimed to read emails while driving are reading up to 5 emails per week while driving. These numbers represent the most frequently reported values for sending and reading emails per week while driving based on this survey.

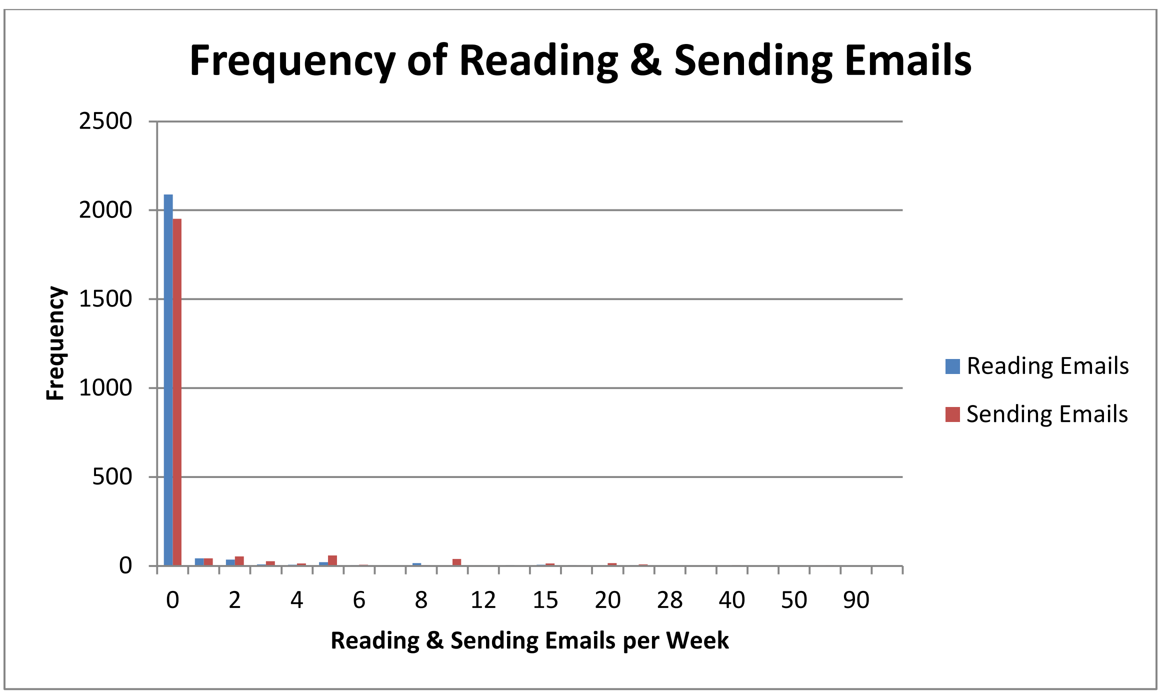

Figure 4.2.2.10: Frequency of Sending and Reading Emails while Driving per Week

Figure 4.2.2.11 shows the email activities for the respondents who reported they were not involved in any crashes due to cell phones usage. As suggested by Figure 4.2.2.10 previously, 90% of the students reported not using email on the mobile phones while driving. Therefore, similar structure can be observed in Figure 4.2.2.11. 93% of students responded that they are not reading emails while driving and 87% students responded that they are not sending emails while driving. The most reported frequency for both reading and sending emails are 1 email per week, followed by 2 emails per week, while driving using mobile phones.

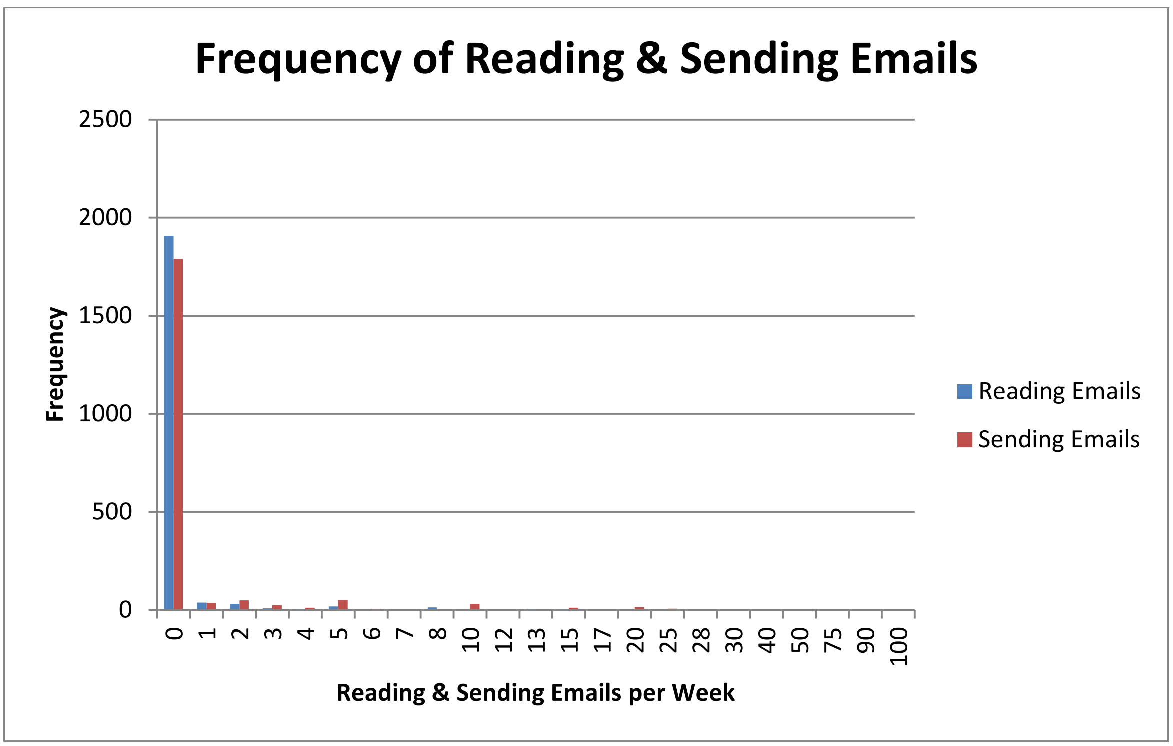

Figure 4.2.2.11: Frequency of Sending and Reading Emails while Driving per Week (Not Involved in Crashes)

Figure 4.2.2.12 presents the usage of email activities by students who admitted to have suffered crashes due to the usage of mobile phones while driving. Similar trend can be observed compared to the previous two figures such that only 10% students responded to have read emails while driving and about 20% students responded to have send emails while driving. Nevertheless, the percentages of reading and sending emails are higher in this group of students.

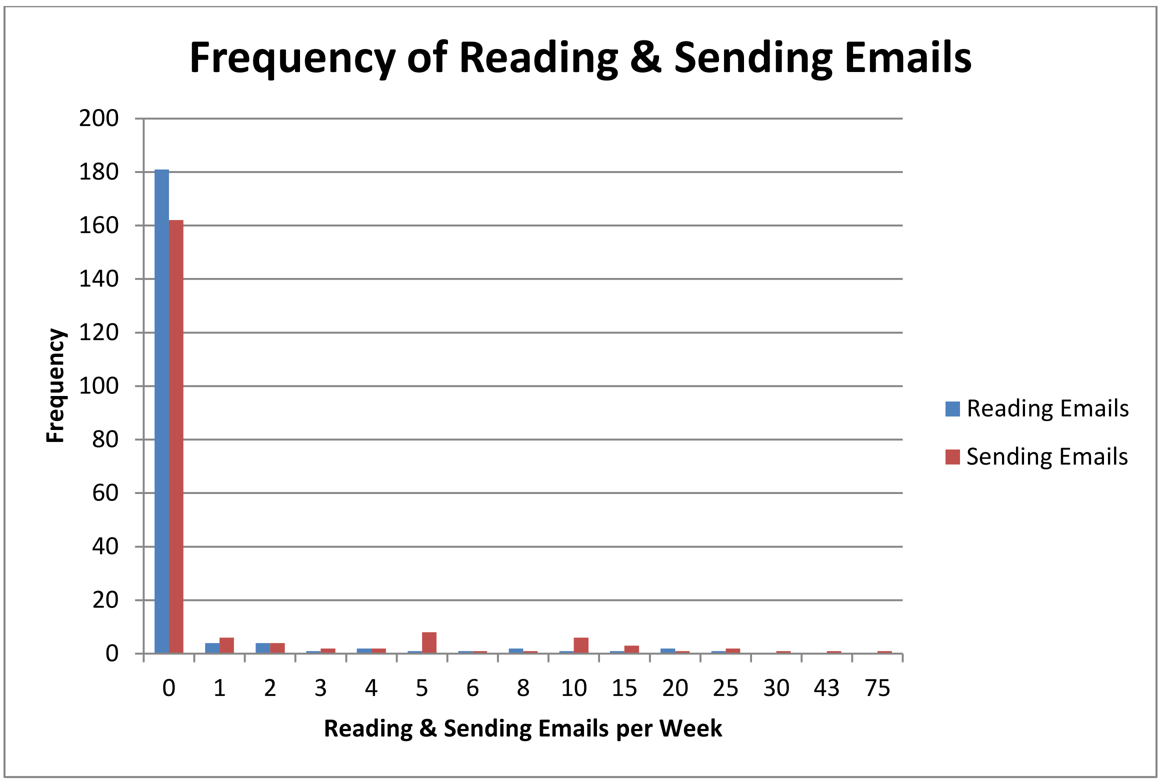

Figure 4.2.2.12: Frequency of Sending and Reading Emails while Driving per Week (Involved in Crashes)

Two hundred sixty three out of 2253 college students (about 12%) responded that they are taking pictures with their cell phone while driving. Figure 4.2.2.13 shows the different numbers of pictures reported being taken while driving with a cell phone in a week. According to the survey responses, the most frequent response for taking pictures while driving is 1 picture per week. There are 161 out of 263 (about 62%) responses in this case.

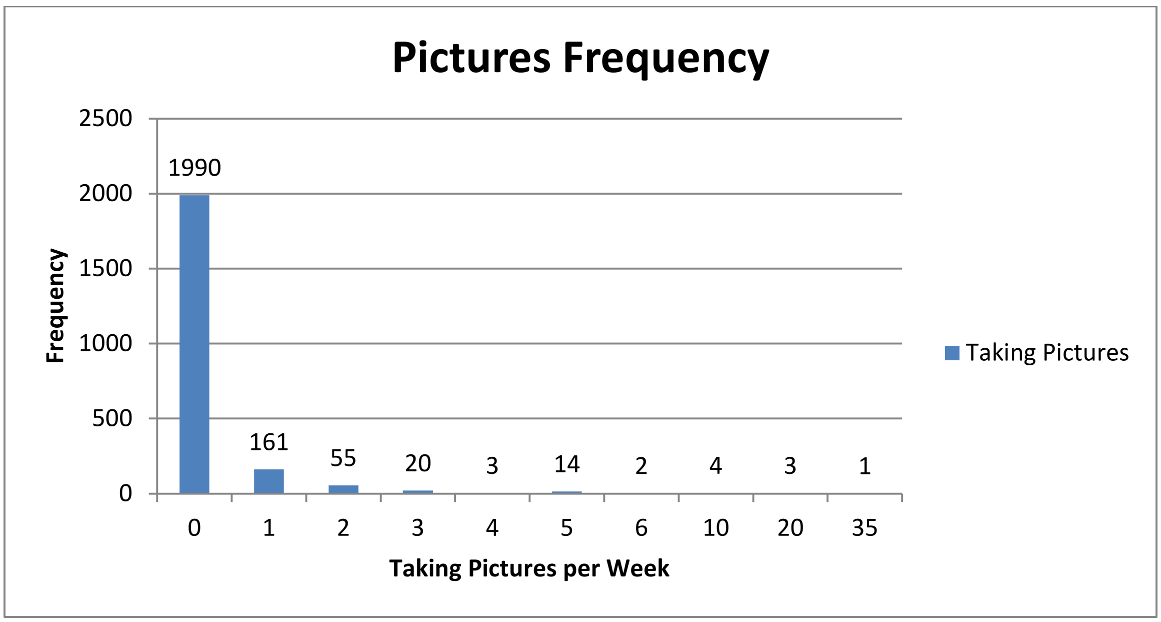

Figure 4.2.2.13: Frequency of Taking Pictures while Driving per Week

Figure 4.2.2.14 describes the pictures taken by students while driving for students reporting they were not involved in crashes due to performing cell phone activities while driving. About 10% of students claim that they are taking pictures while driving and the most frequent reported number is 1 picture per week, followed by 2 pictures per week as the second most reported value.

Figure 4.2.2.15 shows the pictures frequency by the students who have reported to have been involved in crashes due to cell phone usage. About 18% of the students reported to have taken pictures with a cell phone while driving. This percentage is nearly twice as many as compared to Figure 4.2.2.14. The most reported frequency in this case is 1 and 2 picture/s per week while driving which tie at 13 respondents each.

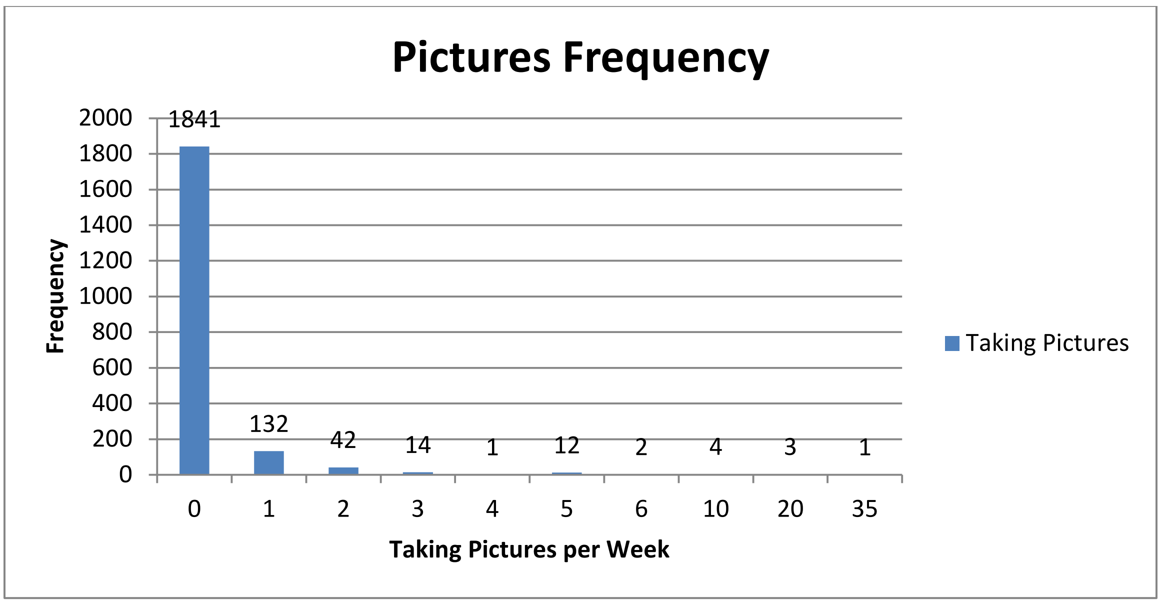

Figure 4.2.2.14: Frequency of Taking Pictures while Driving per Week (Not Involved in Crashes)

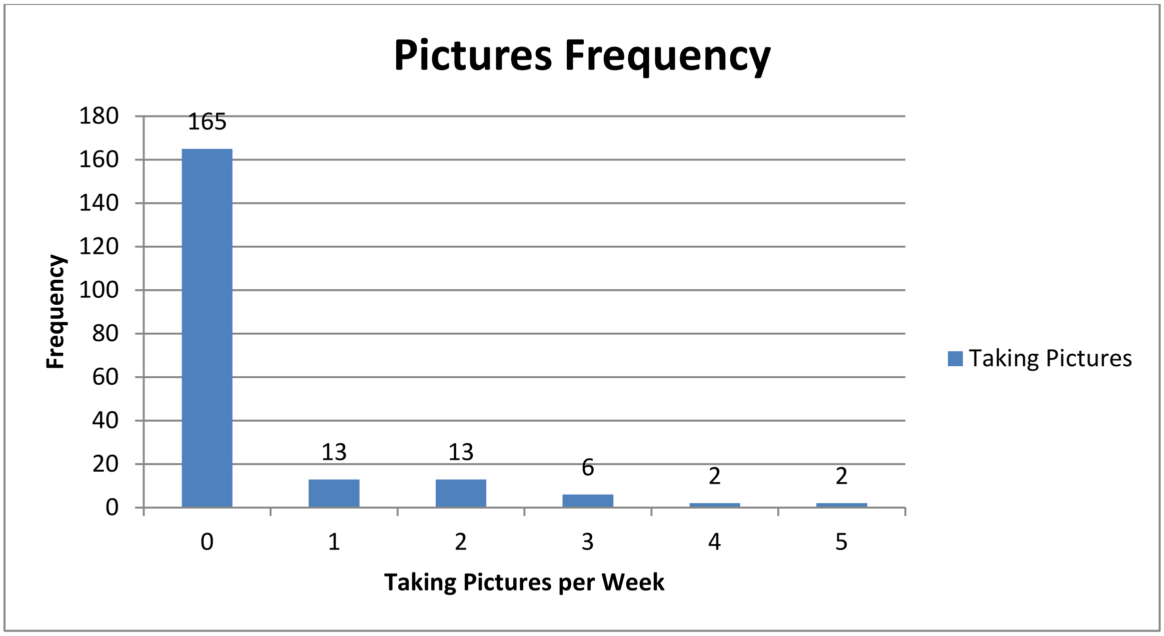

Figure 4.2.2.15: Frequency of Taking Pictures while Driving per Week (Involved in Crashes)

4.2.3 Safety Issues

One thousand four hundred four out of 2,253 respondents (about 62%) reported having experienced a close call situation while driving and using cell phones and 201 out of 2,253 college students (about 9%) reported being involved in an accident because of the use of a cell phone while performing the driving task. The following figure, Figure 4.2.3.1, presents the responses collected from 2,253 college students regarding their involvement in close call or accident situations while using cell phones. More than half of the respondents have suffered close call situations; however, 91% of respondents indicated that they haven't been involved in any accidents involving cell phone usage.

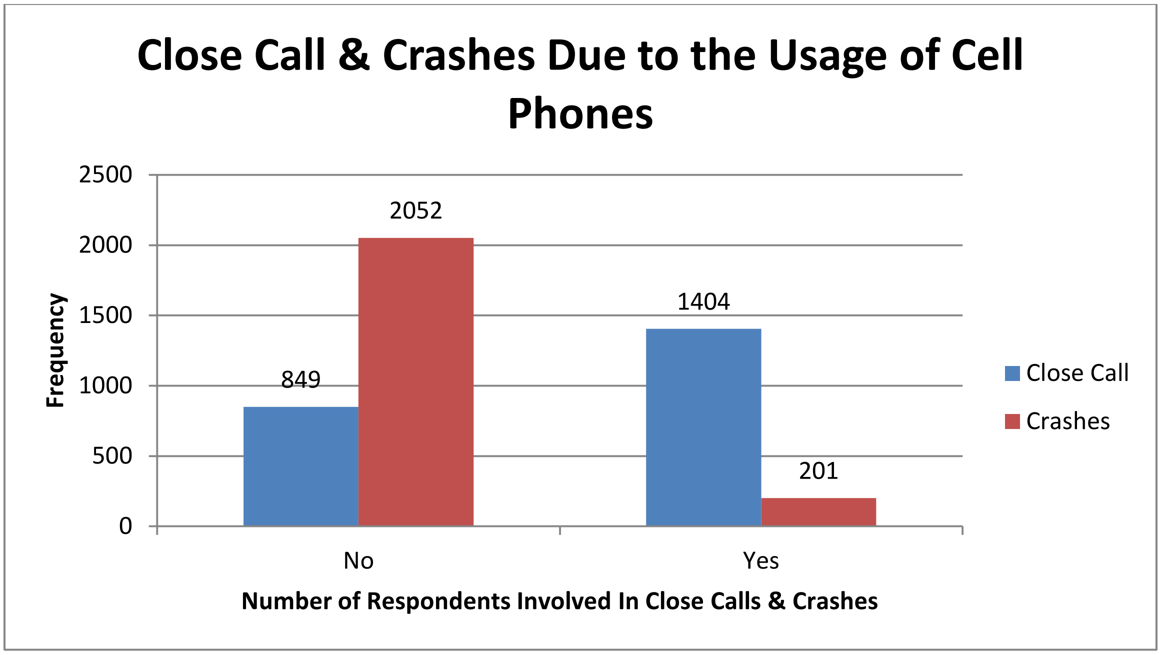

Figure 4.2.3.1: Close Call & Crashes Due to the Usage of Cell Phones

Figure 4.2.3.2 shows the reported close call rates being experienced by college students performing cell phone usage while driving in 30 days. 452 out of 1075 responses (about 42%) have experienced one incident in 30 days, and this was the most frequent value reported for the close call category.

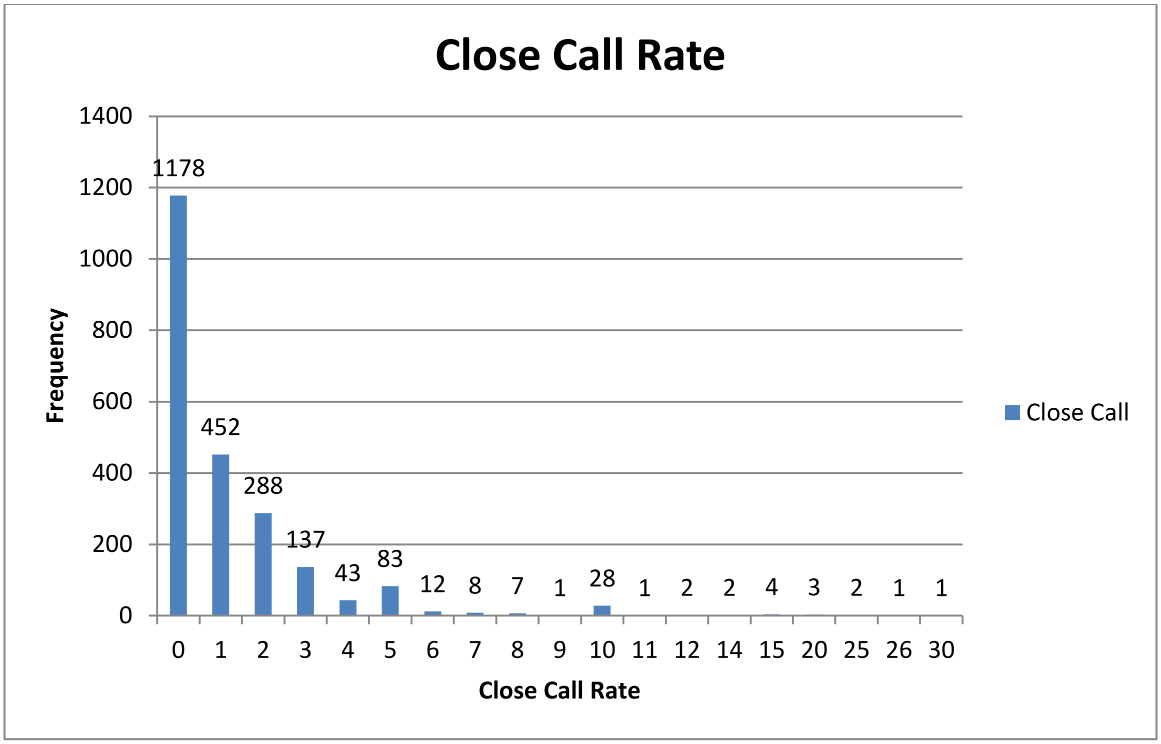

Figure 4.2.3.2: Close Call Rate Using Cell Phone while Driving per Last 30 Days

Figure 4.2.3.3 and Figure 4.2.3.4 divide Figure 4.2.3.2 into two different group of students in which Figure 4.2.3.3 represents the close call rate suffered by students who have reported not to have been involved in any crashes due to cell phone usage while Figure 4.2.3.4 presents students who have suffered crashes due to the cell phone usage while driving. Figure 4.2.3.3 indicates about 46% of the students reported to have suffered close calls in the last 30 days. 44% of these students have experienced one incident in 30 days, and this was the most frequent reported value for Figure 4.2.3.3.

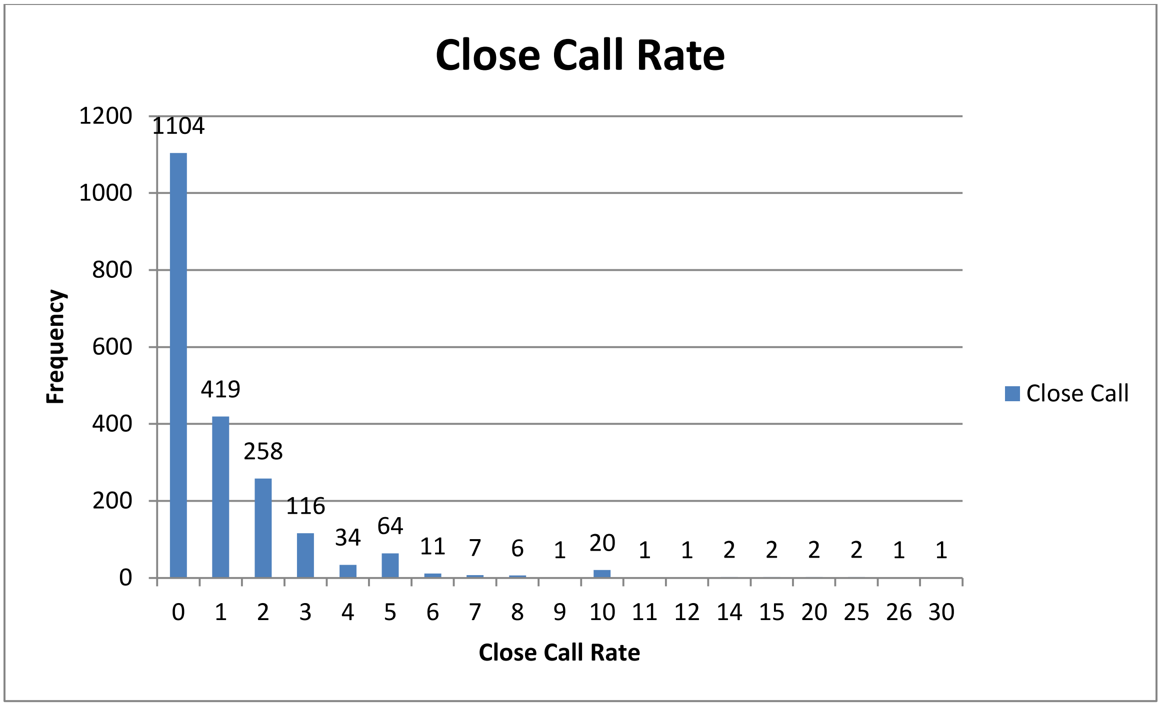

Figure 4.2.3.3: Close Call Rate Using Cell Phone while Driving per Last 30 Days (Not Involved in Crashes)

Figure 4.2.3.4 shows that 63% of the students reported experiencing close calls while driving performing cell phone activities. Students in this category have a higher rate of encountering a close call situation, about 20% higher than students in Figure 4.2.3.3. 88% of these students fall in between 1 and 5 close calls in 30 days.

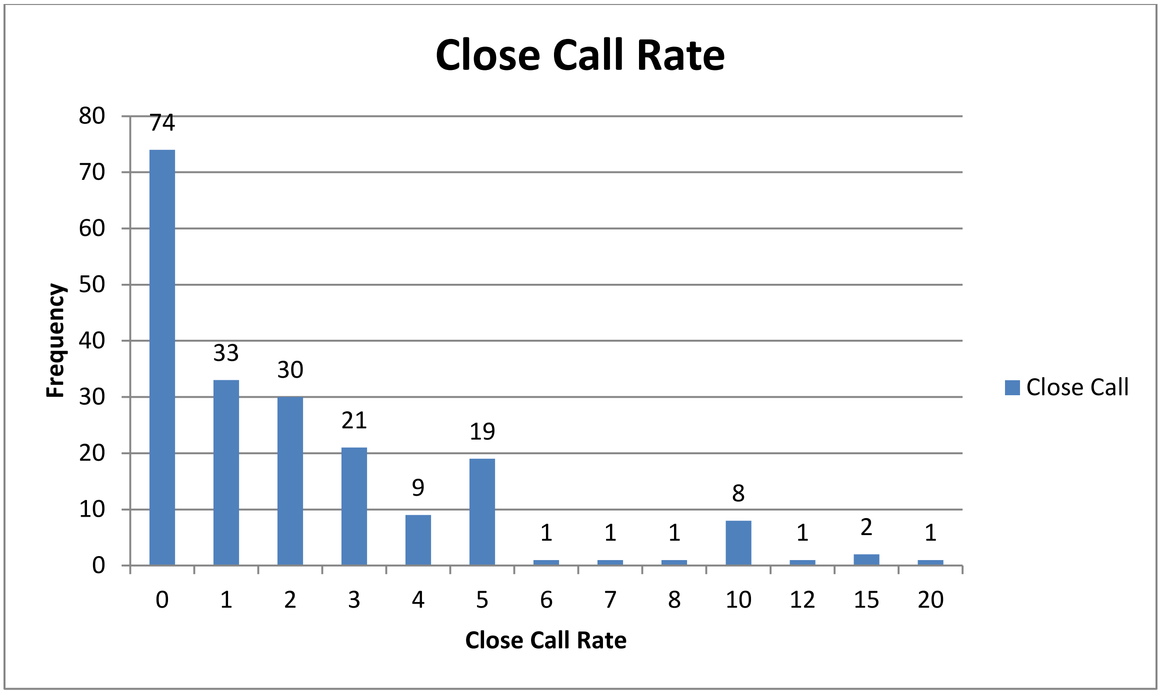

Figure 4.2.3.4: Close Call Rate Using Cell Phone while Driving per Last 30 Days (Involved in Crashes)

Figure 4.3.3.5 shows the accidents reported by college students where either the surveyed driver or the other party involved in the accident was using a cell phone. According to Figure 4.2.3.5, 174 out of 188 college students (about 93%) were involved in one accident involving cell phone usage while driving. In addition, this number is the most frequent value reported for total crashes.

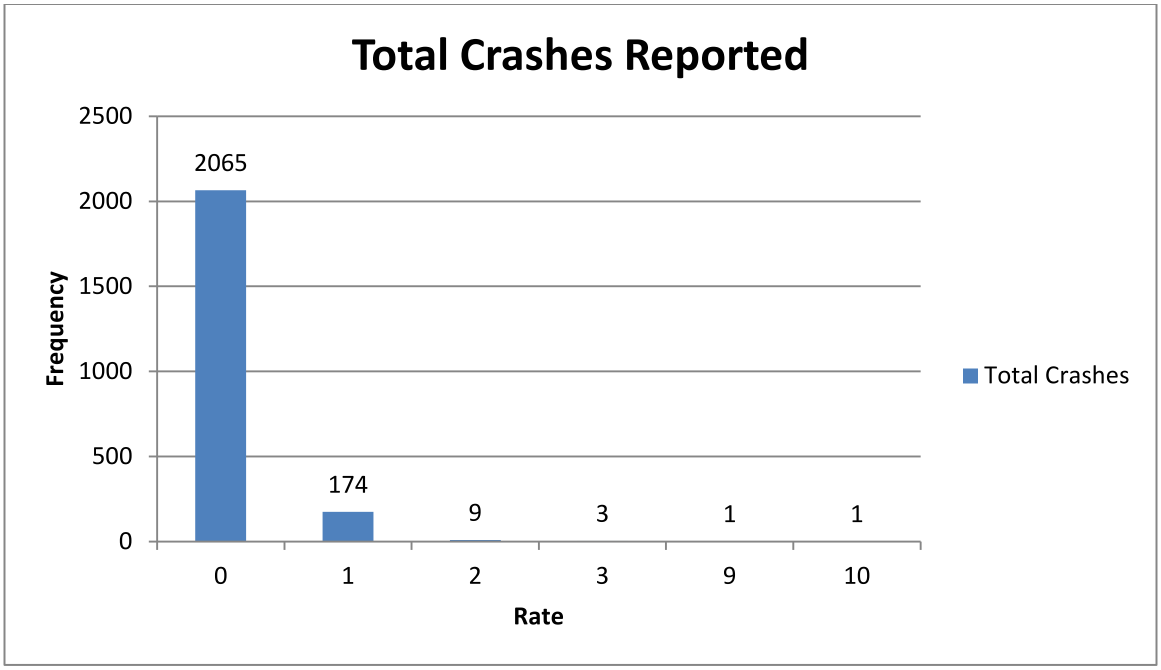

Figure 4.2.3.5: Number of Crashes Using Cell Phone while Driving

4.3 Mann-Whitney U Analysis

Mann-Whitney U test was then performed on the Two thousand two hundred fifty three students to test the equality in response distributions of the students who have suffered crashes and students who haven't had crashes due to the usage of cell phones while driving for these two groups. These data were processed using SPSS and the following tables are the summaries of the findings. Table 4.3.1 shows the ranks of all the variables between the crashes group of students and non-crashes students. Refer to Table 4.1.1 for the explanation of the abbreviations. Table 4.3.2 presents the result of Mann-Whitney U test.

Table 4.3.1 Ranks of the Variables of Crashes Group and Non-crashes Group (obtained from SPSS 13.5)

	ac	Mean Rank	Sum of Ranks
dh	No	1131.65	2322136.50
	Yes	1079.57	216994.50
c	No	1124.55	2307585.00
	Yes	1151.97	231546.00
a	No	1125.19	2308898.50
	Yes	1145.44	230232.50
hf	No	1130.01	2318770.50
	Yes	1096.32	220365.50
ab	No	1122.41	2303193.00
	Yes	1173.82	235938.00
rms	No	1119.42	2297054.50
	Yes	1203.17	241838.00
sms	No	1119.42	2297054.50
	Yes	1204.36	242.076.50
rml	No	1123.99	2306437.50
	Yes	1157.68	232693.50
sml	No	1120.07	2298384.50
	Yes	1197.74	240746.50
p	No	1119.02	2296228.50
	Yes	1208.47	242902.50
pf	No	1118.88	2295945.00
	Yes	1209.88	243186.00
cc	No	1104.63	2266707.00
	Yes	1355.34	272424.00
ccf	No	1102.02	2261342.00
	Yes	1382.03	277789.00
acf	No	1033.00	2119716.00
	Yes	2086.64	419415.00

Note: ac(no) = 2052, ac(yes) =201, total ac(N) = 2253

Table 4.3.2 Test Statistics (Grouping Variable: crashes) for Mann-Whitney U Test (obtained from SPSS 13.5)

	Mann-Whitney U	Z	p (1-tailed)
dh	196693.50	-1.087	.139
c	201207.00	-.572	.284
a	202520.50	-.423	.337
hf	200059.50	-1.099	.136
ab	196815.00	-1.248	.106
rms	190915.00	-1.785	.037
sms	190676.50	-1.785	.037
rml	200059.50	-1.556	.060
sml	192006.50	-2.732	.003
p	189850.50	-3.345	.001
pf	189567.00	-3.491	.000
cc	160329.00	-6.213	.000
ccf	154964.00	-6.329	.000
acf	13338.00	-45.738	.000

The p value is reported in one-tail format as this will indicate which the larger value on the selected variables is. Secondly, the crashes group students are expected to have a higher value as well.

Based on the results produced from Table 4.3.1 and Table 4.3.2, the evaluation of the hypothesis will be reported based on the three categories of the variables.

4.3.1 Driving Hours

A Mann-Whitney U test was conducted to evaluate the hypothesis that students who suffered crashes due to the cell phone usage while driving would have higher driving hours, on the average, than students who have not suffered crashes due to the usage of cell phone while driving. The results of the test were not in the expected direction and insignificant, z = -1.087, not significant. Students in the crashes group had an average rank of 1131.65, while crash-free students had an average rank of 1079.57.

4.3.2 Type of Cell Phone Usage

The Mann-Whitney U test was conducted to evaluate the hypothesis that students who suffered crashes due to cell phone usage while driving would have a higher phone calls rate, both calling and answering, on the average, than students who have not suffered crashes due to the usage of cell phone while driving. The results of the test were not in the expected direction and significant, z = -.572, not significant for calling and, z =-.423, not significant for answering. Crashes students had an average rank of 1151.97, while crash-free students had an average rank of 1124.55 for calling. For answering, crashes students had an average rank of 1145.44, while crash-free students had an average rank of 1125.19.

The Mann-Whitney U test was also used to evaluate the hypothesis that students who suffered crashes due to the cell phone usage while driving would read and send SMS more frequently, on the average, than the students who have not suffered crashes due to the usage of cell phone while driving. The results of the test were in the expected direction and significant, z = -1.785, p <. 05 for reading SMS and, z =-1.785, p <.05 for sending SMS. For reading SMS, crashes students had an average rank of 1203.17, while crash-free students had an average rank of 1119.54. For sending SMS, crashes students had an average rank of 1204.36, while crash-free students had an average rank of 1119.42.

The Mann-Whitney U test was also used to evaluate the hypothesis that students who suffered crashes due to the cell phone usage while driving would read and send emails more frequently, on the average, than the students who have not suffered crashes due to the usage of cell phone while driving. The results of the test were partially in the expected direction and significant, $z = -1.556$, not significant for reading emails and, $z = -2.732$, $p < .05$ for sending emails. For reading emails, crashes students had an average rank of 1157.68, while crash-free students had an average rank of 1123.99. For sending SMS, crashes students had an average rank of 1197.74, while crash-free students had an average rank of 1120.07.

Lastly for the type of cell phone usage, Mann-Whitney U test was also used to evaluate the hypothesis that students who suffered crashes due to the cell phone usage while driving would take more pictures, on the average, than the students who have not suffered crashes due to the usage of cell phone while driving. The results of the test were in the expected direction and significant, $z = -3.491$, $p < .05$. Crashes students had an average rank of 1209.88 while crashes-free students had an average rank of 1118.88.

4.3.3 Safety Issues

Finally, Mann-Whitney U test was performed to evaluate the hypothesis that students who suffered crashes due to the usage of cell phone while driving would have a higher close call rate, on the average, than the students who have not suffered crashes due to the usage of cell phone while driving. The results for the test were in the expected direction and significant, $z = -6.329$, $p < .05$ for close call rate. Crashes students had an average rank of 1382.03, while crash-free students had an average rank of 1102.02 for close call rate.

4.3.4 Summary of Mann-Whitney U Test

The Mann-Whitney U test was used to successfully evaluate the major hypothesis that cell phone and cell phone function usage for the students who had suffered crashes is significantly higher compared to students who had not been involved in crashes. Table 4.3.3 shows significantly different variables of the Mann-Whitney U results.

Table 4.3.3 Successful Test Statistics (Grouping Variable: crashes) for Mann-Whitney U Test (obtained from SPSS 13.5)

	Mann-Whitney U	Z	p (1-tailed)
rms	190915.00	-1.785	.037
sms	190676.50	-1.785	.037
sml	192006.50	-2.732	.003
pf	189567.00	-3.491	.000
ccf	154964.00	-6.329	.000

Section 5: Discussion

In this section, the significant differences observed from the data are presented in the order of the three categories that have been used throughout this paper. The following sections present the discussion of the driving hours, functions of the cell phone usage, and safety issues concerned. A conclusion will be presented in the summary section.

5.1 Driving Hours

The more driving hours a responder has, typically greater risk is associated for the driver to be involved in a crash. However, this has not been the case for this research, as demonstrated by Table 4.1.3 and Table 4.1.4. The mean for the students who were not involved in a crash for driving hours is 8.22 hours per week, which is higher than students who were involved in crashes, 7.80 hours per week. This difference is further supported by the Mann-Whitney U test, with the rejection of the hypothesis that students involved in crashes have higher driving hours than students who were crash-free. Therefore, the study indicates that driving hours is not the major component that results in the crashes among the college students observed in this research. In addition, students who commute through longer distance may have a safer driving environment on the interstate as oppose to students who are driving on congested urban corridors'.

5.2 Type of Cell Phone Usage

Forty three precent of the survey respondents reported they were browsing in their address book before making a call while driving. This is not a good driving practice and will affect the driving task because drivers' eyes are away from the road the moment they are looking at their address book on the phone screen. Figure 4.2.2.6 shows that the group of students who have been involved in crashes has a higher percentage compared to Figure 4.2.2.5 (crash-free students) for browsing address book while driving. Additionally, less than 20% of the total respondents were using hands free devices while talking on the cell phone. Again, holding a phone with one hand while driving is not a good driving behavior.

Students who have been involved in crashes have a higher mean than students who have never suffered crashes in terms of making and answering phone calls, according to Table 4.1.3 and Table 4.1.4. This is indeed in an expected direction as this again distracts the driver's attention from the driving task. These data suggest, that these respondents are engaging in unsafe driving behavior that is increasing their risks of suffering close calls and crashes.

Students who have been involved in crashes also have a higher mean for both reading and sending text messages (16.4 messages per week for reading & 18.0 messages per week for sending) as opposed to crash-free students (13.2 messages per week for reading & 14.5 messages per week for sending). Texting has been considered as an important key event responsible for increasing nationwide crashes for the last few years. Therefore, the results shown above are in the expected direction. This claim is further supported by Mann-Whitney U test that students who suffered crashes due to cell phone usage while driving would read and send SMS more frequently, on the average, than the students who have not suffered crashes due to the usage of cell phone while driving. To be able to send a text message, at least one hand is holding the phone while typing and the drivers' eyes are on the screen while typing. Driver attention is completely diverted from the driving task. If the vehicle in front is slowing down or completely stops, a driver may not be able to react to any incoming alert as their attention was directed to the phone screen while typing or reading a text message. Reaction time is slowed as a result of using cell phones as mentioned by Strayer and Drews (2004). Therefore, the more text messages a student is trying to read, respond to, or send, the more risk that is associated for a student to encounter close calls or crashes. Virginia Tech Transportation Institute was able to prove that texting is increasing the risk of 'close calls' and accidents as high as 23 times as compared with non-distracted driving (Virginia Tech Transportation Institute, 2009).

Emailing is a new addition to smart phones. 7% of the students in this research admitted to reading emails while driving and 13% students claimed that they were sending emails while driving. The numbers of respondents were low and it is hard to draw a solid connection that emailing is an important factor to close call encounters or crashes. This may change as more students begin to own smart phones that have the capability to read or send emails. Another factor which may limit students use of this functionality is that, to be able to use your mailbox while driving, phone subscribers need to pay extra charges for edge or 3G services. Many students may not have the budget for cell phone Internet subscriptions. Currently, there is no literature that has introduced emails as a factor to distractions, or crashes while driving. Nevertheless, this is an important factor, and may become an even concern as technology prices decrease. The Mann-Whitney U test results suggested that sending emails is significantly higher for students that have been involved in crashes compared to students who have not been involved in crashes. The extent of the impact of emailing while driving should be considered as a future direction for further research.

Twelve percent of the students admitted that they take pictures with their cell phone while driving. Almost all cell phones have the capability to take pictures, including the basic cell phones. For students that have responded to having taken pictures while driving, the most frequent number is 1 picture per day for both crash-free and non-crash-free students. The Mann Whitney U test was also used to further examine the hypothesis that students involved in crashes would have taken more pictures than students that are crash-free. The analysis yields positive results suggesting that taking pictures while driving could have been a factor leading to crashes. It is possible that taking pictures while driving can be related with text messages and emails. A driver might have taken a picture while driving and then attached this picture as an email or text message to a recipient. This is repeating the same risk that was being discussed for sending or reading text messages while driving. Taking pictures and attaching a picture to a text message or email in addition to working on the text content will decrease driver attention and may increase the risk of drivers being involved in a crash. However, there is not any additional published researched in this area and it is hard to further support the suspicion of pictures relationship with texting and emails, given the limited extent of the data in this study.

5.3 Safety Issues

Last but not least, students who have been involved in crashes are suffering higher close call scenarios than students who are crash-free. Table 4.1.3 and Table 4.1.4 reveal that the mean for close calls is 1.1 for students who are crash-free while students who are involved in crashes is 2.2 which is about twice the amount being suffered by students who have been involved in crashes. This is again further supported by Mann-Whitney U analysis that revealed that students involved in crashes have a higher average for close calls compared to students who are crash-free. A close call scenario happens when a driver is still able to react to the alert; the worst-case scenario, which is a crash, may occur a result of drivers being unable to comply with the incoming alert.

With so many functions of cell phones discussed in Section 5.2, all of these functions can trigger a close call scenario. For example, students who text while driving are putting themselves at risk for more close calls. This is true because the driver's eyes were directed to a cell phone screen rather than focusing on the driving task. Any incoming alerts will not be intercepted by the drivers because their eyes were away from the road. This will delay a driver's reaction time and may make them unable to perform a quick measure to incoming alerts such as a complete stop or slowing down or yielding to incoming traffic and so forth.

Nine percent of the respondents indicated that they actually were involved in a traffic accident due to the usage of a cell phone by themselves or another driver. This indicates that college students are engaging in bad driving behaviors that are challenging their safety in our community.

5.4 Conclusion

In conclusion, students in this study that were involved in crashes are shown to spend more time with their mobile phones while driving. Students belonging to the crashes group were shown to have a higher mean (such as talking on the phone, emailing and texting, taking pictures, and also close calls) on descriptive statistics tables (Table 4.1.3 and Table 4.1.4) as oppose to students who were crash-free. Mann-Whitney U analysis further supported the claim on most of the cell phone functions that students in the crash group, on average, were having a higher usage of cell phone functions compare to the non-crash-group. As mentioned repeatedly, the more time students spend on the cell phone while driving, the more likely they were associated with suffering close calls and crashes. It also showed that in this analysis driving hours were not a factor contributing to crash or near crash scenarios among students.

As mentioned earlier in Section 2, younger drivers are not trained to handle multitasking while driving. This multitasking procedure is complicated and challenges the students' abilities to attend to the driving task and drive safely.

The findings from the survey conducted for this research indicate that engaging in the following cell phone tasks while driving will invoke crash or near crash scenarios:

1. Texting While Driving
2. Emailing While Driving
3. Taking Pictures While Driving

Therefore, it is suggested that using a cell phone while driving is not a good driving behavior for college students.

Emailing can be related to texting; however, there is not any research available to support this at this time. Similarly, no previous research has been conducted on taking pictures while driving. This, this study suggests new areas of areas of research that are important for identifying additional factors in distracted driving that lead to safety issues.

5.5 Future Direction

Overall, the data that has been gathered through this research suggests that operating with a cell phone while driving is negatively impacting college students' driving performance. This is an important finding, particularly given the reported number of college students that are engaging in unsafe driving practices. Previous research has focused on talk time on the cell phone in general while in this study, a higher level of detail is obtained and analyzed including the different functionalities of cell phones such as texting SMS, emailing, and taking pictures while driving.

More research should be conducted on emailing and taking pictures while driving and how it can impact close call frequency or crash rate. Identifying type of texting, for example, short messages, long messages, or even animated or picture messages may have a different impact on safety issues. Larger samples including more age groups will be important to assess how frequently a driver's attention is averted from the driving task due to these functions. In the current study, the time spent on completing the process of texting, emailing, and taking pictures was not ascertained. These more complicated tasks may have a different impact on the driving task, thus further study is warranted.

In addition, a demography survey should be included as well to determine if gender, ethnicity, income, etc. are related to, the driving behaviors in question.

While different states are working on partial banning of cell phone usages while driving, cell phone technology has been evolving rapidly over time. The original concept of a cell phone was to be able to talk wirelessly. However, cell phones are now capable of sending and receiving emails, text messaging, providing GPS functions as well as Internet access. Although some states have banned several functions of cell phones while driving, there are still some other functions that can challenge driver safety, and should be investigated.

Newer smart phones are as powerful as a small PC. Smart phones are capable of running a variety of applications that normally can be found on computers. As technology is evolving, it is important to determine what impact these capabilities have on driver safety. These changes may lead to difficulties with legislation for the usage of mobile phones. A state can ban drivers from talking, texting or emailing while driving, however, if a driver is using a mobile phone to handle different tasks than those specifically mentioned, will these functions also be included in the ban? It is hard to conclude what the driver is looking at on the screen of his or her cellphone. One may say that he is looking at the Google Map for direction, and one may say that she is checking the traffic condition on I-40. Will these kinds of actions also be part of the violation of cell phone usages?

In conclusion, it is important to enforce education for younger drivers to understand the safety risks that they are facing – when multitasking while driving with a multi-function electronic device. The lack of education is a key factor that may contribute to the number of close calls and crashes among college students. More campaigns should be carried out for public awareness regarding the dangers of distracted driving, as these may help to provide a safer driving environment.

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Appendix

Pilot Survey

1. On average, in a week, how often do you **make** a phone call while driving?
   __________________ (ie, 0 – 2 or 3 – 4)

2. On average, in a week, how often do you **answer** a phone call while driving?
   __________________ (ie, 0 – 2 or 3 – 4)

3. Do you typically use a hand free device to talk on phone while driving?
   Yes/No

4. Do you typically browse address book to locate a contact number while driving?
   Yes/No

5. On average, in a week, how often do you **send** a text message while driving?
   __________________ (ie, 0 – 2 or 3 – 4)

6. On average, in a week, how often do you **read** a text message while driving?
   __________________ (ie, 0 – 2 or 3 – 4)

7. Do you take pictures with your phone while driving?
   Yes/No

8. If yes for question 7, on average, in a week, how many times?
   __________________ (ie, 0 – 2 or 3 – 4)

9. Have you ever been involved in a traffic accident involving the use of a cell phone either by your or another driver?
   Yes/No

Final Survey

1. On average, in a week, how many hours do you drive?
   __________________ hours per week

2. On average, in a week, how often do you **make** a phone call while driving?
   __________________ calls per week

3. On average, in a week, how often do you **answer** a phone call while driving?
   __________________ calls per week

4. Do you typically use a hands free device to talk on phone while driving?
   Yes/No

5. Do you typically browse address book to locate a contact number while driving?
   Yes/No

6. On average, in a week, how often do you **type and send** a text message while driving?
   __________________ messages per week

7. On average, in a week, how often do you **read** a text message while driving?
   __________________ messages per week

8. On average, in a week, how often do you **compose and send** an email while driving?
   __________________ emails per week

9. On average, in a week, how often do you **read** an email while driving?
   __________________ emails per week

10. Do you take pictures with your phone while driving?
    Yes/No

11. If yes for question 10, on average, in a week, how many pictures do you take?
    __________________ pictures per week

12. Have you ever been involved in a “close call” situation **<u>involving the use of a cell phone</u>** either by you or another driver?
    Close call: a situation where you have successfully prevented a traffic accidents; ie. Drift into lane, stop short, having to “slam on brakes”, and etc
    Yes/No

13. If yes for question 12, how many time(s) have you been involved in a “close call” for the last 30 days?
    _________________ time(s) last 30 days

14. Have you ever been involved in a traffic accident **<u>involving the use of a cell phone</u>** either by you or another driver?
    Yes/No

15. If yes for question 14, how many time(s) have you been involved in an accident related to above issue?
    _________________ time(s)

THE UNIVERSITY OF MEMPHIS

Institutional Review Board

To: Hak Loy Lim
Civil Engineering

From: Chair, Institutional Review Board
for the Protection of Human Subjects
Administration 315

Subject: Cell phones usage among college students (E09-119)

Approval Date: November 25, 2008

This is to notify you that the Institutional Review Board has designated the above referenced protocol as exempt from the full federal regulations. This project was reviewed in accordance with all applicable statutes and regulations as well as ethical principles.

When the project is finished or terminated, please complete the attached Notice of Completion and send to the Board in Administration 315.

Approval for this protocol does not expire. However, any change to the protocol must be reviewed and approved by the board prior to implementing the change.

Chair, Institutional Review Board
The University of Memphis

Dr. M. Lipinski
Dr. S. Ivey