A MIXED METHODS EXAMINATION OF DISTRACTED DRIVING IN COMMERCIAL TRUCK DRIVERS

by
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Abstract

Distracted driving, a hazard that is increasingly common in the United States (U.S.), creates a risk for occupational injury and death for truck drivers. The overall goal of this dissertation was to understand the burden of distraction-involved truck fatalities in the U.S. and gain insight into workplace and personal factors that would affect distracted driving in this occupational population. First, after describing the rates of truck crashes by state, I used a longitudinal analysis of fatality rates in crashes involving distracted truck drivers and whether or not state and federal distracted driving bans affected these rates. Second, I undertook a mixed methods study using surveys of drivers and interviews with experts on distracted driving and truck driving safety.

Research findings are presented in three manuscripts: Effects of State on Fatalities Involving Distracted Truck Drivers; The Effects of Safety Climate on Distracted Driving in Commercial Truck Drivers; and Understanding Commercial Truck Drivers' Decision-Making Process Concerning Distracted Driving. First, I examined the rates of distraction-involved truck fatalities in the U.S. over an 11-year period and found that while state texting and handheld cell phone use bans were not associated with decreases in fatality rates, fatality rates to truck drivers and all vehicle occupants had been decreasing since 2007. The second manuscript explored the relationship of organizational safety climate, using an established questionnaire and key informant interviews, and found that management commitment to safety and communications and procedures were important for keeping drivers safe from the hazard of distracted driving. The third manuscript explored how the constructs of the Theory of Planned Behavior (TPB) affected truck drivers' decision-making concerning communication on the job. Key informants described how the different aspects of the TPB could influence drivers' decision making; in regression analysis for both texting and dispatch device use, the TPB constructs of intentions, norms, and perceived behavioral control were correlated with distraction-involved near-crashes on the job.

Results from this dissertation revealed that while distraction-involved truck crash rates are decreasing, there is wide variation between states. Furthermore, truck drivers' supervisors play an important role in creating an organizational climate where drivers do not feel pressured to undertaking distracting tasks while driving. These results should impact organizational policies and enforcement of these policies to prevent distracted driving. States, worker representatives, industry groups, and academic researchers will influence future enactment of governmental and organizational policies concerning distracted driving in truck drivers.

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Table of Contents	**Page**

List of Tables **Page**

List of Figures **Page**

List of Appendices **Page**

Abbreviations

ATA- American Trucking Association

BLS- Bureau of Labor Statistics

CDC- Centers for Disease Control and Prevention

CPWD- Cell phone use while driving

DD- Distracted driving

DOT- Department of Transportation

FARS- Fatality Analysis Reporting System

FCC- Federal Communications Commission

FHWA- Federal Highway Administration

FMCSA- Federal Motor Carrier Safety Administration

GES- General Estimating System

GHSA- Governors Highway Safety Association

GPS- Global Positioning System

GVWR- Gross vehicle weight rating

IBT- International Brotherhood of Teamsters

IRB- Internal review board

MVC- Motor vehicle crash

NETS- Network of Employers for Transportation Safety

NHTSA- National Highway Transportation Safety Administration

NIOSH- National Institute for Occupational Safety and Health

OSHA- Occupational Safety and Health Administration

OSHMS- Occupational safety and health management systems

PBC- Perceived behavioral control

SCQ- Safety climate questionnaire

SCQ-MD- Safety climate questionnaire- modified for drivers

TPB- Theory of planned behavior

TRA- Theory of reasoned action

VIF- Variance inflation factor

VMT- Vehicle miles traveled

VTTI- Virginia Tech Transportation Institute

Introduction

Although distractions have always existed for drivers, the recent availability of mass-marketed electronic communication devices has brought this hazard to the forefront of motor vehicle safety. For the worker who drives on the job, electronic communication while driving has become the norm due to both social and occupational pressures. Commercial truck drivers in the United States (U.S.) face numerous distractions of varying degrees of danger while trying to safely operate multi-ton vehicles. This thesis seeks to understand the scope of the problem that distracted driving creates for truck drivers, how distraction affects driver behavior, how company safety climate affects distracted driving, and how policies can positively or negatively affect this problem.

This introductory section will first describe distracted driving from its origins to modern hazards. Second, I will delve into distractions that are unique to commercial truck drivers. Third, I will describe how workplace safety climate affects safe worker and driver behavior. Fourth, I will also describe how drivers make decisions on safe driving behaviors and how this will apply to commercial truck drivers. Finally, I will discuss what steps have been taken to reduce distracted driving and what effects, if any, these steps have had.

Distracted Driving

Defining distracted driving first requires a description of all tasks that drivers can undertake while driving. Ablassmeier and colleagues break down these tasks into three categories: primary tasks that only control vehicle speed and direction; secondary tasks that support the primary tasks, such as turning on headlights or checking mirrors; and tertiary tasks that are any activities the driver undertakes that are unrelated to driving [1]. It is these secondary and tertiary tasks that distract from primary driving. Distraction from primary driving comes in four forms: 1) visual distractions that take the driver's eyes off the forward roadway; 2) auditory distractions that take the driver's aural perception from relative driving cues; 3) cognitive distractions take the driver's mind off the driving task; and 4) manual distractions take the driver's hands off the wheel [2]. The first two forms of distraction delay the driver from receiving necessary information for the driving task, the third affects the processing of this incoming information, and the fourth delays the driver from taking corrective action necessitated by the situation [3]. Thus, based on this classification the definition of distracted driving that I will use for this thesis is, "any secondary or tertiary task that takes the driver's eyes, hands, or attention away from the primary task of driving."

Studies of driver behavior using in-vehicle cameras have found over two dozen secondary and tertiary tasks as sources of distraction [4-7]. Distractions cover a range of behaviors, from common activities, such as reading a map or GPS and talking with a passenger, to less frequently observed activities, like reading the newspaper or shaving. An emergent threat is activities involving cellular phone use [8]. The term cell phone use while driving (CPWD) encompasses any task involving a cell phone, including dialing a phone, talking on the phone, and reading or writing messages [9]. CPWD has been increasing in recent years due to the proliferation of cellular phones in the United States and elsewhere [10, 11]. Two of the most dangerous CPWD tasks are dialing the phone and sending, reading, and writing short message service text messages (a.k.a. texting) [6]. Dialing and texting both involve manual, visual, and cognitive distractions [2]. Both in the laboratory setting [12, 13] and during actual driving [6], texting has been shown to be the greatest hazard for crash or near crash. This hazard is magnified by the exponential growth of text messages sent in the U.S. since 2006: the number of text messages sent in to U.S. doubled from 2006 to 2007, then doubled again from 2007 to 2008 [14].

Not all drivers are equally likely to drive distracted, nor are they affected equally by distractions. While teens and drivers in their twenties [15, 16] are more likely to undertake phone-related distraction while driving, drivers over 65 might take longer to cognitively process such distractions [17]. A review of risk factors associated with distracted driving found no evidence that males or females were more affected by cell phone distraction than the other gender [18]. Drivers who choose to drive distracted are less likely to see it as a dangerous activity [19], are more likely to undertake aggressive driving behaviors like speeding and drink driving [20], and cannot accurately gauge their own level of distraction [21].

Prior studies have examined the effects of distracted driving on the crash risk, yet the results have varied depending on the definition of distraction under study as well as what study method was used in a given investigation. As CPWD is the most studied distraction, I will use it as an example. The first study of CPWD and crash risk by Redelmeier and Tibshiriani in 1997 used a case-crossover study design and found that “telephone calls” increased the relative risk of injury crash 4.3 times [22]. One year later, Violanti used a case-control study of fatal crashes to find that “phone use” increased the odd ratio (OR) for crashing 9.3 times [23]. Into the 2000s, case-control [15] and case-crossover [24] studies still produced crash ORs of 2.5 and 4.1, respectively. Technological advances have allowed for naturalistic driving studies, where researchers can view drivers in their natural state and more accurately estimate the risks of specific aspects of CPWD. The trade-off for precision in these studies is a lower number of drivers that can be analyzed and, consequently, the infrequent crashes and near crash situations. Klauer and colleagues conducted a study for the National Highway Traffic Safety Administration (NHTSA) and found that dialing a phone increased crash risk 2.8 times yet talking on a device did not increase crash risk [5].

It is important to note that the above studies generally surveyed the same activity (“talking on a cell phone”) yet their methods and definitions of the observed behaviors produced different results. Few studies have the statistical power to accurately measure crash risk for all subtasks involved in a cell phone conversation [6], such as dialing the phone, answering the phone, or holding the phone during a conversation. Critical analysis of distraction definitions and comparing these crash risks between studies should inform researchers when they are considering which aspects of a given distraction are most dangerous.

The largest naturalistic driving study to examine distracted driving in commercial truck drivers and was conducted by the Virginia Tech Transportation Institute (VTTI)

[6]. The VTTI Study, as it is referred to, compared 4,452 safety critical events (defined by the authors as crashes, near crashes, crash-relevant conflicts and unintentional lane deviations) to 19,888 control periods and calculated the OR of safety critical events for 35 different secondary and tertiary tasks. Table 1 lists the ORs for all CPWD tasks in the VTTI Study. Of note, texting-while-driving produces an OR for safety critical events of 23.2.

Table 1. Odds ratios (ORs) for safety critical events in commercial truck drivers for cell phone use while driving sub-tasks. Adapted from Olson *et al*. 2009, Table 3 (p xxi) [6].

CPWD sub-task	Safety critical event OR	95% confidence interval
Text messaging	23.24	9.69 – 55.73
Dialing cell phone	5.93	4.57 – 10.69
Talk or listen to handheld phone (excluding dialing)	1.04	0.89 – 1.22
Talk or listen to hands-free phone (excluding dialing)	0.44	0.35 – 0.55

Commercial Truck Drivers and Distracted Driving

Commercial trucks, under the jurisdiction of the Federal Motor Carrier Safety Administration (FMCSA) in the U.S., are those vehicles that either 1) have a gross vehicle weight rating of more than 10,000 pounds; 2) have a gross combination weight rating of 26,001 or more pounds; or 3) are of any size and transports hazardous materials [25]. (The term “commercial” does not necessarily mean that the driver works for a for-profit organization; it is simply the wording used by the FMCSA.) Generally speaking, this definition includes semi-cabs and trailers and non-pivoting, unibody trucks. Commercial truck drivers, as they will be referred to from here on, are distracted by

CPWD, texting, adjusting the radio, eating and all the other hazards faced by non-commercial drivers [4]. There are additional occupational distractions that commercial truck drivers face not found in personal vehicle operation, such as interacting with a dispatch computer and using a CB radio [6]. Appendix 1 is from the aforementioned VTTI Study and lists the OR and 95% confidence intervals for safety critical event for 35 secondary and tertiary tasks that commercial truck drivers were observed undertaking while driving.

Even without the modern hazard of distracted driving, commercial truck drivers are a population that is already under occupational stress. Trucking and courier services (as grouped by the U.S. Bureau of Labor Statistics) have the highest costs for nonfatal occupational injuries and illnesses in the U.S. [26]. As has been described by other authors [27-29], truck driver health and well-being is affected by issues such as sleepiness and fatigue, poor physical fitness, and the work being shift work-based.

Motor vehicle crashes are the main cause of occupational fatality in the U.S. and not surprisingly this is the case for commercial truck drivers [30, 31]. The Centers for Disease Control and Prevention (CDC) conducted a descriptive analysis of workplace transportation fatalities and found that increased occupational MVC fatality was associated with workers characteristics such as being over 55 years of age, of male gender, or of Native American and Alaska Native race [30]. The CDC also found that the highway transportation fatality rate for truck drivers (19.6 per 100,000 workers) is 22 times higher than the national average [30]. In 2010, 304 of the 415 fatalities (73%) of occupational fatalities to workers classified under Truck Transportation by the Bureau of Labor Statistics (BLS) were from motor vehicle incidents [31].

Although it would make sense that workers exposed to frequent occupational driving would have high incidence of motor vehicle fatalities, the fatality rate for truck occupants was lower than passenger vehicle occupants, 3.7 per billion vehicle miles traveled (VMT) and 19.3 per billion VMT in 1999, respectively [32]. There are a few possible explanations for the lower fatality rate in truck passengers versus passenger vehicle occupants. Truck drivers, in obtaining their commercial driver's license, are required to have more training than operators of privately owned vehicles. Using Maryland as an example, applicants for a commercial driver's license must have already obtained a regular Class C license in addition to other requirements, such as being 21-years-old for Interstate licensure and proof of a physical exam [33]. Also, the large mass of commercial trucks offers relative protection to its occupants compared to occupants of smaller vehicle [34]. Thus when a commercial truck driver is involved in a crash with other vehicles, occupants in the other vehicles are at greater risk for fatality than the truck driver him- or herself.

For commercial truck drivers the vehicle cab is their workplace, so distraction on the job becomes and occupational hazard. Aside from work on commercial truck drivers done by VTTI, other researchers have examined distracted driving in the occupational setting. A study by Walsh and colleagues examined attitudes toward CPWD among Australian drivers and found that those who claimed to drive mainly for business purposes were more like to have positive attitudes towards CPWD and intended to undertake CPWD in the future versus those who drove mainly for non-business purposes [35]. Walsh *et al.* recognize that cell phones have become a business tool and the ability to both drive and conduct business simultaneously is a draw for business drivers. While some drivers may want to undertake CPWD activities to improve work efficiency, some drivers are forced to do so against their will. When drivers are under time pressures, they lose what Caird and Kline [36] refer to as "adaptive degrees of freedom," or the ability to avoid unsafe behaviors in adverse driving situations. If an employer requires drivers to multitask while driving, it becomes an issue of workplace safety climate.

Safety Climate and Occupational Driving

Drivers believe that they can be more efficient by taking phone calls while driving [35]. This would seemingly be a time saver employers and worker, yet it is well established that DD raises crash risk. If a company was to consider creating a policy on CPWD or other DD, a cost-benefit analysis should be conducted to weigh these supposed time saving versus the potential of a property damage-, injury-, or fatality-involved crash, any potential ensuing liability claims [37], or costs associated with workers compensation [38]. Although such an economic analysis is beyond the scope of this paper, similar analysis has been done for company seat belt policies (for an example, see Boyce and Geller [39]).

Not all occupational drivers face similar pressures concerning whether or not they should undertake distractions while driving. Employers could send implicit or explicit signals to their drivers concerning driving distracted on the job. On one end of the spectrum, an organization's drivers could be explicitly told that it is against company policy to undertake distractions while driving, and communications equipment in the cab would only work when the vehicle was at rest. At the opposite end of the spectrum, an organization could require drivers to take calls or answer messages while driving to "improve" efficiency. Between the two extremes there are numerous other options: an organization could ban personal communication for its drivers while still requiring them to be available to communicate with management; an organization could have no policy on distracted driving at all; or, an organization could explicitly say that drivers were not to undertake distractions, yet still contact drivers when management knows that those drivers are on the road. Measuring workplace communications, time pressures, and safety procedures are some of the elements that fall under the broader study of workplace safety climate [40, 41].

The concept of safety climate was developed by Dov Zohar, and he defines it as shared perceptions among employees of an organization concerning the procedures, practices, and reinforced behaviors surrounding the performance of high-risk operations [41]. Most commonly measured using the Safety Climate Questionnaire (SCQ) [42], this workplace assessment asks workers to describe how highly they feel management values communication, work pressures, training, and management's commitment to safety [41-44]. Two meta-analyses found that the perception of management's commitment to safety is the most commonly assessed aspect of safety climate [42, 43]. Taken *in toto* as advised by Zohar [41], safety climate can describe the complex signals sent by management to workers in regards to the value of worker safety.

The SCQ is an instrument that has workers answers questions on a Likert scale, the score of which are compared to occupational outcomes, such as injuries or safe behavior for a given workplace [43, 45]. Originally consisting of 40 questions across different aspects of employee perception [40], the questionnaire has been modified and validated across many occupations [42]. Wills and colleagues conducted a pair of studies where they developed and validated a version of the SCQ for occupational drivers [46, 47]. Their first study used a factor analysis to examine the components of SCQ- Modified for Drivers (SCQ-MD) [46]. Their second study used the SCQ-MD in conjunction with other established measures of driver behavior and compared these various instruments to workplace traffic offenses and crashes [47]. Because distracted driving is a workplace safety issue for commercial truck drivers, based on a review of the literature I hypothesize that safety climate will be correlated with driver safety in regards to distracted driving.

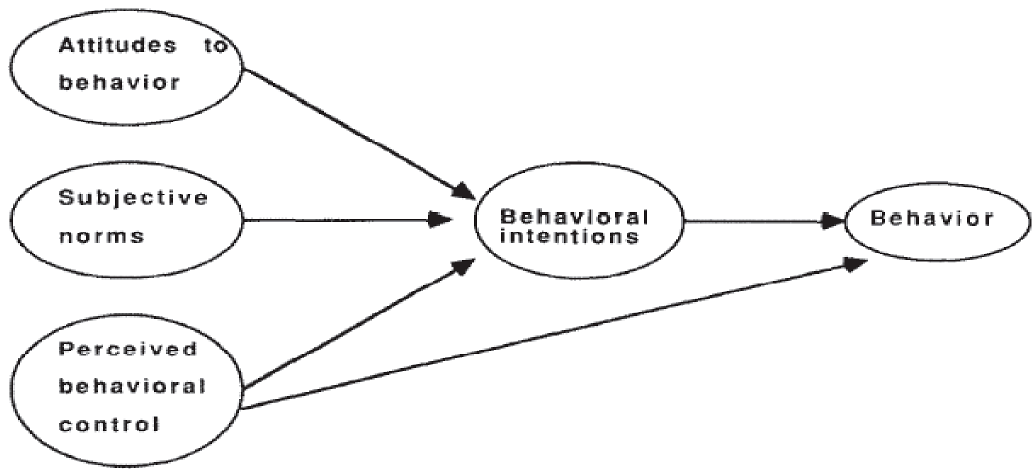
Worker Decisions on Safe Behaviors

When making decisions on whether or not to undertake distracted driving while on the job, commercial truck drivers must weigh personal, social, and occupational costs and benefits for the distractions. The occupational safety approach of behavior-based safety is one method for understanding injuries in the workplace; however, it is more focused on safely changing behavior than describing it [48]. The Theory of Planned

Behavior (TPB) has been used to describe decision-making surrounding safe driving behaviors [49] and driving in the occupational setting [35, 50]. Using the dimensions of the TPB described below, I will explore how commercial truck drivers weigh social and occupational considerations when undertaking driving distractions.

In the 1970s, Fishbein and Azjen developed the Theory of Reasoned Action (TRA) hypothesizing that attitudes and subjective norms surrounding a behavior influenced intentions to undertake that behavior and that those intentions led the individual to do or not do the behavior [51]. A limitation of the TRA is that it could not account for an individual's ability to make decisions in situations of reduced volitional control [52]. Ajzen modified the TRA to include the construct of perceived behavioral control (PBC) [53]. PBC is "the subjective probability that one is capable of executing a certain course of action" (p 93) [53], a concept that is very similar to self-efficacy in Bandura's Social Cognitive Theory [54]. However, Bandura's model of self-efficacy involves the individual weighing the outcomes [55], whereas in the TPB the individual considers the outcomes in Intention and Attitude aspects of the model. Figure 1 is a model of TPB as depicted by Parker and colleagues.

Figure 1. The Theory of Planned Behavior from Parker *et al.* 1992. [56]



The first step in measuring TPB constructs is conducting elicitation interviews to specify the questions for the target population of interest. Montaño and Kasprzyk [52] outline the execution of the elicitation interviews: first, the subjects are asked to describe any positive or negative attributes associated with performing the action (i.e. a description of attitudes); second, they describe social referents (individuals or groups) that could affect their decision, either positively or negatively; finally, PBC is assessed by eliciting any facilitators or barriers towards performance of a behavior. In the current study, I used elicitation interviews to identify distractions that commercial drivers commonly face, which social referents would affect their decisions to undertake these distractions, what benefits or costs could result from the distractions, and whether or not drivers had decisive control over undertaking or not these distractions while driving. The elicitation interviews used to generate the TPB constructs in this study will be explained in greater detail in the Methods section.

Union Membership and Driver Safety

Part of this study will examine truck drivers who are members of the International Brotherhood of Teamsters (IBT). The IBT represents over 1.4 million workers, mainly in truck transportation such as long-haul freight trucks, tanker trucks, and package delivery [57, 58]. Historically, the IBT has been a strong union [59, 60]. An example of their political power applied to occupational health is their role in influencing President Nixon to compromise in the creation of the Occupational Safety and Health Act [61]. Although they currently represent one tenth of all union workers in the U.S. [57], a review of the literature only found a single study of IBT members and occupational health [62]. There is no existing literature on IBT members and crash risk.

There is existing literature that compares union workers in many industries to their non-union counterparts. Compared to non-union work sites, unionization promotes workplace safety initiatives, such as proper labeling of chemical hazards and ergonomic protections [63, 64]. Union construction workers report more management support for safe work practices than non-union construction workers [65]. This has resulted in union workers having lower occupational injury and fatality rates than non-union workers in the U.S. [66-68]. Thus, when interpreting the results of the second and third manuscripts, I must be aware that the union drivers whom I am surveying are likely in safer occupational climates than if I had surveyed non-union drivers.

Distracted Driving Counter Measures

As has been done for other behaviors that increase motor vehicle injuries and fatalities (e.g., speeding, drunk driving), states and municipalities have passed laws prohibiting distracted driving, specifically CPWD. Ibrahim and colleagues summarize the history of state distracted driving laws in the U.S. [69]. As of July 2013, 41 states ban texting-while-driving and 11 states ban all handheld cell phone use (Washington, DC bans both) [70]. Although research has shown that there is no difference in crash risk comparing talking on a handheld versus hands-free phones, no state bans hands-free CPWD [22, 24]. Some states that don't ban either or both activities have partial bans for novice drivers or bus drivers; no state has a ban specific to commercial truck drivers [70]. Aside from laws pertaining to CPWD bans, Connecticut, Maine, New Hampshire, Oklahoma and the District of Columbia have laws banning general distracted driving [71]. To use Connecticut's general distracted driving statute as an example, drivers are prohibited from engaging "in any activity not related to the actual operation of a motor vehicle in a manner that interferes with the safe operation of such vehicle on any highway" [72].

Due to the federalized system of government in the U.S., the federal government in Washington, DC has little control over state driving laws. In the past, the federal government has necessitated that states have such regulations by making their enactment a stipulation for receiving federal highway funds dispensed by the U.S. Department of Transportation (DOT) [73]. As of yet, no legislative action (necessary for funding appropriations) has been taken by the federal government on distracted driving for all drivers. However, the Executive Branch of the government does have jurisdiction over some aspects of transportation. Under the guidance of DOT Secretary LaHood and with the support of President Obama, the Executive Branch has taken action on distracted driving [74]. Because the FMCSA has jurisdiction over commercial trucks, on September 30, 2009, Secretary LaHood issued a rule stating that commercial truck and bus drivers would be banned from texting-while-driving through the entire U.S. [75]. The Final Rule went into effect October 2010.

Because texting and handheld cell phone bans are fairly recent developments, there are few thorough analyses of their effectiveness. The Governors' Highway Safety Association summarized the literature in 2011 and found that CPWD laws had temporary effects on CPWD activity and little, if any, effect on crash and fatality rates [2]. There are many reasons why these laws have not been effective in achieving their goals. Some states allow for primary enforcement of CPWD laws while others limit officers to secondary enforcement [69]. Primary enforcement of a regulation allows for law enforcement officers to initiate a traffic stop upon observing the violation. If a law enforcement officer observes a regulation prohibited under secondary enforcement, he or she cannot pull over the offending driver specifically for that offense, and can only issue a citation for the secondary offense if the driver was pulled over for a primary offense. A legal review of the Pennsylvania texting ban describes the hurdles both law enforcement officials and prosecutors face in enforcing the ban [76].

A series of studies of teen drivers in North Carolina found that although knowledge of a CPWD ban for teen drivers in the state slowly increased after the law was passed, there was no decrease in handheld cell phone use in either the short- or long-term [77, 78]. If the threat of punishment does not exist, then enforcement as a means to reduce distracted driving is no longer effective. In fact, other researchers have hypothesized that lack of enforcement, or inconsistent enforcement, is a major reason that prior CPWD bans have failed to reduce CPWD crashes or prevalence [14, 69, 79].

If the laws alone do not increase awareness nor result in high levels of enforcement, more concerted efforts could be necessary to produce an effect. NHTSA conducted a demonstration project of high-visibility enforcement in conjunction with a public relations campaign in up-state New York and Connecticut for such a purpose [80]. This NHTSA project, simultaneously implemented at both locations, was designed using elements of previously successful driving safety campaigns, such as the seatbelt enforcement project call "Click It or Ticket" and various drunk driving enforcement efforts. Combining paid media, earned media, and high-visibility enforcement, this project significantly reduced texting and handheld CPWD at both study sites. The NHTSA report on the project even included best practices for law enforcement [80]. Yet because it was so localized in time and place, there is no indication that this program reduced CPWD-related crashes or injuries. Also, because the project was conducted in 2010 and 2011, there has been no follow-up study of the long-term effects in the two communities. Due to the high cost of conducting such a coordinated program, it would be difficult to scale-up such a program to the state or national level; however, this project is evidence that government intervention can reduce prevalence of distracted driving.

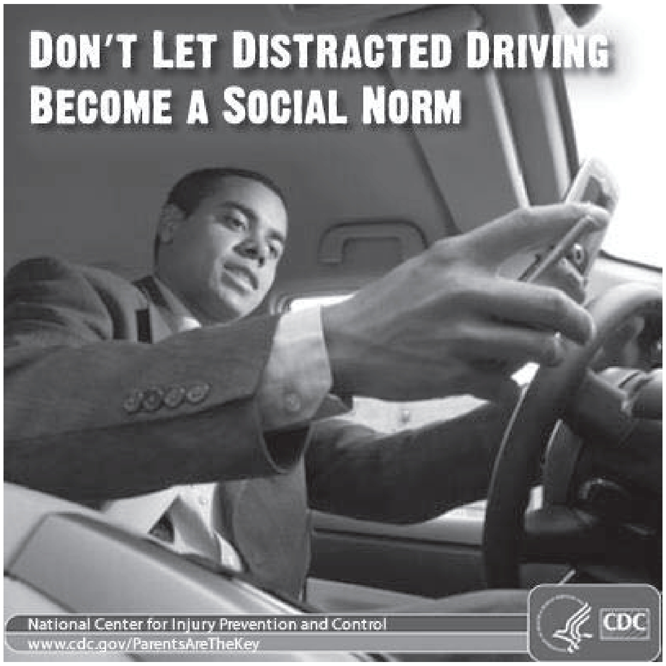
Employers recognize that distracted driving can be an occupational hazard, so some organizations that require frequent driving have created their own policies on distracted driving for employees. These policies are not exclusive to only transportation companies: President Obama issued an Executive Order in 2009 banning all Federal employees from texting while driving while on government business [81].

Organizations understand that not only are their employees at risk for injury, but also that they could be liable for injuries to third parties caused by their employees who are driving distracted [37]. At a 2011 conference on distracted driving in the occupational setting, members of the Network of Employers for Traffic Safety (NETS) described some of the steps their companies had taken to deal with occupational distracted driving [82]. The NETS members, such as Johnson & Johnson and Exxon, described how their companies have taken steps not just to curtail CPWD for their drivers, but also change management practices to insure that drivers are not being contacted when on the road. A 2010 VTTI study of company cell phone policies have been shown to be more effective than state laws at reducing CPWD prevalence [4]. The VTTI researchers hypothesized that on-board safety monitoring technology gave management the ability to observe CPWD and those drivers working under a fleet cell phone policy knew that they could be directly impacted (i.e. punished) for violating the policy. This hypothesis is supported by the finding that state bans did not reduce CPWD for drivers because the police could not monitor cell phone use directly, as thus punishment was less likely [4].

Aside from the aforementioned NHTSA demonstration project involving high-visibility enforcement [80], prior studies of CPWD bans have shown no effect on prevalence or crashes, transportation safety experts have been forced to explore other possible methods to reduce distracted driving. Consistent with the previously described Theory of Planned Behavior described above, current efforts on curbing distracted driving are considering the roles of social norms in CPWD. On March 22, 2013, the CDC's National Center for Injury Prevention and Control sent an image (Figure 2) out via social networking service Twitter with the text "Don't let distracted driving become a social norm." Three studies of non-American drivers all found that subjective norms, what one's peers think about a given behavior, have a major influence on younger drivers' decision-making surrounding CPWD [35, 83, 84]. One of these studies, examining Kuwaiti drivers, found that injunctive norms, i.e., the perception of frequency and acceptability of a given activity, were found to highly correlate with CPWD [84]. Thus, to change social norms on distracted driving, safety advocates will have to address both subjective norms and injunctive norms [85].

Figure 2. Image sent out by the CDC' via Twitter on March 22, 2013

(https://twitter.com/CDCInjury/status/315130180316323841/photo/1)



Methods

This Methods chapter will first describe the methods used in manuscript 1, then the methods used jointly in manuscripts 2 and 3. Manuscript 1 is a statistical exploration of fatality data and is mainly descriptive in nature. Manuscript 2 examines the effects of workplace safety climate on driver distraction and manuscript 3 uses the Theory of Planned Behavior to describe the decision-making process for drivers concerning distracted driving on the job. Manuscripts 2 and 3 were developed in concert and were conducted simultaneously using mixed methods.

Manuscript 1: Statistical Analysis of Distraction-Related Truck Crash Fatalities

As described in the Introduction, motor vehicle incidents are the leading cause of occupational fatality in the U.S. Truck drivers face many forms of distraction while driving on the job [6], yet this issue has emerged in the national consciousness with the increase in cell phone use while driving, especially texting while driving. Prior to the current study, little research has been conducted on the burden of distracted driving on the population of truck drivers in the U.S. The Fatality Analysis Reporting System (FARS, formerly known as the Fatal Accident Reporting System) maintained by NHTSA [86] has been often used by researchers to track occupational [87, 88] and non-occupational motor vehicle fatalities in the U.S. [14, 89]. FARS data are reported annually and fatalities can be assessed by state or territory. Using these design characteristics as the basis of the analysis, the purpose of Manuscript 1 is two-fold: 1) describe distraction-involved truck fatalities by state and across the study period; and 2) assess the impact of state and federal distracted driving regulations on fatality rates.

Data Collection

The FARS data are publicly available and free to download. Cases in FARS are downloaded by year and each case is assigned a unique observation number. Any crash that involves a motor vehicle and result in the death of a motorist or non-motorist within 30 days of the crash is required to be compiled by each state (by a state FARS Analyst); these state-level reports are then combined by NHTSA [90]. Sources that the states use to complete data entry include Police Accident Reports, death certificates, state vehicle registration files, coroner/medical examiner reports, state driver licensing files, hospital medical records, state highway department data, emergency medical service reports, and vital statistics data [90]. FARS has over 120 variables for each case (all of which are not always recorded or required) [90]. It has been shown that when the variables get more specific (e.g., vehicle make and model), the less likely they are to be consistently entered in FARS [91]. NHTSA states that each Analyst's data entry is checked for consistency and completeness on a continuing basis; however, the manual describing the FARS data does not indicate how levels of completeness and accuracy are measured and what is considered acceptable [90].

The variables that I downloaded from FARS for each year were Seating Position, Injury Severity, Body Type, Gross Vehicle Weight Rating, Related Factors- Driver Level (up to four values of this variable were available for each subject), State, Case Number, Vehicle Number, and Person Number. Data were downloaded from FARS as text files and uploaded into Stata v.12.1 (Stata Corp, College Station, TX). I downloaded every case for each individual year, and then used the following process to identify the cases of interest.

To collect the appropriate fatalities, I first needed to identify crashes involving trucks and then determine when the drivers of the trucks were distracted. To identify crashes involving trucks, two FARS variables were used: Body Type and Gross Vehicle Weight Rating (GVWR) for each year of data [92]. Because the GVWR variable was first included in the 2000 database, this year was established as the first year of the study period. Table 2 lists the Body Type categories designating commercial trucks. These Body Type values were validated using GVWR, as recommended by NHTSA in the FARS Coding Manual [92]. I checked to insure that each vehicle identified as having a Body Type found in Table 2 aligned with the FMCSA definition described in the Introduction [25] using the GVWR variable. For vehicles with values of 64 and 79 for Body Type, 204 vehicles were designated as not Commercial Motor Vehicles (CMVs) because their GVWR was below 10,000 lbs. threshold that FMCSA uses to define CMVs.

After identifying crashes involving commercial trucks, I needed to identify those truck drivers who were driving distracted. Because of a change in the FARS database for 2010, separate methods were necessary to identify those truck drivers who were distracted for the 2000 through 2009 data and in the 2010 data. For 2000 through 2009, I used the Related Factors- Driver Level variable. Table 3 displays the values, as described by Wilson and Stimpson, indicating a distracted driver using Related Factors- Driver Level [14]. Because the Related Factors- Driver Level variable was deleted in 2010, the Driver Condition at Crash Time and Driver Distracted By variables were queried to determine distracted drivers. Table 3 displays the values from these variables that indicate a distracted driver. In a 2010 report, NHTSA indicated that most information on distraction-involved crashes comes from police reports [93]. The report concludes that distraction data are likely unreported due to many factors surrounding police report data entry, including whether or not distraction involvement is a field on the police report form and the rate at which new technologies make it difficult for police reports to accurately repot these data.

Table 2. Codes for the Body Type variable from FARS used to select for crashes involving trucks [92].

Body Type Value	Description of vehicle
60	Step van
61	Single-unit straight truck (10,000 lbs.<GVWR≤19,500 lbs.)
62	Single-unit straight truck (19,500 lbs.<GVWR≤26,000 lbs.)
63	Single-unit straight truck (GVWR > 26,000 lbs.)
64	Single-unit straight truck (GVWR unknown)
66	Truck-tractor (Cab only, or with any number of trailing units; any weight)
71	Unknown if single-unit or combination unit Medium Truck (10,000 lbs. < GVWR < 26,000 lbs.)
72	Unknown if single-unit or combination unit Heavy Truck (GVWR > 26,000 lbs.)
78	Unknown medium/heavy truck type
79	Unknown truck type (light/medium/heavy)

In FARS, identifying a driver-related factor does not assign "blame" to that factor for having caused the crash. This analysis did not account for other vehicular or environmental factors, nor factors related to the other driver (in the case of multiple-vehicle crashes) in our analysis. Thus I will refer to these crashes as distraction-involved or distraction-related crashes; not "caused by" distracted driving. After identifying the above crashes, fatalities to distracted truck drivers were identified using the Seating Position and Injury Severity variables.

Table 3. Values of FARS variables indicating a distracted driver, 2000 through 2010.

Year	FARS variable queried	Values Indicating Distracted Driver
2000 and 2001	Related Factor-Driver Level	3- Emotional; 6- Inattentive; 93- Cellular Telephone; 94- Fax Machine; 95- Computer; 96- On-board navigation system; 97- Two-way radio; 98- Head-up display
2002 through 2005	Related Factor-Driver Level	3- Emotional; 6- Inattentive; 93- Cellular Telephone present in vehicle; 94- Cellular telephone in use in vehicle; 95- computer/fax machine/printers; 96- onboard navigation system; 97- two-way radio; 98- head-up display
2006 through 2009	Related Factor-Driver Level	3- Emotional; 6- Operating the vehicle in a careless or inattentive manner; 93- Cellular Telephone present in vehicle; 94- Cellular telephone in use in vehicle; 95- computer/fax machine/printers; 96- onboard navigation system; 97- two-way radio; 98- head-up display
2010	Driver Condition at Crash Time	8- Emotional
	Driver Distracted By	1- Looked but did not see; 3- By other occupant(s); 4- By moving object in vehicle; 5- While talking or listening to cellular phone; 6-While dialing cellular phone; 7- Adjusting audio and/or climate controls; 9- While using other device/controls integral to vehicle; 10- While using or reaching for device/object brought into vehicle; 12- Distracted by outside person, object or event; 13- Eating or drinking; 14- Smoking related; 15- Other cellular phone related; 92- Distraction/inattention, details unknown; 97- Inattentive or lost in thought; 98- Other distraction

I also identified fatalities to occupants other vehicles in distraction-involved truck crashes. I identified crashes where a truck driver was distracted as described above and used the Case Number variable to identify all vehicles in that given crash. Using the Injury Severity variable, I identified all vehicle occupants who were killed in any vehicle involved in the distraction-related crash. This second list of all vehicle occupants includes all the truck drivers who were killed. Using the State variable and the Year variable, I generated longitudinal fatality counts for each state and the District of Columbia (DC). Each year of data offers a cross-section of fatalities in a given state. When individual years are combined, they form a longitudinal fatality database [94].

Descriptive Analysis

Fatalities were analyzed by both counts and rates. The exposure for the rate calculation was billions of vehicle miles traveled (VMTs). VMT is a commonly used measure of driving exposure [95, 96]. VMTs provided a more precise estimate of driving exposure as opposed to calculating rates per number of individuals in a population. Since this study is examining crashes involving trucks, I used diesel VMTs to calculate rates, as was done by Neeley and Richardson [87], for a more precise measure of exposure data for truck traffic in a state. Data on annual state VMTs was obtained from the Department of Transportation's Federal Highway Administration (FHWA) [97]. I downloaded table VM4 from the annual "Highway Statistics" reports [98]. Fatality rates for truck drivers and all vehicle occupants were calculated for each state and year.

Descriptive analysis was conducted on fatality counts and rates. Fatalities for the total period, by state, by year, and by state and by year (state*year) were described using mean, standard deviation, and inter-quartile range. Because there is high variation between states in motor vehicle crash rates and injuries [99], I conducted an analysis of variance (ANOVA) to compare within- versus between-state variation [100].

Analyzing the Effects of Distracted Driving Bans

To analyze the impact of distracted driving laws on fatality rates, a multi-level longitudinal Poisson model was fit. The Poisson model, often used to describe the count distribution of motor vehicle crashes [101], assumes that the mean (E[Y]) and variance (Var[Y]) of an outcome given covariates ($X_1 \ldots X_n$) are equal [102]. The offset for the Poisson model [94, 102] was diesel VMT in billions of miles. The analysis of state laws was informed by Neeley and Richardson's analysis of the impact of state laws on truck driver safety [87]. These authors designed their analysis of truck-involved fatalities noting that crashes are correlated spatially (by state) and temporally [103, 104]. The regression will employ random intercepts for the individual states with fixed effects for the regression coefficients [103, 105, 106]. An exception was the cell phone saturation variable, which used random effects [107]. The random effects model for cell phone saturation had both a significant regression coefficient and reduced log likelihood versus the fixed effects model.

The purpose of this regression analysis was to examine the effects of state CPWD bans on distraction-involved truck crash fatality rates. Wilson and Stimpson conducted a similar longitudinal analysis of texting-while-driving in the U.S. using FARS data and found that as of 2008 no state texting laws had an effect on reducing distraction-related fatalities [14]. As of July 2013, I could identify no analyses of state handheld CPWD bans. State bans on texting and handheld were identified using data from the Governors' Highway Safety Association (GHSA) [70]. Binary variables were generated for each state*year for presence of a given ban. Because the state*year is the level of analysis, I could only describe which year a ban went into effect. Due to sample size limitations, I was unable to describe cases by the state*month, which would be a more accurate representation of when the bans went into effect. A binary variable for the FMCSA texting ban was generated with no ban in 2000 through 2009 and the ban in effect for all states in 2010. Although the FMCSA ban was announced in September, 2009 and the FMCSA solicited open comments on its rule-making procedure in January, 2010, the ban was not put into effect until October, 2010. Since the data were available from 2000 – 2010, this analysis will not be able to assess the impact of the 2010 FMCSA ban on fatality rates

To study the impact of the CPWD bans, other state-level data known to affect crash rates, motor vehicle fatality rates, and distracted driving were added to the model. Table 4 lists these variables, their distributions, and sources. I will briefly describe each of them below.

Cell phone saturation is the number of cell phone subscriptions per capita in a state in a given year and describes the growth in cell phones across the study period [14, 108]. Data on cell phones in a state came from annual reports by the FCC [109] and state population data were downloaded from the Census Bureau. To analyze the effect of the economy on fatality rates [110], annual state unemployment rates were downloaded from the Census Bureau, as were median per capita incomes, standardized to 2011 U.S. dollars. Population density was calculated using annual population and total area, both data also came from the Census Bureau. Because I did not describe crashes as urban or rural, population density serves as an approximation of urbanicity within a state [87].

Table 4. Distribution of and sources of each variable used in the model.

Variable	Distribution	Source
Fatalities	Count	FARS- NHTSA
State texting laws	Binary	GHSA
State handheld cell phone laws	Binary	GHSA
Vehicle miles traveled	Continuous	DOT- Traffic Safety Facts
Cell phone saturation	Continuous	FCC/Census Bureau
State unemployment rate	Continuous	Census Bureau
State ethanol consumption	Continuous	NIAAA [111]
State 0.08 BAC law	Binary	DOT- Traffic Safety Facts
Highway capital expenditures	Continuous	DOT- Traffic Safety Facts
Per capita income	Continuous	Census Bureau
Population density	Continuous	Census Bureau
Primary seat belt law	Binary	DOT [112]
Truck length restrictions	Categorical	Rand McNally Motor Carrier's Road Atlas
Rural truck speed limit	Categorical	Rand McNally Motor Carrier's Road Atlas

Primary enforcement of driver seatbelt laws reduces fatality rates in all crashes [113]; thus this variable was included as a potential confounder. A report on primary and secondary enforcement of seatbelt laws from NHTSA provided information on the years that states enacted primary seatbelt enforcement [112]. I only examined primary enforcement for drivers, because data were not available on all state laws for primary and secondary enforcement of passenger seatbelt use. By the end of the study period, all states had primary seat belt laws.

Two variables were included to account for the effects of drunk driving on fatality rates. The first was a binary variable on whether or not a state used 0.08 mg/dl blood alcohol content (BAC) as the threshold for driving while intoxicated (DWI) or driving under the influence (DUI). These data came from the DOT's annual Traffic Safety Facts reports. Second, per capita alcohol consumption, measured in gallons of ethanol, was obtained from a report from the National Institute on Alcohol Abuse and Alcoholism [111]. Capital expenditures represent the investment that a state makes in roadway infrastructure [87]. These data were also obtained from the Traffic Safety Facts reports and converted to 2010 U.S. dollars. Traffic Safety Facts data were only available through 2010.

All the previous data are publically available online and free to download. Two other variables that impacted fatality rates in the study of truck drivers by Neeley and Richardson were maximum truck length and rural truck speed limit [87]. States are allowed to set both the maximum speed on highways and the maximum allowable length for trucks. The data were obtained from the annual editions of the Motor Carrier's Road Atlas published by Rand McNally. Examining the data, they naturally broke down into categories. For maximum truck length, data were categorized as 1) under 53 feet; 2) 53 feet or 53 feet, six inches; 3) 57 feet, four inches or 57 feet, six inches; and 4) 59 feet or longer. State speed limits were in 5 mile per hour (mph) intervals from 55 mph to 75 mph. I specifically examined "rural truck speed limits" in the analysis: some states have higher speed limits for passenger vehicles versus large trucks and buses; furthermore, some states have higher speed limits in rural areas versus urban areas [87].

Because the Rand McNally atlases were not intended to be used for surveillance, the 2007 through 2009 editions were missing data on rural truck speed limits. Internet searchers produced some missing data: for example, Virginia changed the speed limits by legislative action in from 65 mph in 2009 to 70 mph in 2010 [114]. I imputed the missing data using a method developed by Royston for missing categorical data [115, 116]. Although this method worked, data highly varied between categories year-to-year within a state, which did not reflect the infrequent changes seen in all other years of the study period. As a result, I opted to carry the 2006 observations forward to 2009, a technique for missing data that is commonly used in pharmaceutical studies [117], and noted the limitations of doing so in the manuscript.

Model Diagnostic Tests

As described previously, ANOVA was conducted to compare within- and between-state variation for fatality rates. The results of the F-tests were highly significant for truck driver fatality rates and all vehicle occupant fatality rates, $F_{(50,510)} = 14.51$, $p<0.0001$ and $F_{(50,510)} = 11.47$, $p<0.0001$, respectively. These results reinforced the need for a multi-level model in regression analysis. I used the variance inflation factor (VIF) to test for multicollinearity among the covariates [94]. Since none of the VIF values were above the rule-of-thumb cut-off of 10 no variables were eliminated from the model at this step [118]. Later in the analysis process, Stata dropped the per capita income variable due to collinearity. Other than that, all variables were included throughout the analysis.

Unadjusted regression on truck driver fatality rate and all vehicle occupant fatality rate was conducted for all covariates. For all variables aside from the 2010 FMCSA ban (which was a national ban) state-level fixed-effects (FE) and random-effects (RE) were tested [107]. In only the case of cell phone saturation was there a difference in effect between FE and RE analysis. Other than cell phone saturation, all analyses were conducted using FE.

Two multivariate regression models were fit for both truck driver fatality rates and all vehicle occupant fatality rates. The first model included only those variables that were significant in univariate regression at the $\alpha \leq 0.10$ level. Entering covariates with p-values less than 0.2 has been used in model selection in the past [94]; however, using 0.10 as a cutoff is a trade-off between including relevant covariates and model performance [119]. The second model included the significant variables as well as in the state texting and handheld CPWD bans and the FMCSA ban. These two models were compared using likelihood ratio tests [94, 120].

To test for possible delayed-effects of state laws [121], lagged variables for state texting and handheld CPWD laws were generated. Lagging the effects of the law by one year produced no significant outcomes. Since 2010 was the last year of analysis, lag effects for the FMCSA ban could not be tested.

Manuscripts 2 and 3: A Mixed Methods Examination of Distracted Driving in Commercial Truck Drivers

Manuscript 2 is an analysis of the effects of safety climate on distracted driving behaviors in commercial truck drivers. Manuscript 3 uses the Theory of Planned Behavior (TPB) to analyze the influences on truck drivers' decision-making surrounding distracted driving. Both papers were developed in concert and were conducted using key informant interviews followed by an online survey of commercial truck drivers. First, I will describe the methods for data collection, then I will describe the data analysis methods for each manuscript separately.

When conducting a mixed methods study, researchers must consider what they gain from combining two different paradigms and methods of research. To fully benefit from mixed qualitative and quantitative methods, a researcher has to undertake a pragmatic approach to understanding the strengths and limitations of each method [122, 123]. The term "triangulation" is used as a catch-all to describe how the weaknesses of one method are buttressed by the second method, and vice versa [124]. The mixed methods should grow out of a paradigm, sometimes referred to as post-positivist or pragmatic [123, 124], that builds on both the positivist quantitative data and the constructionist qualitative data.

Qualitative Data Collection- Key Informant Interviews

The TPB, as described in the Introduction chapter, requires key informant interviews to determine the appropriate behaviors, attitudes, social norms, and perceived behavioral control for the population of interest [52]. Originally, I had intended to conduct focus group sessions with truck drivers instead of individual key informant interviews. Working with Mr. Byrd, we had agreed to hold up to five focus group sessions with drivers from IBT Local #639 located in Burtonsville, MD. After Institutional Review Board (IRB) approval was granted through the Johns Hopkins Bloomberg School of Public Health, we were unable to set up focus group sessions that were satisfactory for all parties. Therefore, the qualitative data collection approach was modified slights, and an amendment was submitted and approved by the IRB in November 2012 to conduct key informant interviews.

The purpose of the interviews was four-fold: 1) Understand beliefs and attitudes of truck drivers surrounding distracted driving; 2) Understand correlations between workplace safety climate and distracted driving behaviors; 3) Understand non-crash outcomes that could result from distracted driving; and 4) Determine if commercial truck drivers perceive distracted driving as a threat. The interview script was developed with the input of my Thesis Advisory Committee. After the subject matter was resolved, the survey was pilot tested with a transportation safety researcher from the National Transportation Safety Board and a representative of the American Trucking Association. The recommendations of these experts were used in refining the final language of the interview script. The approved interview script is presented in Appendix 2.

To identify potential respondents for the key informant interviews, I sought out experts in truck driver safety or distracted driving. The initial interview subjects were purposively recruited from the list of attendees at the Symposium on Prevention of Occupationally-Related Distracted Driving sponsored by the Johns Hopkins Bloomberg School of Public Health Occupational Safety and Health Education and Research Center on April 18, 2011 in Laurel, MD. From this conference, two appropriate subjects were identified. Upon completion of the interview, subjects were asked if they could recommend any of their peers who might contribute to data collection; nine subjects were identified by interview participants or attendees from the conference. This snowball sampling technique allowed us to reach interview subjects we might not otherwise have considered [125].

Interviews were conducted via Skype (Microsoft Corp., Redmond, WA) and were recorded using MP3 Skype Recorder v3.1 (www.VOIPCallRecording.com). Audio files of the interviews were transcribed by uploading the .mp3 files to www.productiontranscripts.com (Production Transcripts, Glendale, CA). Data collection was ceased after 11 interviews when data saturation was reached. The recording software failed on one interview, so I ended up with 10 transcripts and notes on all 11 interviews. Data were collected in December, 2012 and January, 2013. The interview subjects remained anonymous throughout data collection; when reference is made to specific interview subjects in Manuscripts 2 and 3, their interview number will be used. Of the 11 interview subjects, five were researchers at academic institutions, three were at private research institutions, and one a piece were from a union, a private company, and a federal agency.

Notes and transcripts were stored as Microsoft Word documents, which were then used for qualitative coding. Data were open-coded line-by-line to label the themes found in subjects' responses [126, 127]. Initial themes were developed by identifying labels that were found in commonly across the interviews. Focused coding, or level-2 coding, was employed to group themes into broader categories [126, 127]. For example, "personal control" and "work pressure" were two labels that often appeared close to one another as interview subjects described the balance the drivers would have to strike in their decision-making process. A codebook (Appendix 4) was developed during the focused coding process. A second coder was employed for a subset of three randomly-selected interviews as a check on the reliability of the coding process. Both coders met to discuss the coding and how well the codebook described the categorizations of the data [128]. The two coders differed slightly in their choice of wording of themes, but no substantive differences emerged. Analysis will be further described for each of the two studies in their respective sections.

Quantitative Data Collection- Online Survey of Commercial Truck Drivers

The International Brotherhood of Teamsters (IBT) represents over one million workers in the U.S. and Canada [57]. I reached out to this group because they represent the largest number of commercial drivers in the U.S. Throughout the design of the study I was in contact with the head of Occupational Safety and Health for the IBT, Mr. Lamont Byrd. Mr. Byrd was able to help refine the language used in study materials and direct me to appropriate groups within the IBT for study.

After the key informant interviews were completed, the driver survey could be finalized. Appendix 3 shows the finalized driver survey. Questions on pages 165 - 169 are the SCQ as modified for drivers by Wills and colleagues [46, 129]. The first step in finalizing the survey was determining which behaviors were most hazardous and relevant and the drivers [52]. The "Behaviors" section in the interview (Appendix 2) asked respondents to give a rating of how distracting each of the behaviors is to truck drivers. This list of behaviors were selected from the table from the VTTI study shown in Appendix 1 [6]. Interview subjects were asked to respond using a Likert scale of 1 through 5 where 1 was "not at all distracting" and 5 was "very distracting." The ratings from all interview subjects were recorded by the interviewer, and a mean perceived hazard was calculated for each behavior. After this section was completed, the interviewer selected three or four of that the interviewee gave the highest distraction scores. The subjects were then asked to describe for each of the selected behaviors if the TPB constructs would affect driver behavior.

Key informants were unanimous in rating "Writing a text message or other message on a cell phone" as very distracting, i.e. 5 out of 5. Dialing a cell phone, reading a message, reading a map, interacting with a dispatch device, and writing notes or a log all had mean perceived distractions above 4.5/5. The TPB survey relies on analyzing behaviors that are relevant to the population. In this case, I choose both "writing a text message…" and "interacting with a dispatch device" as the relevant behaviors that I would use on the survey. After reviewing the literature and consulting with my Thesis Advisory Committee, I settled on the language of "texting" rather than "writing a text message…" for the wording in the online survey. From the interviews, key informants stated that texting could be either from management, if that is an organization's communication method, or personal communications with friends and family.

I chose "interacting with a dispatch device" because this is a distraction that is unique to commercial truck drivers as an occupational hazard. Thus, any interactions that a truck driver has with the device originate solely from his or her occupational situation. One of the pilot testers and a key informant interview subject both recommended that questions about dispatch device use be divided into "looking at" the dispatch device and physically "interacting with" the device. Interview subjects rated "interacting with" as more distracting, on average, than "looking at" the devices, mean perceived distraction 4.5/5 and 4.3/5, respectively. Only those drivers who used dispatch devices as part of their work answered those questions. Two different types of dispatch devices are shown for those survey participants who might be unclear as to what type of equipment the survey referred.

To measure social norms for the TPB, appropriate social referents must be identified [52, 53]. In the interviews, key informants were asked who would positively or negatively influence a driver's decision to undertake any of three or four distractions on which each interview subjects was further probed. The text of all responses on social referents for each behavior were entered into a spreadsheet and color coded indicating whether the interview subject thought that a given referent would have a positive, negative, or neutral/not further specified influence on undertaking such a behavior. In the

10 transcribed interviews, key informants were asked about a total of 32 distracting activities (with much overlap between interview subjects) and only four times did interview subjects report that management had no influence over a given behavior. Interview subjects were specifically asked if family members would influence performance of these behaviors, and in 13 of these same 32 instances, key informants said that family would have no influence. Coworkers and friends had even less influence on behavior performance, according to the key informants. Thus, questions on pages 160, 163 and 164 in Appendix 3 ask about the opinions of supervisors, as they are the most relevant social referents to commercial truck drivers.

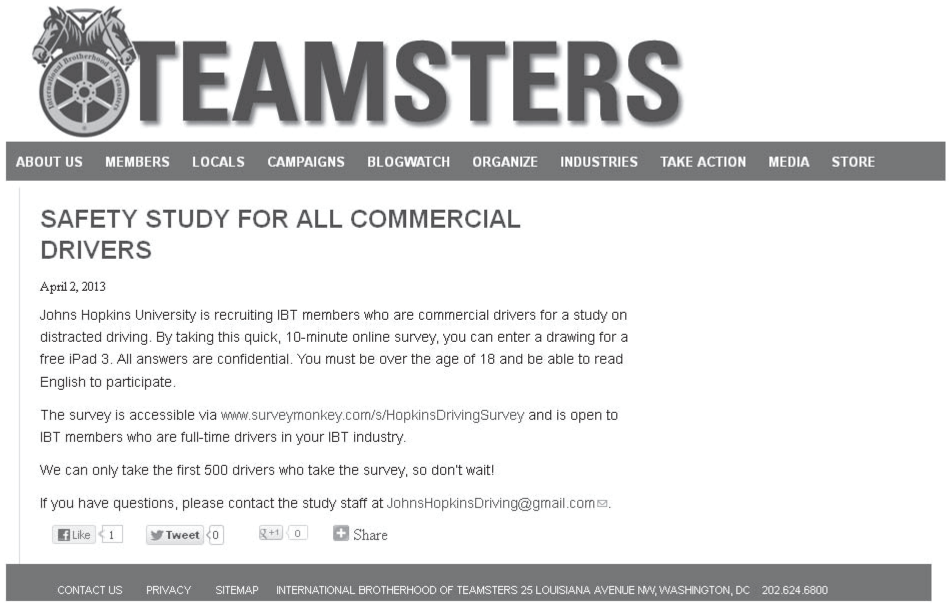
The final page of the survey (Appendix page 170) describes various safety critical events that commercial truck drivers might face. These outcomes were informed by the literature, especially the work of the VTTI researchers [4, 6], and were confirmed as likely scenarios by the key informants. From the Olson study [6] we know that distracted driving crash is least likely, with near crashes being more common outcomes [130]. These four questions will be used as outcomes to analyze against safety climate scores and the components of the TPB. To determine if the language in the survey was appropriate, I went over survey with a Business Representative from an IBT Local with whom Mr. Byrd had put me in contact. After adjusting question order and some wording with the Business Representative, the survey took less than 10 minutes to complete upon pilot testing.

Mr. Byrd and other members of the IBT helped inform the selection of the target population for the survey. Although Teamsters members are generally thought of as truck drivers, the IBT represents a wide variety of drivers, and some non-drivers, whose job duties are highly diverse [58]. From the online list of the various industries that IBT workers work in [58], I narrowed down the target population with the assistance of Mr. Byrd and other IBT representatives. The final sample of eligible drivers included those in the carhaul, express, freight, package, and tankhaul industries. The question on page 157 in Appendix 3 is meant to screen for drivers in these industries. Representative images of the various vehicles are in Appendix 3 on pages 157 and 158. Those drivers who select the option "I don't drive any of these type [sic] the majority of the time" are screened out and redirected to a disqualification page in the survey thanking them for their time, but informing them that they are not appropriate candidates for the research. I estimate that up to 20% of subjects who initiated the survey would be screened out.

On page 174 of Appendix 5, I describe the types of vehicles driven by respondents as they answered on the screening question. The categories in Table 2 of Appendix 5 correspond to the images of the different vehicles on page 157 of Appendix 3. Using a Pearson's χ^2, the distribution of vehicle types is the same for all subjects who passed the screening questions, those included in Manuscript 2, and those in both populations of Manuscript 3. There is no publically available data from the Teamsters that describes the distribution of its members by industry. The U.S. Census Bureau generated a census of all commercial vehicles in the U.S. in 2002 [131]. The Census report found that 62.9% of trucks in the U.S. are "heavy trucks," which in the current study includes semi-trucks, carhaul, tankhaul, and dump trucks; 22.5% were “medium trucks,” which includes the package vans in the current study; and the remaining 14.6% of trucks were small trucks excluded from the current analysis. Although I did not seek specific percentages of each vehicle type in the study, the percent of large trucks and medium trucks in Manuscripts 2 and 3 are not widely different from the Census Bureau report. A caveat is that the Census data were collected 11 years before my data, so the American trucking fleet might have undergone changes in that time.

With Mr. Byrd’s assistance, a link to the survey was posted to the Teamster’s website on April 2, 2013. The survey was created using SurveyMonkey, an online survey tool (SurveyMonkey LLC, Palo Alto, CA). Figure 3 is a screenshot of the survey announcement taken on April 4, 2013. Due to funding constraints, I could not afford to pay each survey participants reimbursement for the time used taking the survey. Thus, as seen in Figure 3, I used the raffle of an iPad 3 as enticement to take the survey. To insure the privacy of any study subjects, a separate survey was created solely for subjects to enter their email addresses if they wished to enter the raffle. As a further blinding procedure, my advisor, Dr. Pollack, randomly selected a winner from email addresses entered in the second survey. The survey was closed on May 19, 2013.

Figure 3. Screenshot of the survey announcement on the Teamster's website (http://www.teamster.org/content/safety-study-all-commercial-drivers accessed 4 April 2013)



Separate sample size requirements were calculated for the safety climate data and the TPB data. The safety climate questions are analyzed using a factor analysis. A rule of thumb for sample size and factor analysis is a ratio of 10 subjects per survey question [118], yet this is not a hard and fast rule [132]. A ratio of 5:1 or 6:1 has also been frequently used, and after 300 subjects the ratio of subjects to questions can does not need to be as high as 10:1 [132, 133]. For the 35-item SCQ modified for drivers [47], a sample of at least 350 subjects would be very strong, whereas 175 subjects would produce the minimal 5:1 ratio.

There are many ways to conduct a sample size calculation for multivariate regression analyses of survey data [134-136], yet many TPB studies lack a sample size or power calculations [134]. Reviews of sample size find that the gold standard method is to use variance inflation factor (VIF) from multivariate regression [134, 136]. Two studies examining TPB and driver behavior were identified for sample size calculations: Elliott and colleagues [49] used the TPB to describe 943 English drivers' speeding behaviors and Wills and colleagues [129] compared the TPB constructs to negative workplace outcomes, such as crashes and traffic violations, for 317 Australian truck drivers. Neither of these studies allowed for sample size calculation using the VIF method.

The Elliott *et al.* study regressed TPB components and demographic data, as I plan to do, on speeding behaviors. The resulting model had an R^2 of 0.63 and an F statistic significant at $p < 0.001$ [49]. Using a sample size calculation from Fisher's and Van Belle's text book [137] I calculated that the 943 subjects in the Elliott *et al.* study resulted in a power of 0.988. The data presented in the Wills *et al.* study did not allow for a similar calculation. Extrapolating from the Elliott results, I estimated that a sample of 500 drivers would result in a study with power of greater than 0.80 and an alpha-level of 0.05.

Because the current study applies the TPB to a behavior (distracted driving) and a population (truck drivers in the U.S.) that have never before been examined, there is no one study that I can point to as a gold-standard when estimating outcome frequency. The VTTI study by Olson and colleagues found only 21 crashes, 197 near crashes, and 1,215 lane deviations in 735,000 miles of recorded data [6]. Crashes and near-crashes are seemingly rare events; however, the driver population in the study by Elliott and colleagues also reports very infrequent speeding behavior and their TPB analysis was able to produce significant results [49]. As a result of the power calculation using the Elliott *et al* the IRB approved sampling of 500 subjects.

Manuscript 2- Safety Climate- Data Analysis

The mixed methods data were collected separately from different populations. Although qualitative data were collected first, in this manuscript the order of data collection was not important to its interpretation. In mixed methods study notation, this manuscript follows a QUAN+qual design for the purposes of complementarity evaluation, that is, elaborating and illustrating quantitative results with the qualitative data [138, 139]. By using qualitative data from a population outside that of the drivers who are surveyed quantitatively, this "between-method" should enhance the data's external validity [124].

Of the 440 subjects who entered the survey, 79 (18%) were screened out when they identified as not driving in one of the vehicles of interest. Over the course of the survey, 122 of the remaining 361 (34%) left the survey before completion. The final population consisted of 239 members of the International Brotherhood of Teamsters. Appendix 5 more thoroughly describes how this final sample size was reached. The online survey consisted of the 35 item SCQ modified for drivers by Wills and colleagues [46, 129]; questions on the subject's gender, age, and years driving experience; and four questions on crashes and near crashes involving distraction. Drivers were asked how much they agreed with a given SCQ question using a Likert scale where 1 represented "Strongly agree," 4 represented "Neutral," and 7 represented "Strongly disagree."

Qualitative data were collected from 11 key informant interviews with experts in truck driving safety, distracted driving, and transportation labor or management groups; 10 of the 11 interviews were successfully transcribed. Transcribed interviews and the interviewer's notes were saved as Word documents (Microsoft Corp, Redmond, WA).

A factor analysis was conducted to determine if the six factors of the SCQ as determined by Wills *et al*. were appropriate for this population. From principal component analysis, the eigenvalues and percent variance explained indicated that there were between three and seven factors [140]. The scree plot with parallel analysis [141] (see Manuscript 2 Results) indicates that the data are best described by three factors. Using Wills *et al*. as a starting point, a 6-fator model was estimated using maximum likelihood; promax factor rotation was used due to correlation between factors [140]. Items with high uniqueness values (i.e., greater than 0.5) were dropped and the model was reassessed. Continued data reduction produced three factors (the first three factors from Wills *et al*.) strongly loaded on SCQ items 1 through 12, 14 through 20, and 21 through 24, respectively. Table 5 is a pattern matrix for the three factors [46].

Table 5. Pattern matrix for three factors for the SCQ. Chronbach's alpha for reliability of each factor is listed.

Items and Labels	1	2	3
Factor 1- Communications and Pressure (α = 0.94)			
1. Changes in working procedures and their effects on safety are effectively communicated to workers	0.74		
2. Employees are consulted when changes to driver safety practices are suggested	0.79		
3. Employees are told when changes are made to the working environment such as the vehicle, maintenance or garaging procedures	0.74		
4. Safety policies relating to the use of motor vehicles are effectively communicated to the workers	0.87		
5. Safety procedures relating to the use of motor vehicles are complete and comprehensive	0.84		
6. An effective documentation management system ensures the availability of safety procedures relating to the use of motor vehicles	0.82		
7. Safety problems are openly discussed between employees and management/supervisors	0.66		
8. Safety procedures relating to the use of motor vehicles match the way tasks are done in practice	0.66		
9. Employees can discuss important driver safety policy issues	0.51		
10. Employees are consulted for suggested vehicle/driver safety improvements	0.72		
11. Employees can identify relevant procedures for each job	0.62		
12. Employees can express views about safety problems	0.50		
Factor 2- Work Pressure (α = 0.93)			
14. Time schedules for completing work projects are realistic		0.85	
15. There is sufficient 'thinking time' to enable employees to plan and carry out their work to an adequate standard		0.88	
16. Workload is reasonably balanced		0.87	
17. There are enough employees/drivers to carry out the required work		0.76	
18. Changes in workload, which have been made on short notice, can be dealt with in a way that does not affect driver safety		0.80	
19. When driving employees have enough time to carry out their tasks		0.82	
20. Problems that arise outside of employees' control can be dealt with in a way that does not affect driver safety		0.61	
Factor 3- Management Commitment (α = 0.95)			
21. Management are committed to driver safety			0.86
22. Management are committed to motor vehicle safety			0.85
23. Driver safety is central to managements' values and philosophies			0.82
24.Driver safety is seen as an important part of fleet management in this organization			0.70

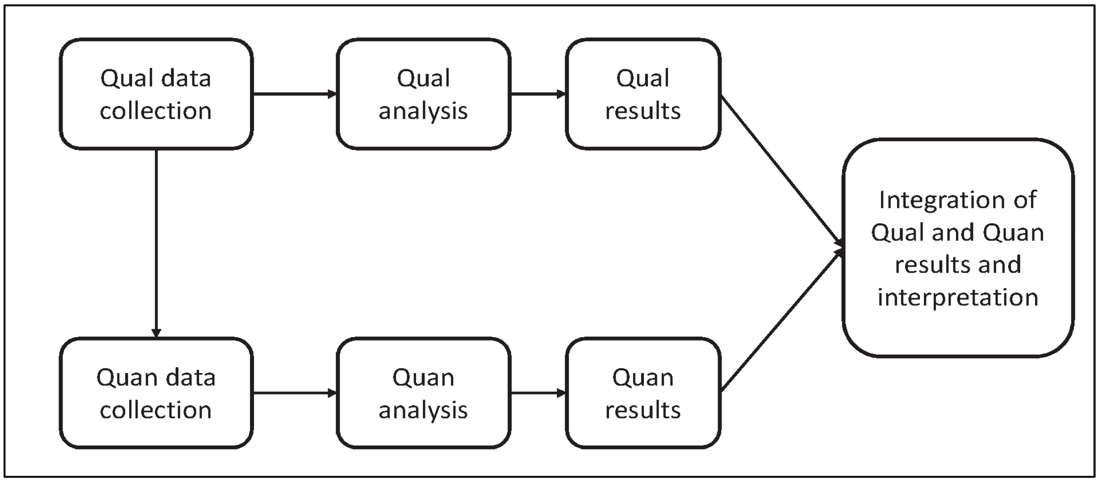
The scores from the questions in a given factor were averaged to create a factor score for each subject. The mean factor scores and demographic data were entered into a multivariate regression for each of the four outcomes of interest [129]: 1) I have ever had a crash while driving on the job; 2) I have ever had a crash while driving distracted on the job; 3) I have ever had to break hard while I was distracted on the job; 4) I have ever had to swerve or jerk the wheel to get back into my lane while distracted on the job. All quantitative analysis was conducted with Stata v.12.1 (Stata Corp, College Station, TX).

The results of the quantitative data and qualitative data are presented together. Using qualitative data in this way to elucidate on the statistical results allows for clarification of the effects of safety climate on drivers and employers [138].

Manuscript 3- Theory of Planned Behavior- Data Analysis

The data collection and analysis in this manuscript follow what has been termed a "concurrent design" [142, 143]. The qualitative and quantitative data are collected and analyzed separately, the results of each method are first presented separately, then integrated for interpretation [144, 145]. The term "concurrent" in this usage does not necessarily designate temporal concurrence, it only means that the qualitative and quantitative data are developed and analyzed separately before integration [145]. Figure 4 is a visualization of the concurrent/triangulation mixed methods design used in this analysis.

Figure 4. Diagram of the analysis of key informant interviews (Qual) and analysis of surveys (Quan) in Manuscript 3. This visualization is based off Plano-Clark's and Creswell's interpretation [146](p. 380) of Luzzo's mixed methods analysis [145].



As described above, key informant interviews were used to elucidate the components of the TPB relevant to distracted driving in an occupational population. This is depicted in Figure 4 as the line from "Qual data collection" to "Quan data collection." Transcribed interviews were saved as Word documents for qualitative analysis. Interview transcripts were analyzed for themes surrounding performance of distracting activities. Specifically, data on social norms and perceived behavioral control were closely assessed using qualitative methods. Online survey data of IBT members were downloaded from SurveyMonkey into Stata statistical software. Of the 440 subjects who entered the survey, 79 (18%) were screened out because they did not drive the appropriate vehicle. All subjects (n=277) answered TPB questions on "texting while driving" and those drivers who indicated that they used a dispatch device in their work (n=153) answered questions on the TPB concerning "interacting with a dispatch device." See Appendix 5 for a more detailed description of how these sample sizes were produced.

The TPB constructs were the independent variables and were scored as described by Montaño and Kasprzyk [52]. Attitude was assessed using the average of three semantic differential 7-point bipolar scales ranging from 1 to 7 with endpoints including "very harmful – very beneficial," "very unpleasant – very pleasant," and "very bad – very good;" intention was measured using a single 7-point bipolar scale (1 through 7) with endpoints "Definitely will – Definitely will not," that is, an increased intention score indicates that a driver had less intention to undertake a given behavior; perceived behavioral control was assessed using a multi-item indirect assessment by multiplying control beliefs (scored on a bipolar 7-point scale) with times perceived power (scored -3 to +3 on a bipolar scale); social norm was assessed with a multi-item indirect assessment multiplying the normative belief (scored -3 to +3) times the motivation to comply (score 1 to 7). The Cronbach's alpha for reliability of the texting and dispatch device use scales were 0.71 and 0.84, respectively.

Exploratory data analysis was conducted on the TPB constructs separately for both the texting and dispatch device populations [147]. Means and standard deviations were generated for each TPB construct and because the range of scores was small, frequency tables and histograms were also generated for visual assessment of the data. Although previous studies on driver behavior and the TPB have used mean scores to analyze each TPB construct [35, 56], our data were not normally distributed and clustered around certain responses. Thus, we categorized the four TPB constructs for the texting and dispatch device use data. Development of the individual categories is described in the Results section of Manuscript 3.

Subjects also self-reported if they ever had experience a series of safety critical events while on the job [148]. Subjects first reported whether or not they ever had a crash while on the job. After being reminded that distracted driving encompasses any activities that that take the driver's eyes, hand, or concentration away from the primary driving task, subjects reported whether or not they had ever had a crash while distracted, had to brake hard to avoid a crash while distracted, and swerve to avoid a crash while distracted. These four outcomes served as the dependent variables in four separate regression analyses, described below, in both the texting and dispatch device populations. The Olson *et al*. study found that truck drivers would undertake distracting activities in the non-crash control periods as well as during crashes or near crashes [6]. Rather than asking drivers if they had ever driven distracted, which can occur without negative consequences, we asked for situations when the distraction was so great that it became a hazard for crash or near crash.

Means and standard deviations (SDs) were calculated for age, years driving experience and weekly driving hours. Descriptive analysis of the categorical TPB variables was conducted. To validate the model in Figure 1 (page 4), we examined whether or not Intentions mediated the effects of the other TPB variables on the four outcomes [94]. To test this model required a multi-step process. First, we correlated

Norms, PBC, and Attitudes to Behavioral Intentions using logistic regression for both texting and dispatch device use [35, 56]. Second, univariate logistic regression was used to analyze the association of each of the four TPB constructs for texting and distracted driving with the four crash and near crash outcomes. Univariate logistic regression was also conducted for demographic data that the drivers reported: gender, age, driving experience, and weekly driving hours. Third, multivariate regressions were first conducted without Intentions, then including Intentions to see if it attenuated the effects of the other three TPB constructs, that is, did the ORs for Norms, PBC, and Attitudes decrease and what, if any, effect was there on the significance of the ORs. A change in the ORs towards 1.0 and/or decreasing significance of the p-values of the ORs was considered to be a mediation effect. Control variables in the multivariate models included on those variables that had p-values ≤ 0.10. Entering covariates with p-values less than 0.2 has been used in model selection in the past [94]; however, using 0.10 as a cutoff is a trade-off between including relevant covariates and model performance [119].

Qualitative and quantitative results are presented separately. Results from both methods are then brought together for meta-inference, defined by Tashakkori and Teddlie as "integration of the inferences that are obtained on the basis of QUAL and QUAN strands of a mixed methods study" (p. 710) [149]. The quantitative and qualitative data will be compared for where they agree and where they differ.

Manuscript 1: Effects of State Policies on Fatalities Involving Distracted Truck Drivers

Abstract

In order to prevent distracted driving-related crashes, states have banned texting and handheld cell phone use for drivers. The present study analyzes the impact of these regulations on state-level fatalities rates for both truck drivers and all vehicle occupants in distraction-involved truck crashes. First, we described each fatality count by-state and by-year using data from the Fatality Analysis Reporting System from 2000 through 2010. A multi-level longitudinal Poisson model was fit to assess the impact of state bans for texting or handheld cell phone use on distraction-related truck crash fatality rates. These results revealed that fatality rates have been decreasing since 2007. We found that there was no effect of state bans on distraction-involved truck crash fatality rates. A nationwide ban on texting for commercial truck drivers implemented in 2010 was associated with a continued decrease in fatality rates, yet further analysis will be necessary to assess the impact of this regulation on distraction-involved truck fatality rates.

Introduction

Although motor vehicle fatality rates have been decreasing for the past few decades [150], the rates and counts of fatalities involving distracted driving (DD) have been increasing since the early 2000s [93]. An emerging contributor to DD crashes and fatalities is cell phone use while driving (CPWD) [151], specifically, reading, writing, and sending SMS messages with a cellular phone (a.k.a., text messaging, or texting) [14].

In addition to these general electronic communication distractions, commercial truck drivers may face occupational distractions, including keeping logs and monitoring a dispatch device [6]. Both states and the federal government have implemented regulations to decrease DD for all drivers and commercial drivers. This study will quantify fatalities in the United States (U.S.) and examine the effects, if any, of state and federal regulations on distraction-involved truck crashes.

Distracted driving

Driving involves primary, secondary, and tertiary tasks [1]. Primary tasks are those that only involve vehicle direction and speed, such as steering and breaking. Secondary tasks support operation of the vehicle depending on the situation, such as using turn signals, checking the speedometer, and turning on the lights. Anything not included as primary or secondary task for vehicle operation is considered a tertiary task. Tertiary tasks include a wide range of activities, such as interacting with passengers, smoking, eating, and cell phone use [6, 7, 152]. Distracted driving (DD) is then defined as any activity that takes the drivers eyes, hands, or concentration away from the primary task of driving [153].

Although DD is not a novel risk to drivers [154], the recent increase in cell phone use while driving (CPWD) has lead to a rise in DD-related motor vehicle crashes (MVCs) [11, 14]. Estimates are that drivers use handheld cell phones approximately 6% of driving time [8, 10]. Two of the most dangerous distractions that drivers can undertake with a phone are texting while driving and dialing the phone [12, 13]. These tasks involve manual, visual, and cognitive distractions, and have been shown to produce the most unsafe driving behavior in both simulator [155] and in-vehicle studies [6].

Commercial Truck Drivers and Distraction

The leading cause of death for all American workers is MVC [156]. The MVC fatality rate is 3.7 deaths per every billion vehicle miles traveled (VMT) [32] for truck drivers. In the U.S., commercial motor vehicles are those vehicles that a) have a gross vehicle weight rating of more than 10,000 pounds; b) have a gross combination weight rating of 26,001 pounds or more; c) are designed to transport 16 or more passengers; or d) are of any size and transports hazardous materials [25]. Aside from distractions faced by non-commercial drivers, commercial truck drivers face additional work- and vehicle-specific distractions that raise their crash risk. A series of studies by the Virginia Tech Transportation Institute has enumerated the unique occupational distractions faced by commercial drivers, such as using a CB radio, and interacting with a dispatch computer [4, 6]. These studies generated a thorough catalog of odds ratios for crashes and near crashes for each distracting activity.

In the occupational setting, it is possible that truck drivers have less freedom over the decision to undertake distracting activities while driving [36]. A study of occupational drivers found that increased work pressures were correlated with driver distractions [47]. It is possible that professional drivers are being required, either explicitly or implicitly, to undertake tertiary activities while driving to increase work efficiency. Whether or not they have control over it, drivers who mainly drive for work purposes are more likely to report CPWD than drivers who mainly drive for non-occupational reasons [35]. An increased number of potential distractions and workplace pressures to attempt distractions while driving make DD an important risk factor for occupational injury and fatality. It is unknown what the burden of DD-involved truck crashes is in the U.S. or globally.

Due to their size and mass, crashes involving large trucks pose a greater threat to other vehicle occupants and pedestrians. For example, in 2009, among fatal crashes involving a large truck and a passenger vehicle, there were only 18 fatalities to truck occupants compared to 1,022 fatalities to occupants of the passenger vehicles [157]. In multi-vehicle crashes, the mass of the truck poses an additional danger to occupants of other vehicles and somewhat protects the truck driver from injury [158]. In fact, the ratio of mass of two vehicle involved in a crash is predictive of fatality risk for occupants in the two vehicles [34, 158]. Therefore, to fully understand the burden of DD-related truck crashes, it is important to examine fatalities to both truck drivers and other vehicle occupants involved in a given crash.

Distracted Driving Laws

In an attempt to address DD, states have passed laws restricting texting while driving and handheld CPWD. New York was the first state to pass a texting ban for all drivers in 2001, and as of April 1, 2013, 39 states and the District of Columbia (D.C.) have passed texting bans [70]. Handheld CPWD is banned in 10 states and D.C. Although research has shown that there is no difference in crash risk comparing talking on a handheld versus hands-free phones [22, 24], no state currently bans all CPWD [70].

The texting bans in 36 of the 40 jurisdictions have primary enforcement; 9 of 11 jurisdictions have primary enforcement for the handheld CPWD ban [70]. Some states without comprehensive texting or handheld CPWD bans have partial bans for given populations, such as novice drivers and bus drivers; no state has a ban specific to commercial truck drivers [70].

Texting and handheld cell phone bans are recent legal solutions to the growing hazards of CPWD. McCartt and colleagues studied the effect of handheld cell phone bans in New York, Washington, D.C, and Connecticut and found immediate reductions in usage rates, but had mixed success in the long-term [159]. The Governor's Highway Safety Association summarized the existing literature and found that there is no evidence to suggest that texting or handheld CPWD bans have reduced crashes [2]. A recent study by Lim and Chi found that handheld CPWD laws were associated with a reduction in total crash fatality rates for drivers in age 18 – 35 cohorts, but had no effect for older drivers [160].

In September 2009, the Federal Motor Carrier Safety Administration (FMCSA) of the U.S. Department of Transportation issued a regulation entitled "Limiting the Use of Wireless Communication Devices," which banned commercial truck and bus drivers from text messaging-while-driving [161]. In the final rule issued by the FMCSA, which went into effect in October 2010, drivers who are found to be texting-while-driving face up to a $2,750 fine and their employers are liable for a fine up to $11,000 [75]. Unlike the patch-work state DD laws, this regulation went into effect for the U.S. at one set time and covered every state equally. However, in the text of the Final Rule, states were given up to three years to implement sufficient enforcement of the regulation. A review of the existing literature did not yield any prior studies on the implementation of this regulation state-by-state.

Materials and Methods

Data Collection

The Fatal Accident Reporting System (FARS) is an annual database published by the National Highway Transportation Administration (NHTSA) that includes all MVCs that resulted a fatality in a given year [162]. Data were collected from 2000, when the gross vehicle weight rating (GVWR) variable was first available, through 2010. Data were downloaded from the FARS Encyclopedia (http://www-fars.nhtsa.dot.gov/Main/index.aspx) into Stata v. 12.1 (Stat Corp., College Station, TX).

Using FARS, fatal crashes involving medium (GVWR from 10,000 to 26,000 pounds) and heavy (GVWR greater than 26,000 pounds) commercial trucks were identified [87]. The Seating Position variable was used to identify the truck drivers. Because of a change in the FARS database for 2010, separate methods were necessary to identify those truck drivers who were distracted for the 2000 through 2009 data and in the 2010 data. For the period from 2000 through 2009, the Related Factors- Driver Level variable was used. Table 3 displays the values, drawing on a method described by Wilson and Stimpson, to indicate a distracted driver [14]. The Related Factors- Driver Level was deleted from FARS in 2010, so the Driver Condition at Crash Time and Driver Distracted

By variables were queried to determine distracted drivers. Table 6 also includes the values from these variables that indicate a distracted driver. FARS does not identify a driver-related factor does not to suggest “blame” to that factor for having caused the crash. Thus, this analysis was unable to account for other vehicular, environmental, or driver-related factors that may have been the root cause of the crash. As a result, this study explores crashes involving distracted truck drivers and not crashes caused by distracted truck drivers. The Injury Severity variable was then used to identify truck drivers and other vehicle occupants killed in the crash. Both of these counts were compiled by year for each state and the District of Columbia.

Table 6. Values of FARS variables indicating a distracted driver, 2000 through 2010.

Year	FARS variable queried	Values Indicating Distracted Driver
2000 and 2001	Related Factor-Driver Level	3- Emotional; 6- Inattentive; 93- Cellular Telephone; 94- Fax Machine; 95- Computer; 96- On-board navigation system; 97- Two-way radio; 98- Head-up display
2002 through 2005	Related Factor-Driver Level	3- Emotional; 6- Inattentive; 93- Cellular Telephone present in vehicle; 94- Cellular telephone in use in vehicle; 95- computer/fax machine/printers; 96- onboard navigation system; 97- two-way radio; 98- head-up display
2006 through 2009	Related Factor-Driver Level	3- Emotional; 6- Operating the vehicle in a careless or inattentive manner; 93- Cellular Telephone present in vehicle; 94- Cellular telephone in use in vehicle; 95- computer/fax machine/printers; 96- onboard navigation system; 97- two-way radio; 98- head-up display
2010	Driver Condition at Crash Time	8- Emotional
	Driver Distracted By	1- Looked but did not see; 3- By other occupant(s); 4- By moving object in vehicle; 5- While talking or listening to cellular phone; 6-While dialing cellular phone; 7- Adjusting audio and/or climate controls; 9- While using other device/controls integral to vehicle; 10- While using or reaching for device/object brought into vehicle; 12- Distracted by outside person, object or event; 13- Eating or drinking; 14- Smoking related; 15- Other cellular phone related; 92- Distraction/inattention, details unknown; 97- Inattentive or lost in thought; 98- Other distraction

Data Analysis

Descriptive analysis was conducted on fatalities involving truck driver and all vehicle occupants in distraction-involved truck crashes. Data were analyzed by raw counts and per billion VMT, an exposure commonly used to calculate motor vehicle crash rates [95, 96]. Since this study specifically examines crashes involving trucks, rate calculations were conducted using diesel VMTs, consistent with prior research, to provide a more precise estimate of exposure [87]. Data on annual state VMTs was obtained from the Department of Transportation's Federal Highway Administration (FHWA) [97]. State fatality rate data were described across states and across years. To compare within- versus between-state variation an analysis of variance (ANOVA) was used [100].

To analyze the impact of distracted driving laws on fatality rates, a multi-level longitudinal Poisson model was fit, where the state was the first level and the U.S. was the second level. The offset for the Poisson model [94, 102] was the log of diesel VMT in billions of miles. Aside from state texting-while-driving bans, state handheld cell phone bans, and the federal regulation banning texting for all commercial truck drivers, we collected other variables that have been shown to influence DD crashes, or motor vehicle fatality rates. Table 7 lists these variables, their distributions, and sources. I will briefly describe each of them below.

Table 7. Distribution of and sources of each variable used in the model.

Variable	Distribution	Source
Fatalities	Count	FARS- NHTSA
State texting laws	Binary	GHSA
State handheld cell phone laws	Binary	GHSA
Vehicle miles traveled	Continuous	DOT- Traffic Safety Facts
Cell phone saturation	Continuous	FCC/Census Bureau
State unemployment rate	Continuous	Census Bureau
State ethanol consumption	Continuous	NIAAA [111]
State 0.08 BAC law	Binary	DOT- Traffic Safety Facts
Highway capital expenditures	Continuous	DOT- Traffic Safety Facts
Per capita income	Continuous	Census Bureau
Population density	Continuous	Census Bureau
Primary seat belt law	Binary	DOT [112]
Truck length restrictions	Categorical	Rand McNally Motor Carrier's Road Atlas
Rural truck speed limit	Categorical	Rand McNally Motor Carrier's Road Atlas

Cell phone saturation is the number of cell phone subscriptions per capita in a state in a given year and describes the growth in cell phones across the study period [14, 108]. Data on cell phones in a state came from annual reports by the FCC [109] and state population data were downloaded from the Census Bureau. To analyze the effect of the economy on fatality rates [110], annual state unemployment rates were downloaded from the Census Bureau, as were median per capita incomes, standardized to 2011 U.S. dollars. Population density was calculated using annual population and total area, both data also came from the Census Bureau. Because I did not describe crashes as urban or rural, population density serves as an approximation of urbanicity within a state [87].

Primary enforcement of driver seatbelt laws reduces fatality rates in all crashes [113]; thus this variable was included as a potential confounder. A report on primary and secondary enforcement of seatbelt laws from NHTSA provided information on the years that states enacted primary seatbelt enforcement [112]. I only examined primary enforcement for drivers, because data were not available on all state laws for primary and secondary enforcement of passenger seatbelt use. By the end of the study period, all states had primary seat belt laws.

Two variables were included to account for the effects of drunk driving on fatality rates. The first was a binary variable on whether or not a state used 0.08 mg/dl blood alcohol content (BAC) as the threshold for driving while intoxicated (DWI) or driving under the influence (DUI). These data came from the DOT's annual Traffic Safety Facts reports. Second, per capita alcohol consumption, measured in gallons of ethanol, was obtained from a report from the National Institute on Alcohol Abuse and Alcoholism [111]. Capital expenditures represent the investment that a state makes in roadway infrastructure [87]. These data were also obtained from the Traffic Safety Facts reports and converted to 2010 U.S. dollars. Traffic Safety Facts data were only available through 2010.

All the previous data are publically available online and free to download. Two other variables that impacted fatality rates in the study of truck drivers by Neeley and Richardson were maximum truck length and rural truck speed limit [87]. States are allowed to set both the maximum speed on highways and the maximum allowable length for trucks. The data were obtained from the annual editions of the Motor Carrier's Road Atlas published by Rand McNally. Examining the data, they naturally broke down into categories. For maximum truck length, data were categorized as 1) under 53 feet; 2) 53 feet or 53 feet, six inches; 3) 57 feet, four inches or 57 feet, six inches; and 4) 59 feet or longer. State speed limits were in 5 mile per hour (mph) intervals from 55 mph to 75 mph. I specifically examined “rural truck speed limits” in the analysis: some states have higher speed limits for passenger vehicles versus large trucks and buses; furthermore, some states have higher speed limits in rural areas versus urban areas [87].

Because the Rand McNally atlases were not intended to be used for surveillance, the 2007 through 2009 editions were missing data on rural truck speed limits. Internet searchers produced some missing data: for example, Virginia changed the speed limits by legislative action in from 65 mph in 2009 to 70 mph in 2010 [114]. I imputed the missing data using a method developed by Royston for missing categorical data [115, 116]. Although this method worked, data highly varied between categories year-to-year within a state, which did not reflect the infrequent changes seen in all other years of the study period. As a result, I opted to carry the 2006 observations forward to 2009, a technique for missing data that is commonly used in pharmaceutical studies [117], and noted the limitations of doing so in the manuscript.

Data were compiled by state and by year into a longitudinal database [94]. Univariate analyses were conducted for the bans as well as covariates that have previously been shown to affect crash fatality rates. Multivariate regression models were fit for both truck driver fatality rates and fatality rates for all vehicle occupants. Two nested models were fit for each outcome: Model 1was only those variables that were statistically significant ($p \leq 0.10$) in univariate regression; Model 2 consisted of the variables in Model 1 plus the texting and handheld cell phone bans. The nested models were compared with a likelihood ratio test [94, 120].

In univariate and multivariate analyses all covariates were examined using fixed effects, other than cell phone saturation, which used random effects [107]. The random effects model for cell phone saturation had both a significant regression coefficient and reduced log likelihood versus the fixed effects model. Analysis was conducted using Stata v 12.1 (College Station, TX).

Results

Descriptive Analysis

From 2000 through 2010, there were 1,007 fatalities to truck drivers who were distracted at the time of the crash. The fatality rate for this period was 0.321 per billion diesel VMT. For all vehicle occupants in crashes involving distracted truck drivers, there were 3,942 fatalities for a rate of 1.101 per billion VMT. Table 8 has descriptive data on fatality counts and rates by state and by year. ANOVA for both truck driver fatality rates and fatality rates to all vehicle occupants found much more variation between than within states ($F_{(50,510)} = 14.51$, $p<0.001$ and $F_{(50,510)} = 11.47$, $p<0.001$, respectively). Table 9 is an example of the variation between states, displaying the highest and lowest state fatality counts and rates over the study period. Figures 5 and 6 show fatality rates by year for truck drivers and all vehicle occupants, respectively.

Table 8. Descriptive Data on Fatality Counts and Rates (per Billion VMT) for Truck Drivers and All Vehicle Occupants in Distraction-Related Truck Crashes (Min-Max= Minimum – Maximum; SD = Standard Deviation; IQR = Interquartile Range)

	Truck driver fatalities			All vehicle occupant fatalities		
	Mean (SD)	Min-Max	IQR	Mean (SD)	Min-Max	IQR
Count per state	19.7 (25.8)	0 – 134	20	77.3 (106.8)	0 – 406	63
Rate per state	0.321 (0.33)	0 – 1.579	0.41	1.101 (0.95)	0 – 5.475	0.97
Count per year	91.6 (21.6)	53 – 129	35	358.4 (82.9)	202 – 498	143
Rate per year	0.303 (0.07)	0.179 – 0.405	0.13	1.185 (0.25)	0.682 – 1.632	0.43

Table 9. Lowest and Highest State Fatality Counts and Rates (per Billion VMT) for All Vehicle Occupants in Crashes Involving Distracted Truck Drivers, 2000 – 2010.

Lowest				Highest			
State	Count	State	Rate	State	Count	State	Rate
DC	0	DC	0.00	TX	406	OK	5.48
HI	2	UT	0.04	OK	405	PA	2.70
NH	2	GA	0.10	PA	399	MT	2.66
RI	2	MI	0.15	CA	383	MO	2.59
UT	2	OR	0.15	MO	257	NM	2.34
ND	4	AL	0.18	FL	160	KY	2.30
SD	4	NH	0.19	KY	156	KS	2.14
VT	4	OH	0.25	NM	119	MD	2.02
AR	5	ND	0.29	NC	103	ME	1.78
OR	7	SD	0.30	LA/MD	101	MS	1.56

Figure 5. Yearly fatality rates for commercial truck drivers in DD-related truck crashes. Dashed-line is mean rate across the study period (0.321 per BVMT).

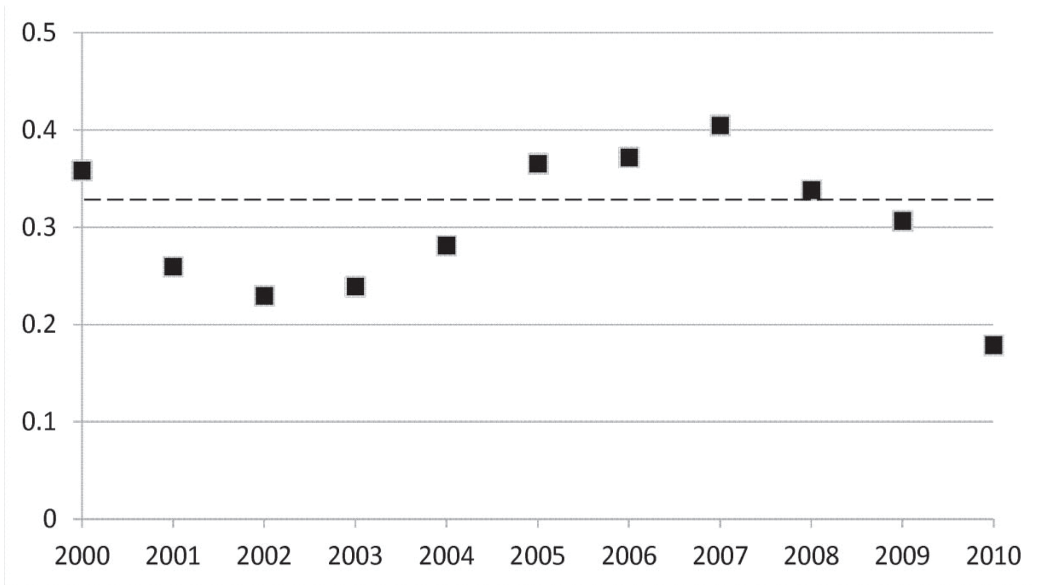
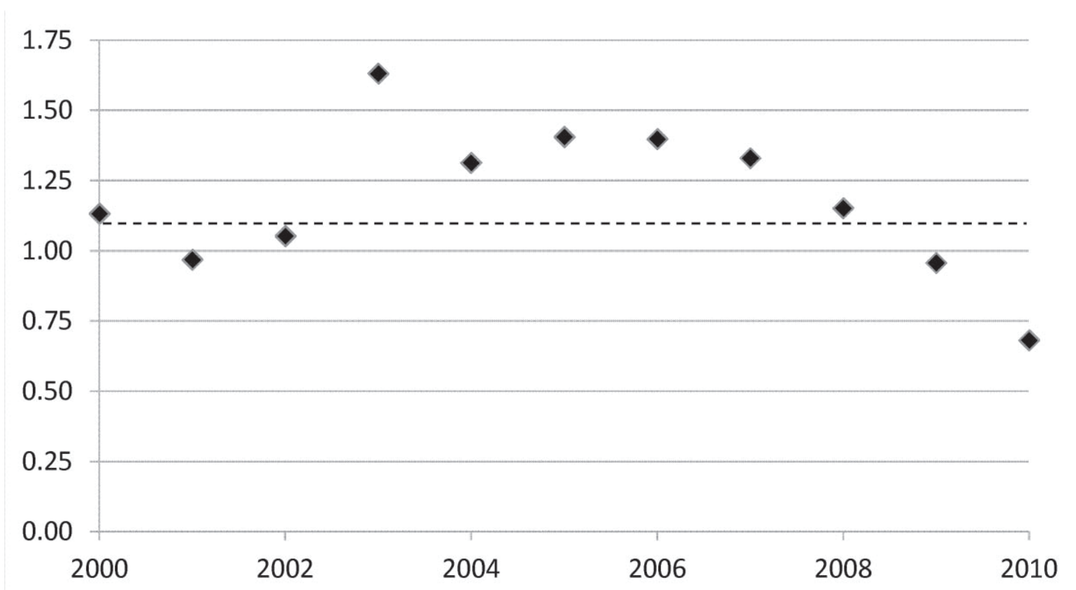


Figure 6. Yearly fatality rates for all vehicle occupants in DD-related truck crashes. Dashed-line is mean rate across the study period (1.101 per BVMT).



Regression Analysis

Table 10 displays results of univariate regression on truck driver fatality rates and fatality rates for all vehicle occupants. For truck driver fatality rates, only maximum rural truck speed limit and maximum truck length were significant predictors in univariate regression. For all vehicle occupants in distracted driving-involved truck crashes, rural truck speed limit, maximum truck length, percent cell phone saturation, unemployment rate, and the federal ban on texting for truck drivers were all significant univariate predictors.

Table 11 displays the results of multivariate regression on truck driver fatality rates. Although states allowing the longest trucks and the highest rural speeds have near significant increases in fatality rates, no significant differences in adjusted IRRs were found. State and federal distraction laws were not significant predictors of fatalities, although the FMCSA ban approaches significance in Model 2. The likelihood ratio test found that there was no significant difference between Model 1 and Model 2. Table 12 displays the results of multivariate regression on fatality rates for all vehicle occupants in distraction-involved crashes. Speed limit, truck length, unemployment rate, and cell phone saturation were all not significant; however, the 2010 federal ban on texting-while driving for commercial truck drivers was associated with a decrease in the fatality incident rate by 41%. When we add state texting and handheld cell phone bans in Model 2, the 2010 ban was associated with a 49% decreased incident rate. A likelihood ratio test found that Model 2, with the added state texting and handheld CPWD bans, resulted in statistically improved model fit (likelihood ratio χ^2=6.36, $p < 0.05$).

Table 10. Results of Univariate Multi-level Poisson Regression on Fatality Rates. IRRs in Bold are Significant at *P*<0.10.

	Truck driver fatality rate		Fatality rate for all vehicle occupants	
Variable	IRR[a]	*P*	IRR[a]	*P*
State texting ban	1.07	0.82	0.96	0.83
State handheld cell phone ban	0.98	0.97	0.83	0.49
Federal texting ban for truckers	0.67	0.19	**0.59**	**0.002**
Cell phone saturation[b]	1.14	0.72	**0.55**	**0.024**
Unemployment	0.95	0.24	**0.95**	**0.018**
State ethanol consumption	1.17	0.61	0.92	0.72
State primary seatbelt law	0.86	0.51	0.85	0.27
State BAC .08 law	0.90	0.64	0.91	0.44
State road capital expenditure	0.95	0.39	0.96	0.22
Population density	1.00	0.87	1.00	0.93
State mean income	0.84	0.26	1.00	0.98
State maximum allowable truck length				
48 feet (reference)	1.00	--	1.00	--
53 feet or 53 feet 6 inches	1.13	0.85	1.11	0.82
57 feet 4 inches or 57feet 6 inches	**2.35**	**0.096**	1.41	0.41
59 feet or longer	**2.33**	**0.039**	**2.48**	**0.008**
State maximum rural truck speed limit				
55 mph (reference)	1.00	--	1.00	--
60 mph	3.00	0.092	1.49	0.30
65 mph	**2.36**	**0.100**	1.09	0.77
70 mph	**2.46**	**0.096**	1.16	0.64
75 mph	**3.43**	**0.027**	**1.84**	**0.069**

[a] IRR = Incidence Rate Ratio

[b] Cell phone saturation was the only variable for which random effects produced a different result from fixed effects. Random effects are displayed in the table

Table 11. Multivariate Multi-level Poisson Regression on Truck Driver Fatality Rate in Crashes Involving Distracted Truck Drivers.

	Model 1		Model 2	
Variable	IRR[a]	P value	IRR[a]	P value
Constant	0.10	< 0.001	0.99	< 0.001
Speed limit- 55 mph	1.00 (reference)	--	1.00 (reference)	--
60 mph	2.88	0.097	2.97	0.089
65 mph	2.39	0.089	2.42	0.089
70 mph	2.11	0.17	2.10	0.17
75 mph	2.51	0.11	2.65	0.091
Maximum length- 48 feet	1.00 (reference)	--	1.00 (reference)	--
53 feet or 53 feet 6 inches	1.03	0.96	1.02	0.97
57 feet 4 inches or 57feet 6 inches	2.04	0.19	1.91	0.24
59 feet or longer	2.18	0.056	2.13	0.066
State text ban			1.73	0.13
State handheld cell ban			0.56	0.31
Federal texting ban for truckers			0.52	0.06

[a] IRR = Incident rate ratio

Table 12. Multivariate Multi-level Poisson Regression on Fatality Rate for All Vehicle Occupants in Crashes Involving Distracted Truck Drivers.

	Model 1		Model 2	
Variable	IRR[a]	P value	IRR[a]	P value
Constant	0.94	< 0.001	1.02	< 0.001
Speed limit- 55 mph	1.00 (reference)	--	1.00 (reference)	--
60 mph	1.39	0.40	1.43	0.35
65 mph	1.14	0.66	1.17	0.60
70 mph	1.10	0.77	1.10	0.78
75 mph	1.73	0.14	1.74	0.13
Maximum length- 48 feet	1.00 (reference)	--	1.00 (reference)	--
53 feet or 53 feet 6 inches	0.69	0.5	0.72	0.55
57 feet 4 inches or 57feet 6 inches	0.77	0.6	0.78	0.61
59 feet or longer	1.61	0.25	1.64	0.24
State unemployment rate	0.98	0.57	0.97	0.29
Cell phone saturation	0.74	0.32	0.72	0.31
Federal texting ban for truckers	0.59	0.008	0.51	0.001
State texting ban			1.76	0.012
State handheld cell ban			0.49	0.061

[a] IRR = Incident rate ratio

Discussion

Fatality rates for truck drivers and all vehicle occupants in distraction-involved truck crashes have been decreasing since 2006 and 2007, respectively. While the 2010 FMCSA ban was associated with a decrease in fatality rates for all vehicle occupants in 2010, without more data after its implementation we cannot draw conclusions about its impacts on fatality rates. As in prior studies [14, 160], our results did not find that state DD laws were not correlated with reduced fatality rates.

Unlike prior studies that found distracted driving and crash fatality increasing in spite of state CPWD bans [14, 18, 159], the 2010 FMCSA texting ban was implemented during a period where distraction-involved fatalities were decreasing. Understanding the decrease in these fatality rates will be important for future assessments of distraction-involved truck crashes. As previously mentioned the total motor vehicle crash fatality rate in the U.S. has been decreasing for decades. However, large truck-related fatalities increased by almost 9% from 2009 to 2010 [150], which would have meant that the decline in this sub-population of distraction-involved crashes occurred despite truck-related MVC fatality rates increasing. In addition, Wilson and Stimpson found that all distraction-related fatalities were increasing through 2008 [14], whereas the present study showed a decrease in truck-involved distraction-related fatalities before 2008. It is beyond the scope of this paper to compare the fatality rate for truck-involved distraction-related fatalities to all distracted driving fatality rates in order to compare our findings to those presented by Wilson and Stimpson. Future analyses in this area should consider possible ways to isolate the effects of time trends in overall crash rates, from those related to specific policy interventions. There are methods that have been used in prior analyses to address this potential bias [163, 164], and the next step of understanding the effects will be to employ such methods.

There are several aspects of the FMCSA ban that potentially make it more effective than the state CPWD bans. Amendola reviewed the Connecticut CPWD ban and found that both law enforcement and the court system were among the factors contributing to that law's ineffectiveness [165]. Unlike states where CPWD laws contain unclear or weak definitions of what constitutes offending behavior [69, 76], the FMCSA final rule clearly amends the Federal Code with instructions on prohibited behavior and recommended penalties [75]. It is possible that the lack of any national comprehensive distracted driving laws in the U.S. was impacting the effectiveness of these laws.

Another important feature of the FMCSA ban is that it includes penalties for both drivers observed texting-while-driving, and a penalty for the drivers' employers [75]. Therefore, employers have a monetary incentive to ensure that their drivers are not texting-while-driving. The Network of Employers for Traffic Safety, a corporate partnership for safe driving, conducted a poll of its membership in 2009 and reported on 24 of its member organizations' corporate cell phone policies [82]. Some of the companies (who were de-identified in the report) reserved the right to terminate workers violating bans on either handheld CPWD or texting-while-driving. In the 13 months between the announcement of the ban and its implementation, organizations would have had an opportunity to establish their own distracted driving policies. Previous analysis by

Hickman and colleagues found that truck drivers who drive for companies with enumerated cell phone policies have significantly reduced prevalence of CPWD compared to those companies that do not have such policies [4].

Through the FMCSA, it is easier for the government to regulate commercial vehicles than it would be if the federal government wanted to ban texting in private vehicles. Because of the distribution of Federal and State authority under the United States' Constitution, the federal government does not have jurisdiction over all driving regulations. If the federal government wanted to take action on texting-while-driving for all drivers, it could pass legislation making federal highway funds dependant on states enacting such a ban; as was done successfully in 2001 when the Bush Administration sought a nation-wide 0.08 BAC threshold for drunk driving [166]. By targeting commercial truck and bus drivers, the Department of Transportation was able to take action on a population that was readily available to them. We must remember that although the crashes examined in this study involved a distracted truck driver, they were not all caused by truck driver distraction, so further federal action to regulate truck driver distraction might not provide such dramatic results.

Limitations

Although FARS is the most comprehensive database, no validation studies of the distracted driving measures were found in the extant literature. A NHTSA report on using FARS analyzing distracted driving notes that police reports of distraction are not consistent across states and jurisdictions [151]. Therefore, it is likely that FARS under-reports the number of crashes involving distraction and the estimates in this paper actually underestimate the true magnitude of this public health problem.

There analyses could have been impacted by some measurement error. We were unable to determine if the crashes in our study were caused by distracted driving. FARS collects personal, vehicular, and environmental factors involved in each crash and does not weigh which of these factors was the “cause” of a given crash or fatality [151]. Thus, this study was limited in that it was only able to confidently explore crashes that involved DD. In addition, it is unknown what effect, if any, the change in coding of distraction-related crashes had on our results. In 2010, the definition for distracted driving became more expansive than it was in prior years. The change in definition also resulted in FARS more closely matching another NHTSA database, the General Estimating System. Research using the General Estimating System found that the percent of police-reported crashes involving distracted driving did not change between 2009 and 2010 [167]. Because of this, we do not believe that the change in FARS codes accounted for the effects of the FMCSA regulation that revealed by these analyses.

Due to sample size considerations, our unit of analysis was the state*year. Distraction-related crashes are rare events, so we needed a time period wide enough to capture them for each state. By doing so, we lose the ability to analyze seasonality as a factor for crashes. To accurately capture within state variation, we used the state as the level as analysis and did not analyze urban versus rural crash rates. Nor did we analyze driver-related factors, such as age, gender, licensure, or drink driving. Due to the omission of these variables in the present study, the results may have been impacted by some residual confounding.

Finally, the FMCSA Final Rule is not explicit on how states are to implement or enforce the law. We were unable to find any analysis of when and how each state implemented and enforced of the regulation, thus we are unable to determine how these factors affected our findings. More years of data after the ban was implemented will be necessary to demonstrate what, if any effect, it had on fatality rates. Any potential effects of the ban will need to be considered in the context of national trends in crash fatalities.

Conclusions

This study quantified distracted driving-involved truck crashes, state-by-state, over an 11-year period. The state fatality rate for truck drivers in distraction-involved truck crashes was 0.321 per billion diesel VMTs and the rate for all vehicle occupants in these crashes was 1.101 per billion diesel VMTs. There was wide variation between states for fatality counts and rates. Fatality rates in these distraction-involved truck crashes were decreasing from 2007 through the end of the study period. State texting and handheld cell phone bans were not associated with decreases in fatality rates over time. While the 2010 FMCSA ban on texting while driving for commercial drivers was associated with a decrease in fatality rates for all vehicle occupants in distraction-involved truck crashes, the ban was not implemented until the last 3 months of the study period, so we cannot say that it was responsible for the decrease in fatality rates.

Important aspects of the FMCSA ban were that it was nationwide in scope and carried very heavy penalties for drivers and employers. When more data from the period following its implementation become available, the longitudinal effects of the ban should be tested on distraction-involved crash fatality rates. Further research should determine how the regulation was implemented and enforced to determine if there are features that could be adopted by states to reduce the prevalence of distracted driving among all drivers.

Manuscript 2: The Effects of Safety Climate on Distracted Driving in Commercial Truck Drivers

Abstract

For those who drive on the job, distracted driving is an occupational hazard. We hypothesize that organizational safety climate will affect distraction-related outcomes for truck drivers in the United States. A mixed methods study design was employed to investigate this relationship: an online survey of union truck drivers using the Safety Climate Questionnaire (SCQ) was complemented with semi-structured interviews of distracted driving and truck safety experts. A factor analysis of the SCQ produced factors that had previously been identified as describing Communications and Procedures, Management Commitment, and Work Pressure. Interview subjects described how these three constructs could decrease distracted driving. In univariate analyses, Communications and Procedures and Management Commitment were associated with self-reported distraction-related near crashes; none of the SCQ factors were significant in multivariate regressions. This is the first study to describe the effect of safety climate on distracted driving in the occupational setting.

Key words: mixed methods; factor analysis; near crash; Teamsters; occupational safety

Introduction

Motor vehicle crashes are the leading cause of occupational fatalities in the United States (U.S.) for all workers [31, 168]. Over half of the occupational fatalities to truck drivers in the U.S. are due to motor vehicle crash [31], and these deaths occur at a rate of 3.7 per billion vehicle miles traveled (VMT) [32]. Truck driver health and well-being has been previously shown to be affected by issues such as sleepiness and fatigue, poor physical fitness, and the work being shift work-based [27, 28]. Distracted driving has long been a hazard for truck drivers; however, the emergence of portable electronic communication devices has only their crash risk [4, 6].

In general, drivers are affected by distractions in four ways: 1) visual distractions that take the driver's eyes off the forward roadway; 2) auditory distractions that take the driver's aural perception from relative driving cues; 3) cognitive distractions take the driver's mind off the driving task; and 4) manual distractions take the driver's hands off the wheel [1, 2]. The first two forms of distraction could interfere with the driver from receiving necessary information relevant to the driving task, the third affects the processing of this new information, and the fourth delays the driver from taking corrective action necessitated by the situation [3]. Tasks that drivers can undertake have been broken into a taxonomy of three types of tasks: primary tasks are those that only control vehicle speed and direction; secondary tasks that support the primary tasks, such as turning on headlights or checking mirrors; and tertiary tasks that are any activities the driver undertakes that are unrelated to driving [1]. Our definition of distracted driving is any secondary or tertiary task that takes the driver's eyes, hands, or concentration away from the primary driving task.

Studies of driver truck behavior using in-vehicle cameras have found over two dozen secondary and tertiary tasks as sources of distraction [4-7]. The term "cell phone use while driving" (CPWD) encompasses any task involving a cell phone, including dialing a phone, talking on the phone, and reading or writing messages [9]. CPWD has been increasing in recent years due to the proliferation of cellular phones in the U.S. and elsewhere [10, 11]. Two of the most dangerous CPWD tasks are dialing the phone and sending, reading, and writing short message service text messages (a.k.a., texting) [6]. These tasks involve manual, visual, and cognitive distractions [2]. Both in the laboratory setting [12, 13] and during actual driving [6], texting has been shown to be the greatest hazard for crash or near crash. The Virginia Tech Transportation Institute (VTTI) has conducted multiple studies on distraction among commercial truck drivers and texting created the greatest increased hazard for distracted driving crash or near crash [4, 6].

For commercial truck drivers the vehicle cab is their workplace; therefore, distraction on-the-job is thus an occupational hazard. Because of this, organizational policies surrounding distracted driving are important in reducing distracted driving among professional truck drivers [4]. So while cell phones and other means of electronic communication give drivers the ability to conduct business while driving [35], because this is an occupational hazard, keeping drivers free from distractions while driving should be a concern for employers. "Safety climate" is a framework for understanding how highly an organization values safe worker behavior [40, 41]. Previously organizational safety climate has been associated with occupational injuries and safe worker behavior [42, 169, 170]. A study of Australian workers who drive on-the-job found that perceived safety climate was correlated with safer driving behaviors [47]. Because truck drivers face so many occupational distractions, we hypothesize that occupational safety climate will have a major impact on safe behaviors surrounding distracted driving.

Materials and Methods

This study was conducted using a mixed methods design. The ensuing sections will describe the qualitative analysis and the quantitative analysis separately. The qualitative and quantitative data were collected from separate populations. In mixed methods study notation, this manuscript follows a QUAN+qual design for the purposes of complementarity evaluation, that is, elaborating and illustrating quantitative results with the qualitative data [138, 139]. Using qualitative data to elucidate the statistical results allows us to further clarify the effects of the different aspects of safety climate on drivers [138]. Furthermore, by using qualitative data from a population outside that of the drivers who are surveyed quantitatively, this "between-method" triangulation should enhance the study's external validity [124]. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board approved of all study procedures.

Qualitative Data Collection and Analysis

A purposive sample of experts in truck driver safety or distracted driving were recruited from the list of attendees at the Symposium on Prevention of Occupationally-Related Distracted Driving sponsored by the Johns Hopkins Bloomberg School of Public Health Occupational Safety and Health Education and Research Center on April 18, 2011 in Laurel, MD. Ensuing interview subjects were recruited using a snowball sampling technique [125]. An interview guide was developed and refined by the study team and was finalized after pilot testing with an expert in motor carrier safety who was a former driver. Semi-structured interviews were conducted via Skype (Microsoft Corp., Redmond, WA) and were recorded using MP3 Skype Recorder v3.1 (VOIPCallRecording.com). Audio files of the interviews were transcribed by uploaded the .mp3 files to productiontranscripts.com (Production Transcripts, Glendale, CA). Data collection was ceased after 11 interviews when data saturation was reached [171]. The recording failed on one interview, so only 10 of the 11 interviews were successfully transcribed. Notes on all 11 interviews were successfully transcribed. Data collection began in December, 2012 and ended in January, 2013.

The 10 transcripts and notes from all 11 interviews were stored as Microsoft Word documents, which were then used for qualitative coding. Data were open-coded line-by-line to label the themes found in subjects' responses [126, 127]. A codebook was developed during the focused coding process. A second coder was employed for a subset of three randomly-selected interviews as a check on the reliability of the coding process. Both coders met to discuss the coding and how well the codebook described the categorizations of the data [128]. The two coders differed slightly in their choice of wording of themes, but no substantive differences emerged. Because the interviews were recorded anonymously, results of the interviews will be reported by subject number.

Quantitative Data Collection and Analysis

Quantitative data were collected via online survey. Members of the International Brotherhood of Teamsters (IBT) in the U.S. were selected as target population for the survey. The IBT represents over one million truck drivers and union members in other occupations in the U.S. and Canada [57]. The IBT was selected due to its size and nationwide reach. A business representative from an IBT Local who was familiar with the project was used to pilot test the survey and finalize the exact wording. The survey required only 10 minutes to complete upon final testing.

With the assistance of personnel in the Office of Health and Safety at IBT headquarters, we sought sub-industries where the drivers were most likely to experience the distractions under study [58]. To identify drivers in the carhaul, express, freight, motion picture, package, and tankhaul industries, study subjects were asked to select the type of truck that they drove (with accompanying images) at the beginning of the survey. Those who didn't identify one of the selected vehicles were directed to a disqualification page and thanked for their time. Of the 440 subjects who entered the survey, 79 (18%) were screened out when they identified themselves as not driving in one of the vehicles of interest. Over the course of the survey, 122 of the remaining 361 (34%) left the survey before completion, resulting in a final sample of 239 subjects.

Of the 239 subjects who completed all portions of the survey, 60 (25%) drove delivery vans and 179 (75%) drove larger trucks. Attempts to determine if the final sample of respondents was representative of the larger population were limited because of few existing publically available data of truck drivers. The most recent was a 2002 Census Bureau report on registered trucks in the U.S. that found that medium trucks (a category that includes delivery vans) comprised 23% of the American truck fleet and larger trucks were 63%, while the remaining 14% trucks that were too small for the current study population [131]. A search of the peer-reviewed and grey literature produced no more recent estimates of the composition of the American truck fleet. Thus, relying on the numbers from the Census, a Pearson's χ^2 found no statistical difference for truck type between the study population and those subjects who dropped out during data collection (p-value = 0.4). While we are unable to make statements about the sample for other key factors, using this historical data, although limited, we are confident that our sample of drivers does not markedly differ from the national truck fleet on vehicle types represented herein.

Survey subjects were recruited via an announcement posted to the IBT website, teamster.org. The survey was administered using www.SurveyMonkey.com (SurveyMonkey Inc, Palo Alto, CA) and was open between April 2 and May 19, 2013. A rule of thumb for sample size when conducting factor analysis, as was done for this survey, is a ratio of 10 subjects per survey question [118], yet this is not a hard and fast rule [132]. However, ratios of 5:1 or 6:1 have also been frequently used [132], and with more than 300 subjects, the ratio of subjects to questions can may not need to be as high as 10:1 [133]. For the 35-item survey, a sample of at least 350 subjects would be very strong, whereas 175 subjects would produce the minimal 5:1 ratio. The final sample size and survey power are described in the Results section.

The online survey consisted of the 35 item Safety Climate Questionnaire (SCQ) modified for drivers by Wills and colleagues [46, 129]. Drivers were asked to what degree they agreed with a given SCQ question using a Likert scale where 1 represented "Strongly agree," 4 represented "Neutral," and 7 represented "Strongly disagree." Demographic data on the subject's gender, age, and years driving experience were also collected. Subjects also self-reported if they ever had experienced any of the following safety critical events while on the job [148]: subjects first reported whether or not they ever had a crash while on the job; after being reminded of the definition of distracted driving, subjects reported whether or not they had ever had a crash while distracted, had to break hard to avoid a crash while distracted, and swerve to avoid a crash while distracted.

A confirmatory factor analysis was conducted to determine if the six factors of the SCQ as determined by Wills *et al.* were appropriate for this population. From principal component analysis, the eigenvalues and percent variance indicated that there were between three and seven factors [140]. Using Wills *et al* as a starting point, a 6-fator model was estimated using maximum likelihood; promax factor rotation was used due to correlation between factors [140]. Items with high uniqueness (greater than 0.5) were removed in an iterative fashion until we arrived at a model with three factors that loaded on SCQ items 1 through 12, 14 through 20, and 21 through 24. These three factors, the pattern matrix of which is presented in Table 13 are the same as the first three factors described by Wills *et al*. [46]. Mean scores for the three factors were 3.44 for Communications and Procedures (standard deviation (SD) = 1.6); 4.21 (SD=1.8) for

Work Pressures; and 3.90 (SD = 1.9) for Management Commitment. The scree plot[1] with parallel analysis [141] in Figure 7 supports our data as best described by three factors [172]. We also generated the factor scores using the original six-factor structure from Wills *et al.* [129]. The mean (SD) scores for the six factors were 3.42 (1.6) for Communications and Procedures, 4.21 (1.8) for Work Pressure, 3.90 (1.9) for Management Commitment, 4.80 (1.6) for Relationships, 3.80 (1.7) for Driver Training, and 4.14 (1.8) for Safety Rules.

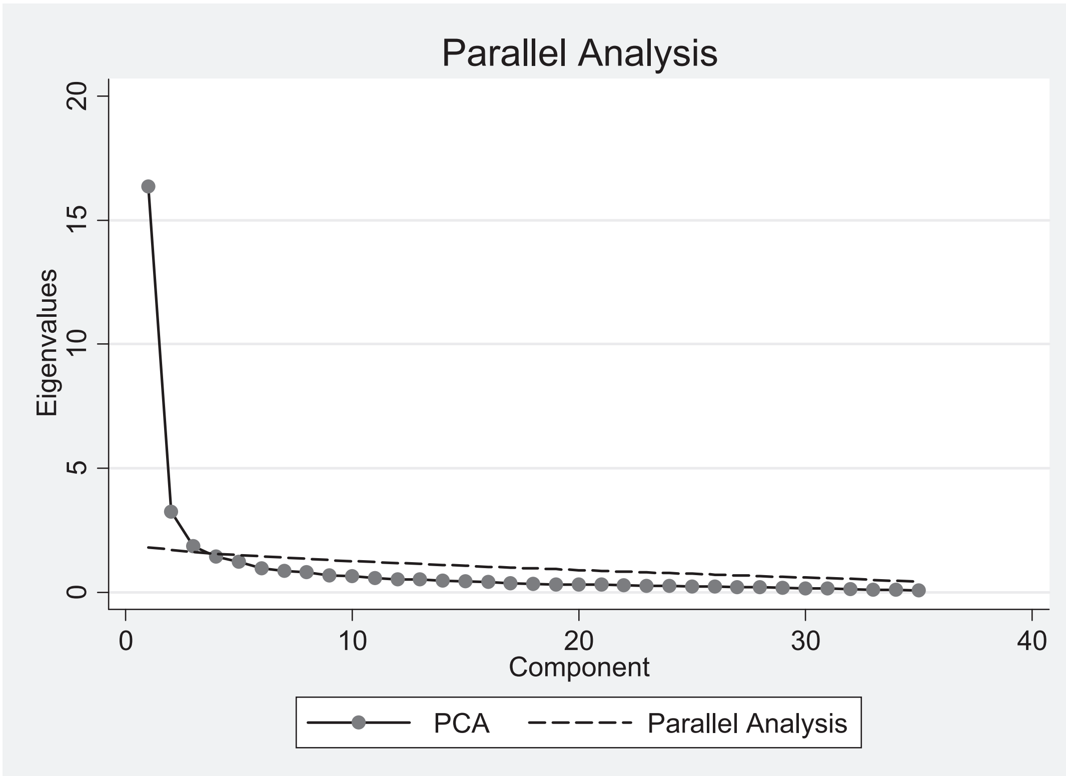
The mean factor scores and demographic data were entered first into univariate regression for each of the four crash and near-crash outcomes. This analysis was conducted for the three-factor model that our analysis generated as well as using scores from the original six-factor model from Wills *et al*. Multivariate regressions were then conducted for each outcome for factors that had p-values ≤ 0.10. Entering covariates with p-values less than 0.2 has been used in model development in the past [94]; however, using 0.10 as a cutoff is a trade-off between including relevant covariates and model performance [119]. All analyses were conducted with Stata v.12.1 (Stata Corp, College Station, TX).

[1] Where a scree plot flattens out (and is passed by the parallel analysis) indicates the number of "interpretable" components/factors. Please see Jackson's 1993 review of principle component analysis (reference number 171).

Table 13. Pattern matrix for three factors for the SCQ. Chronbach's alpha for reliability of each factor is listed.

Items and Labels	1	2	3
Factor 1- Communications and Pressure (α = 0.94)			
1. Changes in working procedures and their effects on safety are effectively communicated to workers	0.74		
2. Employees are consulted when changes to driver safety practices are suggested	0.79		
3. Employees are told when changes are made to the working environment such as the vehicle, maintenance or garaging procedures	0.74		
4. Safety policies relating to the use of motor vehicles are effectively communicated to the workers	0.87		
5. Safety procedures relating to the use of motor vehicles are complete and comprehensive	0.84		
6. An effective documentation management system ensures the availability of safety procedures relating to the use of motor vehicles	0.82		
7. Safety problems are openly discussed between employees and management/supervisors	0.66		
8. Safety procedures relating to the use of motor vehicles match the way tasks are done in practice	0.66		
9. Employees can discuss important driver safety policy issues	0.51		
10. Employees are consulted for suggested vehicle/driver safety improvements	0.72		
11. Employees can identify relevant procedures for each job	0.62		
12. Employees can express views about safety problems	0.50		
Factor 2- Work Pressure (α = 0.93)			
14. Time schedules for completing work projects are realistic		0.85	
15. There is sufficient 'thinking time' to enable employees to plan and carry out their work to an adequate standard		0.88	
16. Workload is reasonably balanced		0.87	
17. There are enough employees/drivers to carry out the required work		0.76	
18. Changes in workload, which have been made on short notice, can be dealt with in a way that does not affect driver safety		0.80	
19. When driving employees have enough time to carry out their tasks		0.82	
20. Problems that arise outside of employees' control can be dealt with in a way that does not affect driver safety		0.61	
Factor 3- Management Commitment (α = 0.95)			
21. Management are committed to driver safety			0.86
22. Management are committed to motor vehicle safety			0.85
23. Driver safety is central to managements' values and philosophies			0.82
24.Driver safety is seen as an important part of fleet management in this organization			0.70

Figure 7. Scree plot with parallel analysis for safety climate questionnaire principal component analysis. The parallel analysis crosses the scree plot after three factors.



Results

Descriptive Analysis

Demographic data of the 239 subjects who completed the survey are presented in Table 14. The subjects were 229 men, 7 women, and 3 who chose not to enter their gender. Self-reported crash and near-crash outcomes were as follows: 130 (54%) reported ever having a crash on the job, 107 reported no crashes, and two did not answer; 41 (17%) reported ever crashing while distracted, 197 reported no such crashes, and one subject did not answer; 112 (47%) reported ever having to brake hard to avoid a crash while distracted, 124 reported no doing so, and three did not answer the question; 108

(45%) reported ever having to swerve to avoid a crash while distracted, 129 reported not doing so, and two subjects did not answer.

Table 14. Descriptive data on 239 subjects who completed the survey.

	Mean	SD	Minimum-Maximum
Age (years)	48.0	8.9	21 – 69
Driving experience (years)	22.7	10.1	1 – 45
Weekly driving (hours)	47.6	11.4	6 – 70

Regression Analysis

Results of univariate logistic regressions for demographic data and the three factors are presented in Table 15. Variables entered into multivariate regressions were differed for each outcome: for ever experiencing a crash, covariates were gender, Communications and Procedures, Work Pressure, and Management Commitment; for ever experiencing a distraction-related crash, covariates were age and driving experience; for undertaking distraction-related braking, covariates were weekly driving exposure and Communications and Procedures; for undertaking distraction-related swerving, covariates were gender, Communications and Pressures, and Management Commitment.

Table 15. Univariate regression for demographic factors and three safety climate factors on negative driving outcomes in the workplace. The odds ratios (ORs) are presented with odds of the negative outcome versus no outcome. OR for Gender are for women's odds over men's odds. There were too few subjects who did not list a gender to calculate ORs. ORs in bold were entered into multivariate regressions.

	Ever experience a crash on the job		Ever experience a distraction-related crash on the job		Ever undertake hard braking while distracted on the job		Ever have to swerve while distracted on the job	
Variable	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Gender	**0.13**	**0.06**	**3.75**	**0.92**	1.51	0.60	**7.62**	**0.06**
Age	1.02	0.25	**1.05**	**0.03**	0.98	0.27	1.02	0.27
Driving experience	1.02	0.13	**1.04**	**0.03**	0.99	0.66	1.01	0.28
Weekly driving	0.99	0.66	1.01	0.45	**0.98**	**0.06**	1.00	0.73
Communications and Procedures	**1.19**	**0.03**	0.98	0.84	**1.15**	**0.09**	**1.21**	**0.02**
Work Pressure	**1.19**	**0.02**	0.94	0.51	1.05	0.54	1.00	0.97
Management Commitment	**1.15**	**0.04**	0.98	0.90	1.08	0.25	**1.14**	**0.05**

Table 16. Results of multivariate analyses on negative driving outcomes.

	Ever experience a crash on the job		Ever experience a distraction-related crash on the job		Ever undertake hard braking while distracted on the job		Ever have to swerve while distracted on the job	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender	0.11	0.01-1.01	3.67	0.75-17.90			8.09	0.93-70.56
Age			1.02	0.94-1.10				
Driving experience			1.02	0.96-1.09				
Weekly driving					0.98	0.95-1.00		
Communications and Procedures	1.17	0.93-1.47			1.17	1.00-1.38	1.12	0.89-1.40
Work Pressure	1.12	0.93-1.36						
Management Commitment	0.99	0.80-1.22					1.09	0.91-1.31

The outcomes of the four multivariate regressions are presented in Table 16. Some of these covariates approached significances. Gender approach significance in both ever experiencing a crash and experiencing distraction-involve swerving (p-values of 0.051 and 0.058, respectively), yet the relationship between gender and these negative outcomes was switched: men were more likely to experience a crash and women were more likely to swerve while distracted. As age and driving experience increased, they approached significance for ever reporting a distraction-related crash. Increasing weekly driving exposure approached was significantly associated (p=0.039) for a reduction in distraction-related hard breaking. Communications and Procedures approached significance (p = 0.057) in multivariate regression for experiencing distraction-related hard braking. No other safety climate factors approached significance in multivariate regression.

Using the Wills *et al*. six factor model, we found significant results in univariate logistic regressions for ever crashing and ever swerving while distracted. Scores from factors 1, 2, and 6 were associated with ever experiencing a crash on the job and factors 1, 2, 3, 4, and 6 were associated with ever swerving while distracted on the job. In multivariate regression, the p-values for all these covariates were 0.2 or greater. Thus, although our three factor model was not highly significant in multivariate regression, the original six-factor model did not perform better.

Qualitative Analysis

Of the 11 interview participants, five were researchers at academic institutions; three were at private research institutions; and one each were from a union, a private company, and a federal agency. Because participants were guaranteed anonymity, no further demographic data were collected. Although interview participants identified ways that drivers would feel pressure from supervisors, coworkers, or family and friends to undertake various distracting tasks, subjects said that it was ultimately up to each driver to make the final decision on whether or do a given distracting activity while driving. Interview subjects addressed how each of the three factors from the questionnaire could impact truck driver safety surrounding distracted driving.

Because we did not interview truck drivers directly, we were unable to get information on specific company policies regarding the Communications and Procedures factor. One participant expressed concerns that it was possible for company culture, be it from management or fellow coworkers, to have a suppressive effect on drivers even bringing up safety concerns, as expressed in SCQ items seven, nine, and 12. To enforce company policies, interview subjects said that organizations could electronically monitor their drivers. Two interview participants cited DriveCam (manufactured by The Driver Science Company, San Diego, CA) as one method for monitoring driver behavior.

The Work Pressure factor, specifically time pressure, was commonly discussed as important aspects of driver safety. A participant described how company culture could vary between companies and influence the need to respond to dispatchers:

> "[D]epending on the company and how they are structured and kind of the underlying safety climate and culture, we might see that drivers are under the impression that they need to be very responsive to anything that comes from the office. Whether it's from dispatch or from a supervisor-- things like that. Whereas, other companies might have policies where that feeling is a little less intense. "

Another participant stated that the pressures to respond quickly could be either explicit company policy or an "[i]mplicit expectation that they use the device while driving so that they can respond in a timely fashion to requests from the company." A final, telling quote about the structure of a delivery driver from a third interview subject demonstrates just how intense time pressure can be for workers:

> "I rode with a truck driver and you know his schedule meant that he had to eat lunch in the truck, you know, he didn't have time to stop, go to the bathroom and you know, that schedule didn't allow it. If he wanted to go to the bathroom he had

to find a restroom at one of his stops and there was no time to go to like a restaurant or a fast food restaurant or a Subway or anything like that."

Interview participants described many ways that organizations could manifest the Management Commitment factor of safety climate. The aforementioned video monitoring of drivers is one such method. Management could also use engineering solutions to protect drivers. Multiple interview subjects described how a Global Positioning System (GPS) device is a safer alternative to a driver reading a map, as the GPS requires less manipulation and many can give audio commands, removing the need for the driver to take his/her eyes off the road to see directions. Furthermore, three subjects described how management could set the in-vehicle dispatch device to promote driver safety, such as only allowing the device to receive messages when the vehicle was stopped, or for the device to relay auditory messages that do not require the driver to look away from the forward roadway.

Discussion

Organizational safety climate has previously been shown to correlate with safe workplace behaviors and injury rates [43, 45, 173]. This study sought to apply measures of safety climate to distracted driving in truck drivers in the U.S. Using key informant interviews and regression analyses of an established questionnaire, we believe that these data will contribute to the understanding of how organizational climate contributes to driver safety.

A VTTI study found that truck drivers who drove for organizations with CPWD policies had a lower prevalence of distracted driving as well as reduced odds for crashes and near crashes compared with organizations without such policies [4]. Our data showed in univariate regression that distraction-involved braking and swerving was correlated with the safety climate factors of Communications and Procedures and Management Commitment. By committing to safe work procedures where drivers are not required to use electronic communications while driving, management can reduce drivers' exposure to distracted driving and decrease their crash risk.

A review of the origins of safety climate defines it as the social manifestation of organizational culture as construed collectively by workers [169]. Interview subjects described how an organization would be able to manifest its culture by consistent practices regarding driver communication safety procedures. Organizations should be consistent in their explicit and implicit expectations for driver behavior. Organizational policies that lead to drivers being conflicted about their work procedures are what organizational psychologist James Reason calls "inadvisable rules" [174]. Reason and colleagues further describe how organizations can prevent driver errors and policy violations with good organizational management and planning [175, 176]. Consistent messaging concerning the separation of driving and secondary communications tasks would reinforce good organizational culture surrounding distracted driving.

In univariate analysis, Management Commitment was associated with drivers ever having a crash on the job and swerving while distracted. Management commitment to safety has previously been identified as the most important aspect of safety climate [42, 177]. The originator of the SCQ, Dov Zohar, hypothesizes that the management commitment is at the heart of safety climate and all other measures of safety climate are somewhat secondary [178]. Therefore while allowing drivers to have personal time for eating or drinking and using the restroom while driving might be explicit manifestations of Work Pressure, it still is a description of how management values the safe conduct of work by their drivers.

This commitment to driver safety can be further manifested by how the driver's work space (i.e., vehicle cab) is designed, such as removing distractions, or programming electronic devices so that drivers can only receive potentially distracting messages once the vehicle is safely stopped. According to a review by O'Toole, mandating engineering controls has been regulatory strategy used by the Occupational Safety and Health Administration to promote occupational safety [179]. Future human factors and ergonomic research could describe the effects of engineering controls on distracted driving.

Male gender was associated with a near significant increase in ever reporting a crash in multivariate regression. This finding is consistent with surveillance data from the Centers for Disease Control and Prevention that found that fatal crash rate on the job is eight times higher for men than women in U.S. [30]. Unexpectedly, we found that female drivers had a much higher odds of reporting distraction-related swerving than males. One of the interview subjects doubted that anyone would admit to the distraction-related outcomes that we asked about. Although anonymous surveys decrease the likelihood that subjects would report "better" outcomes due to social desirability bias [180]. Collet and colleagues reviewed the literature and found no clear evidence that distracted driving affected men or women more [18], so it is possible that an unmeasured confounder resulted in women reporting less distraction-involved swerving than men.

That increased weekly driving exposure was correlated with decreased odds of reporting distraction-related swerving on the job was an unexpected finding. We might expect that drivers who have increased weekly exposure to driving would have increased exposure to distracted driving, and thus an increased likelihood of negative outcomes. Because the mixed methods analysis was concurrent, we did not have the opportunity to present these survey findings to the interview subjects. Future qualitative analysis could offer insight on why drivers with increased weekly driving exposure have lower odds of near crash.

Strengths and Limitations

The current study had limited power compared to the Wills *et al*. studies in which, with sample sizes of almost 100 more subjects, this version of the SCQ was developed and validated [46, 47, 129]. Although we were missing three of the factors from Wills and colleagues' original model, the three factors that we did derive were the factors that accounted for the majority of the variation in the Wills *et al*. studies. Furthermore, other than dropping item 13 from the SCQ, our confirmatory factor analysis produced three factors that matched the exploratory factor analysis of Wills *et al*. [46, 47].

Our analysis of the Communications and Procedures factor was limited because we were unable to interview truck drivers about the procedures surrounding distracted driving at their organizations. While not being able to describe this component of safety climate may have been hindered by our selection of two different study populations, the selection of this between-method approach increases the external validity of the study [124]. So whereas we might lose some precision in describing a given factor of safety climate, the validity of the entire method is raised by drawing results from different, complementary populations.

Since the survey was anonymous, we did not ask IBT members for which organization they drove. This limited our ability to examine the impact of policies within a particular organization on safety climate and distracted driving outcomes. However, we were able to survey drivers in a variety of industries, increasing the external validity of our results. Future analyses should analyze the effects of driving industry and organization on safety climate and distracted driving outcomes.

While surveying IBT drivers creates the potential for a nationally-representative sample; however, in keeping the data as anonymous as possible, no items on the questionnaire asked the respondents to describe in which state(s) they drove and/or lived. Furthermore, there are no data available from the IBT to which we can compare our sample to assess the representativeness of the demographic data or type of vehicles driven by survey respondents. Thus, the degree to which these data are generalizable to a larger population of IBT drivers is unknown, and a limitation of this research.

Conclusion

In univariate regression, we found associations between safety climate constructs and crashes and distraction-involved near crashes in a population of Teamsters in the U.S. In multivariate analysis, demographic factors and Communications and Procedures approached statistical significance. Interviews with safety experts described how organizations could influence safe driver behavior surrounding distractions by establishing a good organizational climate. This could be accomplished through consistent enforcement of company policies designed to prevent distracted driving on the job. This research should lead to further investigations of how organizational characteristics can affect distracted driving in professional truck drivers.

Manuscript 3: Understanding Commercial Truck Drivers' Decision-Making Process Concerning Distracted Driving

Abstract

Distracted driving is an occupational hazard for truck drivers. Truck drivers' decision-making process is affected by their personal views on distractions as well as workplace pressures. The purpose of this study is to understand the personal and organizational factors that affect whether or not truck drivers undertake distracting activities while driving on the job. Using the Theory of Planned Behavior, this concurrent mixed methods study employed an online survey of members of the International Brotherhood of Teamsters and key informant interviews with trucking and distracted driving safety experts. Results from logistic regression analyses showed that drivers' perception of their supervisors' normative beliefs concerning dispatch device use was directly associated with distraction-involved near crashes, regardless of intention to use a dispatch device. Drivers' intentions toward texting while driving, however, mediated the effects of social norms and perceived control on near crash distraction-involved outcomes. Interview participants described how organizations that strictly enforce distracted driving policies, a social normative factor, could reduce unsafe driving. However, interview participants also felt that drivers ultimately had final say, a perceived control factor, concerning distracted driving behaviors. Both intentions toward distractions and perceptions of workplace factors concerning distracted driving were associated with distraction-involved near crash outcomes. The TPB constructs for texting and dispatch device differed in their impact in regression analyses on distraction-involved activities, suggesting that

commercial truck drivers experience different pressures concerning different distracting activities.

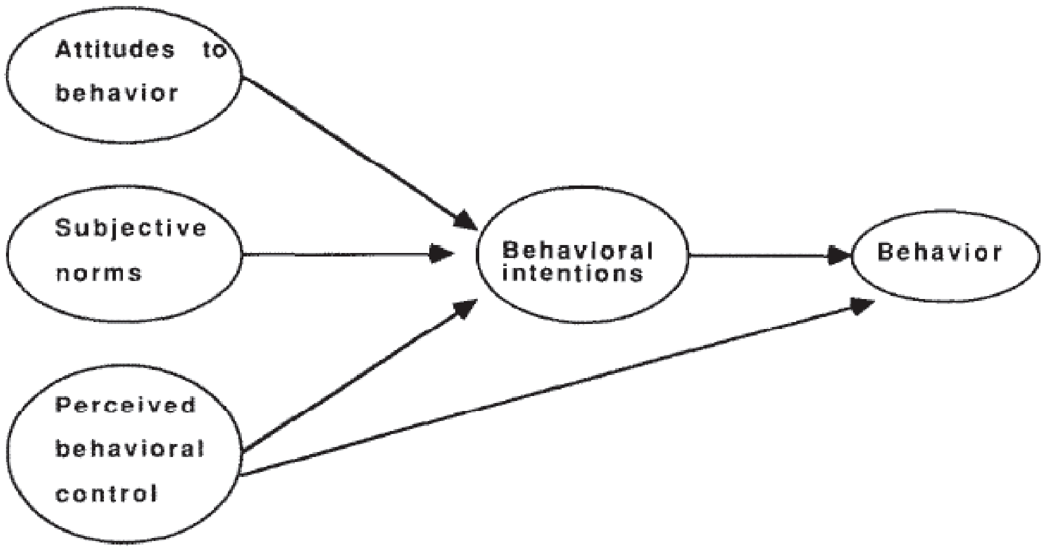
Background

Distracted driving is increasingly becoming a hazard to drivers in the United States (U.S.) [151, 152, 181]. Drivers are distracted from primary driving tasks by 1) visual distractions that take their eyes off the forward roadway; 2) auditory distractions that take their aural perception from relative driving cues; 3) cognitive distractions that take their mind off the driving task; and 4) manual distractions that take the driver's hands off the wheel [1, 2]. Although much of the increase in distracted driving is due to the use of cell phones and other electronic communication [10, 14], truck drivers face additional occupational distractions that stem from their occupational environment, including interacting with a dispatch device and writing notes or a log [6]. When driving on the job, truck drivers are faced with work and time pressures that influence their decision-making about whether or not to undertake distracting tasks [36].

Research from the Virginia Tech Transportation Institute (VTTI) has demonstrated how the odds for crashes and near crashes are increased when truck drivers are distracted [6]. This VTTI study found that texting while driving increases the odds ratio (OR) for crash or near crash 23 times compared to when drivers are not texting. The VTTI study also found increased odds of crash or near crash for such activities as interacting with the dispatch device (OR=9.9), reaching for an electronic device (OR=6.7), looking at a map (OR=7.0), and dialing a cell phone (OR=5.9). Because motor vehicle crashes are the leading cause of occupational death in commercial truck drivers [31], it is important to prevent crashes caused by distraction. The Theory of Planned Behavior (TPB) [53] is a framework for understanding factors that affect individuals when they consider whether or not to undertake a given behavior. Using the TPB, this paper describes how personal, social, and occupational factors affect truck driver decision-making concerning distracting activities while on the job.

The TPB, as shown in Figure 8, seeks to understand how attitudes, perceived behavioral control (PBC), social norms, and intentions affect behavior performance [53, 56]. A previous study of truck driver safety in the United Kingdom used the TPB to understand what factors would be most effective in increasing safe driving behavior and compliance with safety regulations [50]. This prior study by Poulter *et al*. found that while social norms affected safe driving behavior, truck drivers' compliance with driving regulations ("rule compliance") was more affected by PBC. These authors concluded that programs aimed at increasing safe driver behavior and rule compliance would require two different approaches [50]. The TPB has also been applied to understanding distracted driving in young drivers [9]; however, it has not been applied to understand distracted driving among adults in the workplace.

Figure 1. Conceptual model of the Theory of Planned Behavior (from Parker *et al.* Accident Analysis and Prevention, 1992)

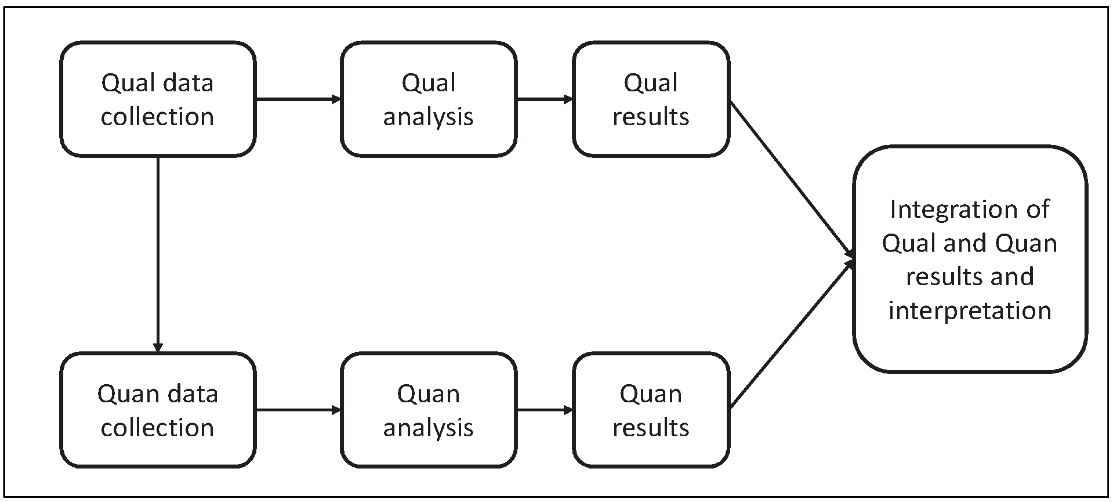


The TPB uses key informant interviews to prepare surveys for the population of study [52], which we did as well. In addition, this study also used key informant interviews to further elaborate on how drivers would be affected by each component of the TPB. The purpose of this study is to utilize a mixed methods concurrent design and analysis to describe quantitatively how the TPB factors affect distraction-related crash and near crash outcomes, and explore qualitatively the meaning of those results.

Methods

This study employed a mixed methods concurrent design and analysis [142, 143]. In a mixed methods concurrent design, the qualitative and quantitative data are collected and analyzed separately, the results of each method are first presented separately, then integrated for interpretation [144, 145]. Although the qualitative data were collected first, both quantitative and qualitative data were analyzed separately before integration [145]. Figure 9 illustrates how the qualitative and quantitative results are triangulated, that is, how the results from the one method converge, correspond, or corroborate those from the other method [139]. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board approved of all study procedures.

Figure 9. Visual diagram of the analysis of qualitative key informant interviews (Qual) and quantitative analysis of surveys (Quan). This visualization is based off Plano-Clark's and Creswell's interpretation [146](p. 380) of Luzzo's mixed methods analysis [145].



Qualitative Data Collection

Key informant interviews were conducted to elicit information on four TPB constructs - Attitudes, Intentions, Norms, and PBC - as they described distracted driving in commercial truck drivers [52]. A purposive sample of experts in truck driver safety or distracted driving were recruited from the list of attendees at the Symposium on Prevention of Occupationally-Related Distracted Driving sponsored by the Johns Hopkins Bloomberg School of Public Health Occupational Safety and Health Education and Research Center on April 18, 2011 in Laurel, MD. Ensuing interview participants were recruited using a snowball sampling technique [125].

The interview guide was developed and refined by the study team, and finalized after pilot testing with an expert in motor carrier safety who is a former driver. Semi-structured interviews were conducted via Skype (Microsoft Corp., Redmond, WA) and were recorded using MP3 Skype Recorder v3.1 (VOIPCallRecording.com). Audio files of the interviews were transcribed by uploading the .mp3 files to productiontranscripts.com (Production Transcripts, Glendale, CA). Data collection ceased after 11 interviews, which was the point when data saturation was reached [171]. The recording failed on one interview, so only 10 of the 11 interviews were successfully transcribed. Since notes were taken during each interview, notes from all 11 interviews were successfully transcribed. Data collection began in December, 2012 and ended in January, 2013. Of the 11 interview participants, five were researchers at academic institutions, three were at private research institutions, and one a piece were from a union, a private company, and a federal agency. Because participants were guaranteed anonymity, no further demographic data was collected. The author of this dissertation served as the interviewer for all 11 interviews.

Qualitative Data Analysis

The 10 transcripts and 11 sets of notes were saved as Microsoft Word documents. Data were open-coded line-by-line to label themes found in the participants' responses [126, 127]. Open coding was employed to develop the initial themes that were found in commonly across the interviews. Focused coding, or level-2 coding, was employed to group themes into broader categories [126, 127]. For example, “personal control” and “work pressure” were two labels that often appeared close to one another as interview participants described the balance the drivers would have to strike in their decision-making process. A codebook was developed during the focused coding process. A second coder, hired for the task, independently coded a subset of three randomly-selected interviews as a check on the reliability of the coding process. Both coders met to discuss the coding and how well the codebook described the categorizations of the data [128]. The two coders differed slightly in their choice of wording of themes, but no substantive differences emerged. Because the interview participants were anonymously recorded, results of the interviews will be reported by subject number.

To establish which distracted driver behaviors were appropriate for the online survey of drivers [52], interview participants were first asked to give their opinions on how distracting certain behaviors would be to truck drivers, including texting while driving; reading the dispatch device; and writing notes or a log. Using a Likert scale, interview participants rated on a scale of one (not very distracting) to five (very distracting) 19 distracting behaviors described by the Virginia Tech Transportation Institute [4, 6] and confirmed as relevant by two pilot tests of the interview. Two behaviors were selected for analysis in the online survey: texting while driving was given a maximum distraction rating by every interview participant; “interacting with a dispatch device” was rated nearly as distracting as texting and is a behavior that is specific to the occupational environment of truck drivers. Only drivers who indicated that they use dispatch devices answered TPB questions regarding dispatch device use and all drivers answered questions about texting.

Quantitative Data Collection

Quantitative data were collected via online survey. Members of the International Brotherhood of Teamsters (IBT) in the U.S. were selected as target population for the survey. The IBT represents over one million truck drivers and union members in other occupations in the U.S. and Canada [57]. The IBT was in part selected due to its size and nationwide reach. In addition, we were able to develop a relationship with the head of Occupational Safety and Health for the IBT in Washington, D.C. in developing this study. This IBT official understood the importance of the research and served as a gatekeeper into the IBT population [125]. A business representative from an IBT Local who was familiar with the project was used to pilot test the survey and finalize the exact wording. The survey took 10 minutes to complete upon final testing. With the assistance of IBT personnel, we sought sub-industries where the drivers were most likely to experience the distractions under study [58]. To identify drivers in the carhaul, express, freight, motion picture, package, and tankhaul industries, study participants were asked to select the type of truck that they drove (with accompanying images) at the beginning of the survey. Those who did not identify one of the selected vehicles were directed to a disqualification page and thanked for their time.

Of the 440 subjects who began the survey, 79 (18%) were screened out because they indicated that they did not drive one of the vehicles included in the study, and 68 dropped out before completing the texting questions and driving outcome questions. For the dispatch device section, 135 subjects were screened out as they indicated that they did not use a dispatch device and 57 dropped out before completing all the questions on dispatch device use. As these questions were part of a longer survey, some subjects dropped out before completing questions on the driving outcomes: a total of 277 subjects (77% of total eligible sample) completed survey questions for texting and the driving outcomes, and 153 (42% of total eligible sample) completed the questions on dispatch device use and driving outcomes.

In the texting group, 26% of subjects indicated that they drove delivery vans (i.e., were in the package industry) and 74% drove larger trucks. A 2002 Census Bureau report on registered trucks in the U.S. found that medium trucks (a category that includes delivery vans) comprised 23% of the American truck fleet and larger trucks were 63%, while the remaining 14% trucks that were too small for the current study population [131]. A search of the peer-reviewed and grey literature produced no more recent estimates of the composition of the American truck fleet. The dispatch device sample was comprised of 35% delivery drivers and 65% larger trucks. The texting population, the dispatch device population, and the 68 subjects who dropped out before completing the survey had statistically similar distributions of vehicles that they drove (Pearson's χ^2 p-value = 0.4). We have no data on the 79 subjects that were screened out as not driving vehicles in the target population.

Survey subjects were recruited via an announcement posted to the IBT website, teamster.org. The survey was administered using SurveyMonkey.com (SurveyMonkey Inc, Palo Alto, CA) and was open between April 2, 2013 and May 19, 2013. A power calculation using data from a similar study of the TPB and speeding behavior [49] indicated that a sample size of 500 respondents would result in a power above 0.80 and α-level of .05 [137]. Survey data were downloaded from SurveyMonkey into Stata v12.1 for analysis (Stata Corp, College Station, TX). The TPB constructs (Attitude, Norms, Perceived Behavioral Control (PBC), and Intentions) were assessed in reference to two behaviors: texting and dispatch device.

The TPB constructs were the independent variables and were scored as described by Montaño and Kasprzyk [52]. Attitude was assessed using the average of three semantic differential 7-point bipolar scales ranging from 1 to 7 with endpoints including "very harmful – very beneficial," "very unpleasant – very pleasant," and "very bad – very good." Thus, an increased Attitude score indicates a more positive view of the distracting behavior. Intention was measured using a single 7-point bipolar scale (1 through 7) with endpoints "Definitely will – Definitely will not." An increased Intention score indicates that a driver had less intention to undertake a given behavior.

Both PBC and norms scores were generated by multiplying the two individual scores together [52]. For the resulting variables, both the sign of the score and the absolute value are informative. PBC was assessed using a multi-item indirect assessment by multiplying control beliefs (scored on a bipolar 7-point scale) with times perceived power (scored -3 to +3 on a bipolar scale). The absolute values of the PBC component describes how confident the driver is in being able to avoid an activity that he/she deems to be easy (positive) or hard (negative) to avoid. Norms were assessed with a multi-item indirect assessment multiplying the normative belief (scored -3 to +3) times the motivation to comply (score 1 to 7). Negative norms values indicated that a driver's supervisor thinks that the driver should undertake a given behavior and positive values indicate that supervisors think that the driver should not undertake the behavior. An increased absolute value for norms indicates how important the supervisor's opinion concerning the distracting behavior is to the driver.

Exploratory data analysis was conducted on the TPB constructs separately for both the texting and dispatch device populations [147]. Means and standard deviations were generated for each TPB construct and because the range of scores was small, frequency tables and histograms were also generated for visual assessment of the data. Although previous studies on driver behavior and the TPB have used mean scores to analyze each TPB construct [35, 56], our data were not normally distributed and clustered around certain responses. Thus, we categorized the four TPB constructs for the texting and dispatch device use data. Development of the individual categories is described in the Results section.

Subjects also self-reported if they ever had experienced a series of safety critical events while on the job [148]. Subjects first reported whether or not they ever had a crash while on the job. After being reminded that distracted driving encompasses any activities that that take the driver's eyes, hand, or concentration away from the primary driving task, subjects reported whether or not they had ever had a crash while distracted, had to brake hard to avoid a crash while distracted, and swerve to avoid a crash while distracted. These four outcomes served as the dependent variables in four separate regression analyses, described below, in both the texting and dispatch device populations. The Olson *et al*. study found that truck drivers would undertake distracting activities in the non-crash control periods as well as during crashes or near crashes [6]. Rather than asking drivers if they had ever driven distracted, which can occur without negative consequences, we asked for situations when the distraction was so great that it became a hazard for crash or near crash.

Quantitative Data Analysis

Means and standard deviations (SDs) were calculated for age, years driving experience and weekly driving hours. Descriptive analysis of the categorical TPB variables was conducted. To validate the model in Figure 9 (page 99), we examined whether or not Intentions mediated the effects of the other TPB variables on the four outcomes [94]. To test this model required a multi-step process. First, we correlated Norms, PBC, and Attitudes to Behavioral Intentions using logistic regression for both texting and dispatch device use [35, 56]. Second, univariate logistic regression was used to analyze the association of each of the four TPB constructs for texting and distracted driving with the four crash and near crash outcomes. Univariate logistic regression was also conducted for demographic data that the drivers reported: gender, age, driving experience, and weekly driving hours. Third, multivariate regressions were first conducted without Intentions, then including Intentions to see if it attenuated the effects of the other three TPB constructs, that is, did the ORs for Norms, PBC, and Attitudes decrease and what, if any, effect was there on the significance of the ORs. A change in the ORs towards 1.0 and/or decreasing significance of the p-values of the ORs was considered to be a mediation effect. Control variables in the multivariate models included on those variables that had p-values ≤ 0.10. Entering covariates with p-values less than 0.2 has been used in model selection in the past [94]; however, using 0.10 as a cutoff is a trade-off between including relevant covariates and model performance [119].

Results

Qualitative Analysis

Some interview participants went beyond the definition of distracted driving given in the Background section for how they conceive of distracted driving. Participants 2, 5, and 8 expressed the belief that non-driving activities rose to the level of "distractions" only when driving performance was impacted. Interview participant number 2 was concerned that the distracting task was prioritized over driving and that safely operating the vehicle then becomes a secondary task. Many participants were concerned for the drivers' decreased driving performance, but as one participant pointed out, while drivers might think that they are increasing their work efficiency by undertaking a second task, there is also a diminished capacity to carry out that second, distracting activity. Interview participants were able to describe situations where drivers crashed or came near to crashing when distracted. Only one of the 11 participants said that he/she did not know of any crashes involving distracted truck drivers and further stated that he/she doubted that any driver would admit to driving distracted after a crash.

All interview participants were asked to comment on whom would influence drivers' decision-making for three or four distinct behaviors, such as texting, dialing a phone, eating or drinking (many behaviors were repeated in multiple interviews). In the 10 transcribed interviews, participants stated that supervisors and/or management would positively, negatively, or both influence drivers' decision-making in 28 out of 32 different activities. No other social referents were named nearly as frequently. Although the interviewer encouraged respondents to describe other potential social influences, such as family members or coworkers, it was clear that supervisors had the biggest influence on drivers' decision-making process.

When asked about distracting activities, interview participants were able to identify pros and cons of a wide variety of behaviors. Dispatch devices and cell phones (both personally owned and owned by the company) were identified as ways for management and drivers to stay in touch. Benefits to staying connected via such electronic devices included updating information, route planning, informing customers on arrival times, and being able to make emergency contacts. Drivers also could benefit from being in phone contact with friends, family and coworkers. According to the interview participants, being in phone contact with family members, either via phone calls or text messages can give the drivers peace of mind from being able to check up on family members. Interview respondents also stated that drivers could use talking on the phone as a way to ward off fatigue. Finally, complex tasks including writing notes or a log, personal grooming, and eating or drinking could benefit drivers by allowing them to finish up tasks that they would otherwise have to do once they have finished driving and exited the vehicle.

Yet interview participants very strongly condemned many of these distracting activities, saying that benefits were minor in comparison to the potential negative consequences. Interview participant number 8 was specific about the main drawback when he/she said:

> "So it goes then beyond what were they doing specifically to their eyes are off the road. And so it doesn't really matter whether they were texting, or reading the newspaper, or interacting with the dispatching device. The bottom line is that their eyes were off the forward roadway."

Interview participants discussed all aspects of visual, cognitive, and manual distractions as drawbacks. Comparing the different distracting behaviors, participants said that whatever tasks took the longest or involved multiple forms of distraction (e.g., visual and cognitive) were the most hazardous. Overall, interview participants felt that drivers would have negative attitudes towards distracting tasks when they weighed the pros and cons.

Interview participants felt that drivers had a great deal of personal control over whether or not they undertake distracting behaviors while driving on the job. Even though work pressures or family pressures might influence drivers to feel that they would need to undertake a secondary task, all the interview participants felt that it was ultimately up to the driver to make the decision. In the words of participant number 4,

> "I mean the decision ultimately rests on the driver. [There are] pressures from things that would weigh into that. But to engage in the actual activity while driving is completely under his control."

However, participants described a range over control of distracting activities. Participant number 10 stated that when reaching for objects in the vehicle cab, the more occupation-related an object is, the less control that the driver has over that choice whereas the more personal an object is, the more control the driver has over that choice.

Organizations could reduce drivers' control over distracting activities by having strong, clear policies against distracted driving. According to interview participants, strict enforcement of these policies would be an effective deterrent, thus inhibiting drivers' freedom to undertake distracting activities. Two interview participants cited DriveCam (manufactured by The Driver Science Company, San Diego, CA) as one method for monitoring driver behavior. Fear of punishment from the employer or receiving a ticket from law enforcement for violating the U.S. Department of Transportation's ban on texting for commercial truck drivers [182] would further discourage drivers from driving distracted, effectively reducing their control over undertaking that given behavior. Heavy traffic conditions or construction zones where the driver's full attention was needed for driving were cited as other times that drivers might not feel free to undertake distracting activities.

One other influence on PBC and norms cited by interviews participants were laws and law enforcement. In 2010, the Federal Motor Carrier Safety Administration issued a rule stating that commercial truck and bus drivers were prohibited from texting while driving [182]. The ban, which prohibits truck drivers from texting with a phone or dispatch device, in the words of Participant 8, will be helpful in creating an organizational safety culture where distracted driving was not the norm. Not only does this ban create a list of prohibited activities that employers know that drivers should not be undertaking, but also the regulation allows for an $11,000 fine for the vehicle's owner [182]. This last provision should give further motivation to organizations to ensure that their drivers are not texting while driving.

Quantitative Analysis

Table 17 describes the demographics of subjects who completed the texting and dispatch device sections of the survey. Both samples, the vast majority of which were men, average over 20-years of experience driving and reported that they drive more than 40 hours per week.

For the texting population, all four TPB constructs were categorized as binary variables, because as previously noted, they were not normally distributed. Table 18 describes the distributions of these variables. The Attitudes categories are 1) those who gave the lowest rating (i.e., one out of seven) to each of the three items on attitudes towards texting and 2) those who gave any ratings higher than that. The Norms categories are 1) those subjects who stated that their supervisor's opinions were against texting and their supervisor's opinions were very important to them and 2) subjects who gave any other answer. The PBC categories are 1) subjects who felt it was easy to avoid texting and stated that they would not text and 2) subjects who gave any other answer. The Intentions categories are 1) those who intended not to text in the next 3 months and 2) any other response.

Table 17. Descriptive data on the respondents to the components of the TPB questions for texting while driving and reading the dispatch device while driving.

Texting while driving (n=277)			
Gender	265 male	9 female	3 unknown
	Mean	SD	Minimum-Maximum
Age (years)	48.0	8.8	21 – 69
Driving experience (years)	22.8	10.1	1 – 45
Weekly driving (hours)	47.6	11.6	6 – 70
Using the dispatch device while driving (n=153)			
Gender	146 male	5 female	2 unknown
	Mean	SD	Minimum-Maximum
Age (years)	46.4	8.4	21 – 69
Driving experience (years)	21.2	9.3	1 – 44
Weekly driving (hours)	47.6	11.3	6 – 70

Table 18. Descriptive data on binary TPB variables for the texting population (n=277).

Variable	Level	Count (%)
Attitudes	Negative attitudes on all three items	202 (73%)
	Any other attitudes	75 (27%)
Norms	Supervisors oppose texting and strong motivation to comply	130 (47%)
	Any other norms	147 (53%)
PBC	Easy to avoid texting and will not text	193 (70%)
	Any other control beliefs	84 (30%)
Intentions	Strongly intend not to text	219 (79%)
	Any other intentions	58 (21%)

There was greater variance for the TPB scores for the dispatch device questions than there was for the texting questions. An example is presented in Figure 10, a histogram of responses to Intentions towards dispatch device use. Histograms for all TPB constructs are presented in Appendix 6 of this Dissertation. Unlike in the texting population, only half the subjects gave the maximum response “Definitely will not use” and the data were more evenly spread among the other responses. Thus, the dispatch device variables for the TPB were categorized differently than the texting population.

Figure 10. Histogram of the Intentions to use the dispatch device while driving. 1 = Definitely will use; 4 = Neutral; 7 = Definitely will not use.

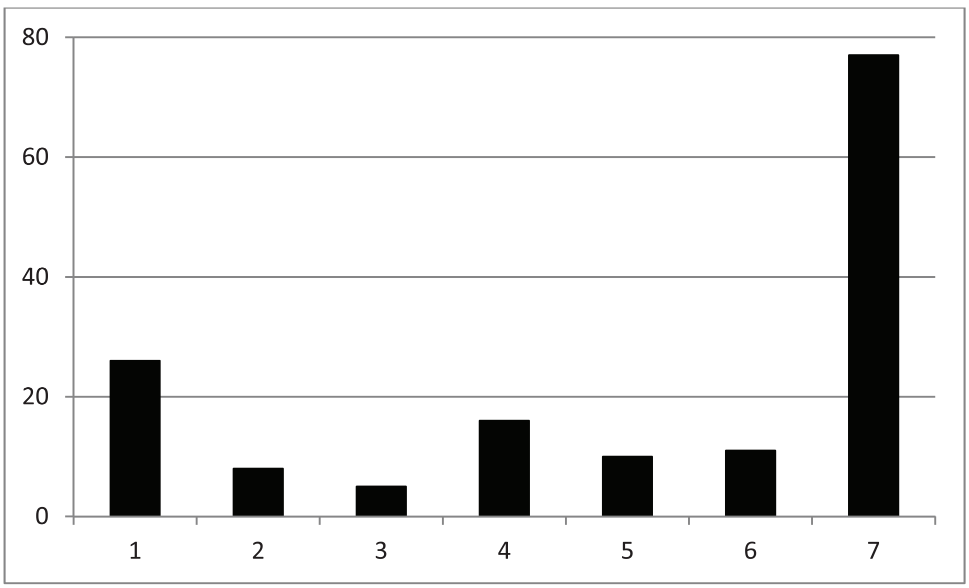


Table 19 describes the distributions for the dispatch device population. The Attitudes categories are 1) very negative attitudes, akin to the first category in the texting populations; 2) negative attitudes; and 3) neutral and positive attitudes towards dispatch device use. The Norms categories are 1) those subjects who stated that both supervisor’s opinions were against use and their supervisor’s opinions were very important; 2) supervisor’s opinions matter and we less strongly opposed to use; 3) supervisor’s opinions neither matter nor do not matter; and 4) supervisor’s opinions do not matter. The

PBC variable is binary, yet the categories are slightly different from the texting PBC variable: 1) confident towards avoiding dispatch device use and 2) not confident towards avoiding use. The Intentions variable is binary: 1) intend not to use and 2) neutral or intend to use.

Table 19. Descriptive data on TPB variables for the dispatch device population (n=153).

Variable	Level	Count (%)
Attitudes	Very negative attitudes	76 (50%)
	Negative attitudes	49 (30%)
	Neutral and positive attitudes	28 (20%)
Norms	Supervisors strongly oppose use and strong motivation to comply	54 (35%)
	Supervisors opposed and strong motivation to comply	45 (29%)
	Neutral motivation to comply regardless of supervisor's opinion	21 (14%)
	No motivation to comply regardless of supervisor's opinion	33 (22%)
PBC	Confident towards avoiding use	83 (54%)
	Not confident towards avoiding use	70 (46%)
Intentions	Intend not to use	98 (64%)
	Neutral intentions and intend to use	55 (36%)

Table 20 describes the reported crashes and near crashes for each of the two populations. Over half of the subjects in both the texting group and the dispatch device group reported ever crashing on the job, with less than 20% in each group reporting distraction-related crashes. Respondents were fairly evenly split on experiencing a distraction-related near crash, both for hard braking and swerving.

Table 20. Reported crashes and near crashes for subjects completing the texting and dispatch device sections. Percent of responses are in parentheses.

	Texting (n=277)			Dispatch device (n=153)		
	Yes	No	Missing	Yes	No	Missing
Any crashes	151 (55%)	124 (45%)	2 (1%)	90 (59%)	62 (41%)	1 (1%)
Distraction-involved crashes	49 (18%)	228 (82%)	0 (0%)	23 (15%)	130 (85%)	0 (0%)
Distraction-involved hard braking	127 (46%)	147 (53%)	3 (1%)	76 (50%)	77 (50%)	0 (0%)
Distraction-involved swerving	121 (44%)	155 (56%)	1 (1%)	68 (44%)	85 (56%)	0 (0%)

The results of the full univariate regression analyses are presented in Appendix 6. Here, I will briefly summarize the univariate results for the TPB constructs. For the texting population, Norms was associated with ever experiencing a crash and distraction-involved swerving; PBC and Intentions were associated with distraction-involved swerving and distraction-involved braking; and Attitudes were not associated with any of the four outcomes. For the dispatch device population, all four TPB constructs were associated with the distraction-involved outcomes: crash, hard braking, and swerving. None of the TPB constructs were associated with ever experiencing a crash. Those items in bold in the tables in Appendix 6 were entered into multivariate regressions.

In the first step of a mediation analysis, the Attitudes, Norms, and PBC were significantly associated with Intentions in logistic regression analysis for both texting and dispatch device use populations. Table 21 presents the multivariate analyses for the texting population for the three outcomes (ever experiencing a crash, distraction-involved hard braking, and distraction-involved swerving) for which there were significant multivariate results. Increased odds of crash were associated with those drivers who did not state that their supervisors were against texting and their supervisors' opinions were very important to them; Intentions have minimal mediation effects on Norms, raising the p-value from 0.038 to 0.054. Drivers who did not state that texting was easy to avoid (PBC) were associated with increased odds of distraction-involved hard braking; however, these effects were mediated by Intentions. For distraction-involved swerving, Intentions mediate the effects of PBC and Norms.

Table 21. Mediating effects of Intentions towards texting on other TPB constructs for crashes and near crashes on the job.

	Direct effects		Mediation effects	
	OR	95% CI	OR	95% CI
Ever experience a crash on the job				
Driving experience	1.02	1.00-1.05	1.02	1.00-1.05
Gender	0.09	0.01-0.74†	0.09	0.01-0.74†
Norms	1.68	1.02-2.75†	1.66	0.99-2.76*
Intentions	--	--	1.08	0.57-2.04
Ever experience distraction-involved hard braking on the job				
Weekly driving	0.98	0.96-1.00†	0.98	0.96-1.00†
PBC	2.42	1.42-4.11†	1.63	0.80-3.30
Intentions	--	--	1.97	0.87-4.45
Ever experience distraction-involved swerving on the job				
Norms	1.64	0.99-2.71*	1.55	0.93-2.58*
PBC	1.77	1.03-3.03†	1.09	0.53-2.25
Intentions	--	--	2.29	1.01-5.20†

* p-value <0.1; † p-value <0.05

Table 22 (p. 119) presents the results of mediation analysis for experiencing a distraction-involved crash and experiencing distraction-involved swerving. None of the demographic data or TPB constructs were associated with distraction-involved hard braking. Subjects who stated that they had neutral motivation to comply regardless of supervisor's opinion were at increased odds of crashing compared to the Norms reference group; Intentions did not mediate these effects. Both subjects who stated that they had neutral motivation to comply regardless of supervisor's opinion and subjects who stated that they had no motivation to comply regardless of supervisor's opinion were at increased odds of experiencing distraction-involved swerving compared to the Norms reference group; Intentions did not mediate these effects as well.

To summarize the quantitative analyses, when testing the TPB model in Figure 9, Intentions did mediate the effects of the other TPB variables on the distraction-involved outcomes in the texting population. Yet in the dispatch device population, Intentions did not mediate the effects of norms on distraction-involved crashes and swerving.

Table 6. Mediating effects of Intentions towards dispatch device use on other TPB constructs for crashes and near crashes on the job.

	Variable level	Direct effects		Mediation effects	
		OR	95% CI	OR	95% CI
Ever experience a distraction-involved crash on the job					
Driving Experience		1.04	0.98-1.09	1.04	0.98-1.09
Attitudes	Very negative attitudes	Reference		Reference	
	Negative attitudes	2.57	0.82-8.11	2.55	0.81-8.03
	Neutral and positive attitudes	0.60	0.12-3.00	0.54	0.10-2.86
Norms	Supervisors strongly oppose use and strong motivation to comply	Reference		Reference	
	Supervisors opposed and strong motivation to comply	1.64	0.34-7.83	1.56	0.32-7.59
	Neutral motivation to comply regardless of supervisor's opinion	8.11	1.52-43.17†	7.87	1.47-42.30†
	No motivation to comply regardless of supervisor's opinion	2.20	0.45-10.74	2.07	0.41-10.37
PBC		1.74	0.54-5.77	1.49	0.39-5.67
Intentions		--	--	1.36	0.43-3.51
Ever experience distraction-involved swerving on the job					
Attitudes	Very negative attitudes	Reference		Reference	
	Negative attitudes	1.46	0.63-3.40	1.46	0.63-3.39
	Neutral and positive attitudes	0.85	0.30-2.47	0.87	0.29-2.62
Norms	Supervisors strongly oppose use and strong motivation to comply	Reference		Reference	
	Supervisors opposed and strong motivation to comply	2.14	0.85-5.43	2.16	0.85-5.53
	Neutral motivation to comply regardless of supervisor's opinion	5.22	1.26-14.08†	4.24	1.27-14.20†
	No motivation to comply regardless of supervisor's opinion	5.29	1.89-14.78†	5.37	1.90-15.14†
PBC		1.31	0.57-3.06	1.38	0.49-3.84
Intentions		--	--	0.92	0.32-2.61

† p-value <0.05

Synthesis of Qualitative and Quantitative Results

While regression analysis supported the TPB framework displayed in Figure 9 for texting, it did not do so for dispatch device use. In the interviews, participants reported feeling that drivers ultimately had control over whether or not they undertook distracting activities, yet one participant stated that drivers had less control over distractions that were more work-related. Drawing from both the quantitative and qualitative analyses, it is possible that drivers felt that they had much better control over their choices surrounding texting than dispatch device use. The quantitative results for the texting population support this conclusion, as Intentions mediates the effects of PBC on distraction-involved near crash outcomes. Yet for the dispatch device use, Intentions were more varied, and thus the social norms from drivers' supervisors were most important in determining distracted driving behavior.

In Tables 18 and 19, drivers indicated negative attitudes towards texting and dispatch device use. Although interview participants believed that drivers would find some positives to undertaking the distracting behaviors, the qualitative and quantitative data both point to drivers having negative attitudes about distracted driving on the job. In key informant interviews, participants felt that drivers would view distractions negatively, yet, because they were not drivers themselves, could not speak directly to drivers' intentions. In this case, the quantitative results give us insight into an aspect of TPB that the qualitative data could not give.

Discussion

The results of these analyses support the important role that truck drivers' supervisors play in preventing distracted driving on the job. Interviews with experts in truck driving safety described how management can create a culture that either encourages or discourages distracted driving, while surveys of IBT members demonstrated the importance of organizational norms surrounding text messaging and dispatch device use while driving. The importance of supervisors to driver safety has been previously explored by Wills and colleagues in a population of professional drivers in Australia [46, 47, 129]. In these studies, Wills *et al.* found that management commitment to safety was the aspect of safety climate most correlated with safe driving behavior [47]. Motor carrier companies have taken proactive steps to prevent distracted driving. Both the Network of Employers for Transportation Safety [82], a private-public partnership concerned with reducing crashes on and off the job, and the American Trucking Association [182], an industry advocacy group, have stated that some of their member organizations had company policies on distracted driving prior to the 2010 federal ban on texting while driving for commercial truck drivers [182].

The results of this study and previous work also show the importance of company policies for driver safety. Interview participants described how clearly enforced, explicit company policies on distracted driving, with no competing implicit expectations, could reduce employee distracted driving. A study of texting prevalence in commercial truck drivers by Hickman and colleagues found that drivers who drove for organizations with texting bans had a lower prevalence of texting while driving than companies without such policies [4]. Enforcement of organizational rules prohibiting electronic communications while driving would affect both drivers' perceived norms and PBC, as was described in the synthesis of the qualitative and quantitative data.

The regression results on attitudes towards the two distractions did not produce significant results. In Tables 18 and 19, the Attitude construct scores are very low, so it is also possible that floor effects were affecting the regression analyses [183, 184]. The interview participants were able to describe both pros and cons to undertaking a wide range of distractions, including complex tasks, such as writing notes and personal grooming, that were previously found to be hazardous for truck drivers [6]. It could be that the drivers felt that they could be more efficient when doing a second task while driving, which was seen in prior research [35] as was described by our interview participants. Further interviews should be conducted with drivers to understand their attitudes towards distractions.

Our regression analyses did not use distracted driving as the outcome of interest. From the VTTI study, we know that drivers can undertake distractions while driving and not experience any adverse events [6]. Previous research using the TPB framework has examined intentions to undertake an activity instead of direct observation of the activity itself [35, 56]. We did find significant correlations to Intentions for the three other TPB constructs for both texting and dispatch device use. By examining distraction-related crashes and near crashes, our outcomes of interest were times when distractions had affected driver safety. This is more in line with the definition of distracted driving given by interview participants 2, 5, and 8, that is, a task is only distracting when it affects driver safety. Alternative analyses could have included a proactive analysis, where we measured TPB constructs then explored their association with future incidence of distracted driving or distraction-related crashes and near crashes.

Strengths and Limitations

This paper was limited in scope in that it could not cover drivers who are owner-operators, which limits the generalizability of these findings to only union drivers. This distinction is important because owner-operated drivers face work and time pressures that are different from the union drivers that this study examined [185]. When interview participants would begin to describe such drivers, the interviewer (DS) had to remind them that that was beyond the scope of the study. While interview participants did describe both union and non-union driver/management interactions, the survey results are only applicable to union drivers. Union workers receive more safety training than their non-union counterparts and are less likely to accept hazardous working conditions [186]. It is possible that the survey populations have safer driving behaviors and better safety climate than non-union drivers in the U.S.

Similar to the present analysis, prior analysis of the TPB found that intentions mediated the effects of other constructs on behavioral outcomes [187, 188]. More advanced statistical models, such as Verschuur and Hurts' structural equation model of the impact of TPB on unsafe driving behaviors [189] or the path analyses of the TPB and truck driver safety by Poulter *et al*. [50], should be conducted to see how each of the TPB constructs affect distracted driving in the workplace for truck drivers. The sample size for both populations made these analytical approaches infeasible and might otherwise have limited our results as well. It was difficult to estimate the necessary sample size for a population and outcomes that had previously not been examined, but researchers will now have the estimates from this study for sample size calculations in future studies. Although we anticipated a sample size of 500 subjects as necessary for analysis, we did find some significant results in populations of 277 and 153 subjects.

While the distribution of vehicle types for the texting population was similar to that seen in the Census Bureau report [131], the dispatch device population has a higher percentage of delivery van drivers. The Census report on the 2002 American truck fleet was the final report in that series before the Census discontinued that analysis, so there is an 11-year gap between when those data were collected and data collection in the current study. We cannot tell if this increase is due to a greater percentage of delivery van drivers using dispatch devices compared to drivers of larger trucks. Yet, the percent of delivery drivers in each study population were not significantly different from one another.

No data are available to compare the percentage of delivery van drivers to larger truck drivers in the total IBT membership in the U.S. While sampling IBT members offers the possibility of a nationwide sample, we had no mechanism to analyze from which states the survey subjects drove. Furthermore, we are unable to compare the demographics of the study populations to IBT members or truck drivers. This population was overwhelmingly male, which is consistent with both previous research [190] and the opinions of interview participants in the current study. The authors know of no nationally-representative studies that describe driver age, experience, and weekly driving exposure to which we can compare our study population.

This study was limited in assessment of outcomes of interest because we had to rely on self-reported incidents. Although self-reported incident report has been validated by previous studies [191, 192], methodological issues still remain. By asking subjects if they had ever had a crash or distraction-related near miss, we increased the time period of interest, and thus potential incidents. Landen and Hendricks caution that by increasing the time period for incidents that recall bias increases beyond 12 months of recall [193]. As the one participant who reported no knowledge of distraction-related crashes implied, there might be social desirability bias when asking drivers to admit to distraction-related driving outcomes; however, anonymous surveys decrease the likelihood of such bias [180].

A final limitation was that not all subjects who completed the texting and/or dispatch device sections answered the outcome questions. This study was part of a larger survey of driver behavior and safety climate factors, so there were an additional 35 questions between the end of the TPB sections and the outcome measures. If the survey was not as long, we might not have seen survey fatigue, which is one possibility for the large numbers of respondents who skipped questions [133].

This study was not designed to examine the same populations with both the quantitative and qualitative methods; however, we believe that the mixed methods design lends strength to our results. Collins and colleagues stated that the legitimacy of each method within any mixed methods study should be the first measure of that study's legitimacy [194]. Both surveys [195] and expert opinion [196] have been used in the past to assess truck driver safety. Using a concurrent design and analysis of the interviews and surveys creates what Onwuegbuzie and Johnson refer to as paradigmatic mixing legitimacy [142, 143]. That is, independent analysis of each method is conducted separately and meta-inference allows us to draw legitimate conclusions across both methods. Although the results of the surveys and interviews could have stood on their own, the mixing of results in this analysis provides additional insight into driver distraction that we would not have been able to gain had we conducted this as two separate studies.

Conclusions

In this study, we described how distracted driving behavior in truck drivers can be strongly impacted by their supervisors. By enforcing strict policies on distracted driving, supervisors can affect drivers' perceived control and norms surrounding distracted driving, two aspects of the TPB that were correlated with negative distracted driving outcomes. Interview participants felt that drivers would have negative attitudes towards driving distracted and would not intend to undertake such distractions. In regression analyses, drivers' intentions towards texting mediated the effects of the other TPB constructs on distraction-involved near crashes; yet their intentions towards dispatch device use did not have the same mediating effects. But utilizing qualitative and quantitative methods for data collection and analysis, this study was able to describe how personal and organizational factors affect drivers when deciding whether or not they should undertake various distracting activities.

Discussion

The purposes of this dissertation was to describe the epidemiology of distraction-involved truck crashes in the U.S., examine the impact of distracted driving laws on these fatalities, understand the impact of safety climate on distracted driving in truck drivers, and understand factors affecting the decision-making process of truck drivers regarding distracted driving on the job. In this dissertation, the first manuscript, Effects of State Policies on Fatalities Involving Distracted Truck Drivers, found that while fatality rates for distraction-involved truck crashes have been decreasing since 2007, state distracted driving laws had no effects on fatality rates. The 2010 federal ban on texting while driving for commercial truck drivers was associated with a decrease in the fatality rate for all vehicle occupants in distraction-involved truck crashes, yet more data will be necessary to establish the effects, if any, of federal ban. This is the first study to examine fatal crashes where truck driver distraction was a factor in the crash and to see if distracted driving laws affected these fatality rates.

The second manuscript, The Effects of Safety Climate on Distracted Driving in Commercial Truck Drivers, explored the relation of safety climate factors to negative outcomes of distracted driving. Although the survey of drivers from the IBT did not produce many significant findings, interviews with experts in truck safety and distracted driving described how these elements of safety climate might affect distracted driving for truck drivers. From the SCQ-MD, the Communications and Procedures and Management Commitment factors were associated with self-reported near crashes in univariate analyses. Interview subjects described how management could affect driver safety, through work processes, time pressures, and communication methods.

In the third manuscript, Understanding Commercial Truck Drivers' Decision-Making Process Concerning Distracted Driving, the Theory of Planned Behavior (TPB) was used to describe how drivers consider whether or not to undertake distractions while driving. Interviews with experts in truck safety and distracted driving elaborated on these findings. For both texting and dispatch device use, TPB constructs of intentions, norms, and perceived control were associated with crash and near crash outcomes in regression analyses. Interview subjects reported that while drivers might gain some benefits in time-saving from undertaking distractions while driving, that the negatives of distractions would vastly outweigh the positives. While supervisors were viewed as having the most influence on drivers' distracted driving behavior, interview subjects felt that the ultimate decision on choosing whether or not to undertake distracting activities fell to the drivers themselves.

While the first manuscript explicitly considers the impact of government policy on truck driver safety, the second and third papers consider factors more related to the workplace and driver-management interaction. It might appear that factors affecting the first manuscript are different from those affecting the second and third, there are government agencies, safety groups, labor unions, and corporate representatives that affect all three areas. This chapter will describe how the results from the three manuscripts are integrated and their impacts on future research and practice. It also includes an analysis of how different policy actors affect the formation and execution of safety policies and if/how they attempted to influence the distracted driving policies under study.

Organizational Texting Bans

The FMCSA ban on texting while driving [75] directly regulates truck driver activity on the job. Because the regulation allows for a fine of both the driver and their employer [75], this policy creates an incentive for companies to enforce this ban for their employees. However, regulations such as these are not the sole reason that companies implement safety programs for their drivers. Some companies had CPWD bans in place prior to the 2009 announcement of the FMCSA regulation and its enactment in 2010, as described in a report by The Network of Employers for Transportation Safety (NETS) [82] and in written testimony to the FMCSA from the American Trucking Association (ATA) [182].

A study led by Jeff Hickman at the Virginia Tech Transportation Institute (VTTI) found that drivers who drove for companies with texting bans had a lower prevalence of texting while driving than for drivers of companies without such policies [4]. Furthermore, the reduction in prevalence in companies with CPWD versus those organizations without such policies was greater than the non-significant reduction found in states that had texting bans versus states that did not have texting bans [4]. Participants in the qualitative data collection outlined in the second and third manuscripts described technological means for monitoring driver behavior, including in-vehicle cameras and company cell phone records. These technologies present a method for management to proactively enforce company policy, rather than having to react to negative events, including distracted driving citations or distraction-involved crashes involving their employees.

The Network of Employers for Transportation Safety (NETS) is a consortium of private and public organizations concerned with reducing crashes on and off the job [197]. Professional organizations like NETS allow for the sharing of information and best practices surrounding driver safety topics like distracted driving among members. The NETS website (www.trafficsafety.org) has some publically available information on distracted driving [198], and the NETS member companies share further information on policies and enforcement with one another (Jack Haley[2], personal communication July 2, 2013). Best practices for occupational distracted driving are also available from the federal government. The National Institute for Occupational Safety and Health (NIOSH) has a fact sheet concerning distracted driving in the occupational setting [199]. While NIOSH is charged with conducting research on occupational hazards, it falls to the Occupational Safety and Health Administration (OSHA) to regulate occupational safety issues. OSHA has a webpage with information on distracted driving [200] and model company policies [201], but it has not issued any regulations aimed at curbing distracted driving in the workplace. The Federal Communications Commission (FCC), which regulates cellular phone traffic in the U.S., also provides an online clearing house for possible distracted driving regulations[202]; however, the FCC states on this website that

[2] Jack Haley is the Executive Director for NETS

it does not endorse any of the technological or managerial interventions listed on the website.

In the Federal Register the FMCSA states that it received over 400 comments during the 6-month open comment period [182]. Some comments came from industry groups, including the American Trucking Association (ATA) and the Owner-Operator Independent Drivers Association. In its comments to the FMCSA, the ATA stated that many of its member organizations already had texting bans. On its website the ATA states that it seeks to educate policymakers about the needs of its members [203]. If the ATA was submitting comments to the FMCSA concerning texting, it was likely because its members felt that this was an important issue. Although the texting ban did not go into effect until October 2010, companies in the commercial trucking industry would have had forewarning that the ban was coming, both from the FMCSA's call for comments, as well as from organizations like the ATA.

Because the unit of analysis in Manuscript 1 was the state*year, I could not analyze the effects of the FMCSA regulation in 2010 month-by-month. A drop in fatalities after October in comparison to January through September in 2010 would provide some evidence that the statistically significant drop was due to the FMCSA ban, and not other reasons, such as pre-emptive implementation of organizational policies. I could find no analysis describing if the proposed texting ban had prompted organizations to implement their own policies in the months prior to enactment of the FMCSA's rule. However, federal regulation can prompt organizations to enact policies before regulation takes effect, a recent example of which is fast food companies posting calorie information at their stores before the relevant provisions of the Affordable Care Act went into effect [204].

Company policies concerning distracted driving on the job would seem to fall under the safety climate construct of "communications and procedures" [46, 129]. As part of the key informant interviews in manuscript three, one participant said that the FMCSA ban might create safety culture in an organization where distracted driving was previously the norm. Moreover, as shown in Manuscript 3, those drivers who had lower scores on the Norms TPB construct for texting and dispatch device use were more likely to have reported swerving while distracted (lower Norms scores mean that drivers stated that their supervisors wanted them to be in more contact while driving). So while some companies may believe it is efficient for drivers to communicate with their supervisors while driving [35], having a consistent policy that workers not drive distracted would result in safer outcomes for drivers. Later in this chapter I will use the results of this thesis and the prior literature to describe the most important factors in creating distracted driving policies.

Management Commitment to Safety

Described elsewhere in this dissertation, Flin and colleagues identify the most commonly examined aspects of safety climate as 1) management/supervision, 2) safety systems, 3) risk, 4) work pressure, and 5) competence [42]. Previous research, including the work of Wills and colleagues in formulating the modified version of the Safety

Climate Questionnaire used in manuscript two [46], describes management commitment to safety as most important aspect of safety climate [42, 177, 178, 205]. One way for management to commit to worker safety is through the establishment of safety and health management systems, also known as safety management systems, or occupational safety and health management systems (OSHMS) [206].

Systematic management of occupational safety and health has grown out of the fields of psychology, sociology, industrial relations, occupational safety, occupational health, and management [207]. The International Labor Office defines OSHMS as "a set of interrelated or interacting elements to establish [occupational safety and health] policy and objectives, and to achieve those objectives" (International Labor Office 2001, p 19) [208]. These programs started to gain popularity in the 1990s when "accident analysis" moved from focusing on individual errors to considering system-wide failures as the root cause of traumatic injury and death [174, 176, 207].

Although some countries such as Canada and Norway have mandatory OSHMS programs [206], OSHA does not require any such programs in the U.S. Aside from online materials with best-practices for setting up these programs [209, 210], OSHA also administers the Susan Harwood Training Grant Program for non-profit organizations that can be used to expand safety and health capacities or for demonstration projects on safety and health [211]. Robson *et al.* refer to OSHMS programs not mandated by regulation as "voluntary" [206]. These programs can be incentivized by government agencies (such as OSHA) or insurers. Robson and colleagues find that mandatory OSHMS programs are by their regulatory nature, very broad in their requirements, whereas voluntary programs are highly complex and usually only found in large companies [206].

An examination of all aspects of OSHMS programs for truck driver health and safety is beyond the scope of this dissertation. I will now discuss what I believe to be important factors for organizations to consider when creating a distracted driving component of a SMS. To do so, I will draw on data both from the Olson *et al.* VTTI study [6] (see also Appendix 1) from my dissertation research.

An organization should first consider whether or not a specific type of driver should require contact with his or her supervisor while driving. As part of the surveys in this dissertation research, I asked IBT drivers to identify which industry [58] they drove for. The different types of drivers would all have different requirements put on their time and scheduling. One of the participants in key informant interviews described how little personal time a UPS delivery driver has while driving his/her route. In this example, a UPS driver (who would fall under the IBT "express" industry) would have much less control over their personal time than drivers who drove more point-to-point routes, such as carhaul, tankhaul and freight industries [58].

I had hoped that the survey sample would be large enough to analyze crash and near-crash risk by IBT industry; however the power for such analysis was not possible with this sample. The third study on the SCQ by Wills *et al* was the only previous work that I could identify where safety climate was compared across organizations [129]. This

Wills *et al*. study, which did not any information about the organizations, including the kind of driving employees were undertaking, did not find any significant differences between the different organization's safety climate scores. Future analyses should compare safety climate across organizations and across driving industries. (Similarly, Poulter *et al*. analyzed the effect of TPB on driver behavior in three different motor carrier organizations, yet they did not analyze between-company differences either [50].)

If organizations decide that the cost-benefit analysis of contact between drivers and supervisors is beneficial [35], they should consider risk to the drivers and other legal factors. The Olson *et al.* VTTI study [6] (see Appendix 1) found an increased odds of crash or near crash when truck drivers were texting while driving (odds ratio (OR)= 23.2); reaching for an electronic device like a cell phone or two-way radio (OR= 6.7); or interacting with or reading a dispatch device (OR=9.9). The risk for crash exposes companies to liability from property damage-, injury-, or fatality-involved crashes [37], or costs associated with workers' compensation [38].

Management should also be aware of what laws and regulations certain methods of contact would violate. If drivers are contacted via text message for delivery updates, that would violate the FMCSA regulation and force drivers to break the law. The Final Rule from the FMCSA also states that drivers cannot use the dispatch device for text messages while driving [212]. If drivers were required to answer their handheld cell phone while driving to respond to their supervisors, then that would violate the law in several states [70]. Yet, as I described in the second manuscript, a participant said in the second manuscript, drivers could get conflicting messages from supervisors where they have the "[i]mplicit expectation that they use the device while driving so that they can respond in a timely fashion to requests from the company."

These conflicting messages would affect the Intentions and Norms aspects of the TPB. Drivers might not intend to violate the law and explicit company policy, but they would still feel pressure to do so. If drivers know that violating internal policy and law is the norm within an organization, it could create a climate where drivers have poor attitudes concerning Wills and colleagues' safety climate factors of communications and procedures, work pressure, management commitment, and safety rules [46, 129].

Implications for Federal Policy-Making

While considering the ban on texting for truck drivers, the FMCSA also received comments advocating for and against banning all CPWD [182]. The FMCSA acknowledged the existing research on CPWD and crash risk, yet stated that banning all cell phone use for commercial truck drivers was beyond the proposed rule-making. However, because of the powers delegated to the FMCSA [25], it could consider a handheld or hands-free cell phone ban in the future.

It could be that regulating commercial truck and bus drivers was an example of the federal government regulating where it was easily able to do so. Other examples of the federal government regulating texting under its jurisdiction includes CPWD for federal employees [81], and train operators [213]. As described in the Introduction chapter, it is easier for the federal government to regulate driver behavior in truck drivers than it is for it to regulate drivers of personally owned vehicles. If the DOT was to connect highway funding to state texting bans, as it had previously done for state drunk driving laws [73], such legislation would face a much more difficult path through Congress than simple regulation by the executive branch. In this section, I will review how some of the stakeholder groups already mentioned in this chapter have affected the previous regulatory process with an eye towards future regulations.

Advocacy organizations like NETS and the ATA can also influence the rule-making process. In John Kingdon's analysis of the federal policy process, interest groups are found to more often oppose changes in the status quo and block action rather than promote regulation [214]. During the comment period for the FMCSA texting ban, the Federal Register reports that the ATA supported this ban; however, elsewhere in the Federal Register reporting the FMCSA's rule-making process, the ATA resisted many of the regulations that the FMCSA was proposing [182]. For example, the ATA wanted texting from the dispatch device to be exempted from the ban, a decision that the FMCSA ruled against, and the ATA also felt that the fines on employers were not warranted for companies that already had their own texting bans [182]. During motor carrier industry deregulation, completed in 1980, the ATA was also initially against changes to the system, yet ultimately supported the final legislation that was move favorable to their constituents [215]. If the FMCSA was to offer future regulation on CPWD, the ATA would definitely be opposed to that. Although it is beyond the scope of this dissertation, the comments submitted to the FMCSA could be analyzed in terms of which organizations were for and against different components of the proposed rule.

Apart from federal regulation are the state bans on texting and handheld CPWD. On June 19, 2013 Florida became the 41st state to ban texting while driving [70]. As reviewed in the Introduction, and reinforced in manuscript one, there is currently no evidence that state texting or CPWD bans reduce crashes or fatalities. Although state CPWD laws have not been shown to decrease crashes or fatalities, the exact way that the states enact, implement, and enforce the laws might affect the laws' effectiveness [69]. Amendola reviewed the Connecticut CPWD ban and enumerated many reasons why it had not yet been shown to be effective [165]. For example, Amendola found that unlike Washington, DC, which aggressively enforces its handheld cell phone ban, other states do not do a very good job of enforcing CPWD bans and as a result, drivers do not feel that the laws apply to them. In some states like Pennsylvania [76], there is a high burden of proof placed on the law enforcement officers when attempting to issue such a citation for CPWD. Requiring the officers to pass a very high burden of proof to issue a citation might further discourage officers from issuing CPWD citations.

When NHTSA created its pilot distracted driving deterrence program in 2010 – 2011 [80], high-visibility law enforcement was one of the pillars of the program. Shown to be effective in the seat-belt enforcement programs of "Click it or Ticket" [216], raising the profile of law enforcement and also the threat of receiving a citation, this might be one method for countering the perception of drivers who do not believe that the texting bans apply to them [165]. Although the FMCSA acknowledged that there would be a period where law enforcement would have to learn best practices for enforcing the texting ban for commercial drivers, the agency reasoned that this should not be sufficient to delay enacting the rule. How well this ban is implemented and enforced in the future will impact its effectiveness. A complication of observing distracted driving activity in truck drivers is how difficult it is for officers or observes to see into these large vehicles. The FMCSA sought to address such a problem during an investigation of seatbelt use in truck drivers [217], so observing distracted driving might be able to be accomplished by similar methods. To observe seatbelt use in truck driver, law enforcement needed to be positioned on overpasses or other raised locations. Thus, enforcement of truck driver behavior could be more resource-intensive, but is not infeasible.

In the first manuscript, I found that truck length and rural maximum speed limit were state-level regulations that affected distraction-involved truck crash fatality rates. This reflects the analysis of Neeley and Richard's paper on the effects of state regulations on truck crash fatality rates [87]. Neeley and Richardson's analysis influenced me when I was designing my analysis because they showed how fatality rates in trucks can be affected by aspects beyond policies directly related to truck drivers, including state highway expenditures and unemployment rates. Because of the social and monetary costs of the motor carrier industry, such as fatalities, pollution, and road maintenance, that are not completely offset by the taxes and fees levied by the states [218], states should have an interest in motor carrier safety. Analyses like mine and that of Neeley and Richardson show that states should be able to effect distracted driving motor carrier safety through means other than just regulation of distracted driving. So while my analysis finds that states can impact distraction-involved truck crash fatality rates, the regulations whose aims are specifically to reduce the crash risks presented by distracted driving (i.e., CPWD bans) did not affect distraction-involved crash rates.

The Impact of Research on Policy-Making and Next Steps in Research

According to Kingdon, academics, researchers and consultants are important parts of the policy process that often affect the policy alternatives more so than the policy agenda itself [214]. In the case of the texting ban, research from the Virginia Tech Transportation Institute actually helped drive the agenda. As discussed throughout this dissertation, the VTTI study led by Rebecca Olson produced a very thorough analysis of crash risk for truck drivers undertaking different distracted driving activities [6]. The study, funded by the FMCSA, has also been heavily cited by the federal government. Simply referred to as "the VTTI Study," the statistic that texting while driving increases crash risk by 23 times was referenced by the federal government in such locations as the FCC's distracted driving information page [202], and the texting ban Final Rule in the Federal Register [182].

Research on motor carrier regulation has previously influenced federal policy on truck driver safety. When the FMCSA changed its hours-of-service regulations in 2003 [219] it directly affected an important aspect of driver safety: fatigue [220]. Recent analyses of the 2003 hours-of-service regulation found that drivers were not driving more after the increase in allowable consecutive driving time [221], and, in two studies by

VTTI, drivers were not experiencing increased crash risk during the longer hours-of-service [222, 223]. By court order the FMCSA was forced to revisit the hours-of-service regulations [221] and in the subsequent 2011 regulatory analysis the FMCSA cited work by VTTI in their analysis of the new regulations [224].

Policy Implications of This Dissertation Research

Further analysis of the FMCSA will be required to determine whether or not the decrease in fatality rates associated with the ban is sustained. Although I chose to follow the method of Wilson and Stimpson for analyzing state fatality rates [14], there are other regression methods available for analyzing these fatalities. Fowles and colleagues conducted an econometric analysis of truck crash-related fatalities in relation to cell phone use across a 30-year span in the U.S. [108]. Their analysis did not analyze states, nor consider state CPWD bans or the 2010 FMCSA ban; however, their study lays out a detailed method for further analysis. I also believe that further analysis using the naturalistic driving method found in the VTTI study would be an appropriate way to test the effectiveness of the ban. The VTTI studies resulted in thousands of hours of in-vehicle video [6] of drivers that could serve as baseline for a follow-up study. Although this was a personnel- and resource-intensive, repeating the study could be a way to compare prevalence of distracted driving pre- and post-ban.

Future research will also be necessary to consider how organizations can affect distracted driving in their employees. In the NETS report on distracted driving, some of the anonymous member companies reported reserving the right to terminate workers violating bans on either handheld CPWD or texting-while-driving [82]. Future analysis should examine the safety climate for drivers from different organizations operating under different CPWD bans to determine the effects of specific prohibition and enforcement components, expanding on the work of Wills *et al*. that did not find any between-organizational differences in organizational safety climate [129]. I believe that this could be done with either quantitative or qualitative methods. A quantitative approach would be to use the methods of Hickman *et al*. to naturalistically observe the prevalence of CPWD and examine which aspects of company policy are best for reducing prevalence [4]. Interviews or focus groups could also be conducted with drivers and management, from the same organizations and different organizations, to understand what both sides view as effective organizational policies for reducing driver distraction.

My third manuscript used the TPB as the conceptual framework for describing distracted driving behavior. Gielen and Sleet [225] reviewed behavioral health theories for their impact on behavior change. Their review could provide the framework for changing driver behavior at the individual-level (e.g., using the stages of change model) or at the organization- or community-level (e.g., using community mobilization) [225]. Due to logistical challenges, I was unable to conduct focus groups with truck drivers as part of my research, a method that allows for participants to comment on and accept or reject their peers' reasoning on decision-making [226]. Because I relied on key informant interviews with driving safety experts and not drivers themselves, the qualitative analysis of the Attitude and Intentions TPB constructs was not as in-depth as it could have been.

Strengths and Limitations of the Study Methods

As has been described throughout this thesis, the methods employed have strengths and limitations. In this section I will now review the strengths and limitations of the methods used in this dissertation, and describe how the limitations could be addressed with future research.

Using the Fatality Analysis Reporting System (FARS) database as the basis for Manuscript 1 produces both challenges and great opportunities in the analysis. A first limitation is that this database only captures crashes involving fatalities. Crashes involving no injuries or non-fatal injuries are much more common than fatal crashes [130]. The National Highway Transportation Safety Administration (NHTSA) has another database, the National Automotive Sampling System's General Estimating System (GES), which captures data on crashes of all severities [151]. While FARS is a census of all fatal crashes in a given year, GES is only a representative sample of crashes in the U.S. Thus, in choosing to use FARS over GES, I was trading the breadth of crash types found in GES for the validity of capturing every fatal crash in the U.S. during the study period.

Although previous research has used FARS to study distraction-related crashes in the U.S. [14, 160], it is not without limitations. In a report for NHTSA, Ascone and colleagues find that both FARS and GES distraction data could be limited in their reliance on police reports for distraction data in crashes [151]. Furthermore, Ascone *et al.* raise concerns about the consistency of police reporting of distractions across jurisdictions. Validation of the distraction variables as described in Table 1 of Manuscript 1 should be undertaken in the future as more studies of distracted driving rely on the FARS database. Ascone *et al.* describe the National Motor Vehicle Crash Causation Survey as a resource-intense method previously used for analyzing a small sample of crashes [151]. A similar analysis could serve as a validation method for distraction-involved crashes. While the validity of the distraction variables is not yet established, the FARS database has been so often used for other fatal crash analyses (see Chen *et al* [162] and Carpenter and Pressley as two examples [227]) that it allows for comparison to the wider literature on motor vehicle crash fatalities in the U.S.

The statistical model used in Manuscript 1 is another strength of the analysis. From the ANOVA, there was more between-state variation than there was within-state variation. Because of this clustering, a multi-level model was necessary [94]. A recent study of the effects of cell phone on truck crashes released in early 2013 by Fowles and colleagues did not employ such a mutli-level analysis [108]. Whereas the Fowles *et al.* paper was more concerned with long-term longitudinal effects of cell phones, they did not explore the effects of state laws on truck crashes. This decision to analyze state laws did not allow for the in-depth model testing seen in the Fowles *et al* paper [108]; however, analysis of truck driver fatalities from Neeley and Richardson showed the effects of state laws [87], and thus the multi-level approach was chosen. Finally, the choice of the longitudinal model allows for analysis of change within states over time. This is consistent with many prior analyses of health and transportation policies.

The selection of diesel VMTs was another choice that adds strength to Manuscript 1. The selection of VMT for rate calculation was consistent with many other occupational and non-occupational transportation studies. An alternative method for calculating occupational fatality rates would have been to use data from the Bureau of Labor Statistics (BLS) on workers in a given industry [156]. Although this would allow for fatality rate comparisons between industries [228], the BLS data do not have the number of employees in a given industry by state. Choosing diesel VMTs was another important selection for the analysis. The DOT publishes data on VMTs for all vehicle traffic in a state, but the choice of diesel VMTs allowed for the observation of occupational exposure for this population.

Although the analysis of fatality rates using VMTs was a strength of the study design, Manuscript 1 did not account for other trends in distraction-related crashes or commercial truck crashes. Snowden and colleagues conducted one such analysis, examining the effects of random alcohol testing on large truck fatal crashes, using light truck as a comparison group [163]. To conduct such an analysis, an appropriate comparison group would be required. Future analyses could be conducted comparing truck-involved distraction fatalities to rates of all distraction-involved fatalities in the U.S. [14] or for all truck-involved fatalities [150].

Another method for examining the impact of state laws would be an interrupted time series difference-in-difference approach [229]. This difference-in-difference method is useful in examining the effects of transportation policies on crashes and fatalities, yet it requires a greater number of time points than was available in our state*year analysis [229, 230]. Such an analysis might be feasible in the future for states with very high fatality counts, such as California, Texas, Oklahoma, and Pennsylvania, using state*month as the time period of interest.

In Manuscript 1, I analyzed fatal crashes where the truck driver was killed and fatal crashes where any vehicle occupant in any vehicle involved in the crash was killed. This creates the assumption that crashes in the first group and second group are similar. NHTSA analyzed fatal crashes in the U.S. and found that 2/3 of crashes in which a truck driver was killed were single-vehicle crashes [150]. The same NHTSA report finds that 2,790 occupants of other vehicles were killed in multi-vehicle truck-involved crashes in 2010 compared to only 192 truck drivers who were killed in multi-vehicle truck-involved crashes. These data indicate that the types of crashes resulting in fatalities to truck drivers are different than those crashes that result in fatalities in other vehicle occupants. This study was not designed to analyze crash type, but future analysis of truck crashes should account for these differences.

In Manuscripts 2 and 3, there were strengths and limitations for both methods, in addition to how the methods were mixed. Although the study proposal originally included focus groups of IBT member drivers, logistical challenges necessitated the use of key informant interviews. While expert opinion has been used to understand truck driver safety in the past [196], the elicitation interview process for TPB studies usually is performed with the same population that will be surveyed [52]. The snowball sampling technique also allowed me to access experts that I would not have previously known of, or considered for study. For example, I had met Jack Hanley of NETS at a conference and although he felt that he was not an appropriate study subject, he was able to direct me to another NETS member who was able to provide the prospective of an expert from the management side of driver safety.

Although interview subjects made occasional reference to owner-operators during the interviews, no analysis of situations unique to owner-operators was conducted [185]. Further analysis should examine the effects of distracted driving on owner-operators and consider how their work pressures affect decision-making while driving. Although analysis of interviews was not only limited to discussion of union drivers, the survey was a purely union population. Union workers receive more safety training than their non-union counterparts and are less likely to accept hazardous working conditions [186]. It is possible that the survey population in Manuscript 2 and 3 have safer driving behaviors and better safety climate than non-union drivers in the U.S.

In Appendix 5, I describe the frequency with which drivers reported which vehicles they drove. As discussed in the Methods section, I believe that the samples in Manuscripts 2 and 3 are representative of the American truck drivers, although I had few variables on which to test this hypothesis. While the Census data on the American truck fleet provided a comprehensive picture of vehicles in the U.S., that particular series of reports was ceased in 2004. The annual Highway Statistics reports from the FHWA report on vehicle fleet composition by state, but these data are not comparable to the IBT industry groups used in this analysis [97]. While previous studies of commercial truck drivers in the U.S. have provided demographic data on their study populations (see Suzuki *et al*. as an example [190]), no national demographic data were available to which I could compare my survey samples. Although I partnered with the IBT to conduct this study, I have no data indicating how representative these samples are of IBT drivers.

A benefit of partnering with the IBT is that the union represents drivers across the U.S., giving me the potential for a nationwide sample. However, as an attempt to keep the data as anonymous as possible for the respondents, I did not ask in which state(s) they drove or lived. So while Manuscripts 2 and 3 had the potential to be a nationally-representative sample, I regret that I did not gather information on state or at least region of the country from the respondents. Another limitation of the survey was that subjects were able to skip some pages of the survey without penalty. This led to incomplete answers to the TPB questions, the SCQ-MD, or both. Furthermore, the four crash and near crash outcomes were at the end of the survey, and thus the most commonly skipped items. It is possible that better organization of the survey might have produced stronger quantitative results.

This selection of different populations resulted in a trade-off of study validity. By not restricting interviews to only examine the driving experiences of union members prior to the survey of IBT members reduces internal validity; yet, external validity is increased when qualitative analysis of a broader driver population is used to elucidate surveys of the chosen population [142]. Part of this decision about which populations to include was pragmatic: I was able to access a wide number of IBT drivers online via the organization's own online media, whereas contacting as large a population of non-union drivers would have been more difficult. Furthermore, partnering with the IBT lent increased legitimacy to my recruitment announcement. By posting the material on the IBT's website, members would understand that the study has gone through some sort of vetting process by IBT leadership and that I wasn't seeking to take advantage of them.

For both Manuscripts 2 and 3, *a priori* relationships (the TPB, Wills *et al.*'s work on the SCQ-MD) were hypothesized to describe distracted driving and safe driver behavior. Because of the existing theoretical framework, these studies were conducted using what Morse refers to as a deductive framework [138]. That is, while quantitative and qualitative data were analyzed together in Manuscript 3, the underlying TPB framework drives study design and data analysis. An alternative to this method would have been to develop the theoretical framework *de novo* with the qualitative methods being complemented by the surveys. This study did not allow for the time for developing and pilot-testing new surveys that may have been developed from a grounded theory approach [127127]. Furthermore, the use of TPB and safety climate frameworks allows for the results of Manuscripts 2 and 3 to be placed more easily into the larger occupational safety climate and health behavior literatures, respectively.

Conclusion

In this dissertation, I examined the effects of state and federal policies, organizational safety climate, and driver behavior on distracted driving in commercial truck drivers. This study will make significant contributions to the growing literature on distracted driving. By examining an occupational population, this study also contributes to the greater research on occupational health and safety in the motor carrier industry. While recent research on the motor carrier industry has focused on driver health and wellness, this dissertation is a return to examining their occupational safety for a risk factor that has been understudied in this population. Finally, by using a mixed methods approach, I expanded this methodology into new areas of occupational health and driver behavior. This dissertation has shown that federal policy, organizational safety climate, and driver decision-making are important factors that should be considered when seeking to reduce distracted driving in commercial truck drivers in the U.S.

Appendix 1. Secondary and tertiary distractions undertaken by commercial truck drivers in the VTTI Study. Odds ratios and lower confidence limit (LCL) and upper confidence limit (UCL) are for safety critical events (Olson *et al*, Table 3, p xxi).

TASK	Odds Ratio	LCL	UCL
Complex Tertiary Task			
Text message on cell phone	**23.24***	9.69	55.73
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	**10.07***	3.10	32.71
Interact with/look at dispatching device	**9.93***	7.49	13.16
Write on pad, notebook, etc.	**8.98***	4.73	17.08
Use calculator	**8.21***	3.03	22.21
Look at map	**7.02***	4.62	10.69
Dial cell phone	**5.93***	4.57	7.69
Read book, newspaper, paperwork, etc.	**3.97***	3.02	5.22
Moderate Tertiary Task			
Use/reach for other electronic device (e.g. video camera, 2-way radio)	**6.72***	2.74	16.44
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	**5.86***	2.84	12.07
Personal grooming	**4.48***	2.01	9.97
Reach for object in vehicle	**3.09***	2.75	3.48
Look back in Sleeper Berth	**2.30***	1.30	4.07
Talk or listen to hand-held phone	1.04	0.89	1.22
Eating	1.01	0.83	1.21
Smoking-related behavior—reaching, lighting, extinguishing	**0.60***	0.40	0.89
Talk or listen to CB radio	**0.55***	0.41	0.75
Look at outside vehicle, animal, person, object, or undetermined	**0.54***	0.50	0.60
Talk or listen to hands-free phone	**0.44***	0.35	0.55
Simple Tertiary Task			
Put on/remove/adjust sunglasses or reading glasses	**3.63***	2.37	5.58
Adjust instrument panel	**1.25***	1.06	1.47
Remove/adjust jewelry	1.68	0.44	6.32
Other—Simple (e.g., opening and closing driver's door)	2.23	0.41	12.20
Put on/remove/adjust hat	1.31	0.69	2.49
Use chewing tobacco	1.02	0.51	2.02
Put on/remove/adjust seat belt	1.26	0.60	2.64
Talk/sing/dance with no indication of passenger	1.05	0.90	1.22
Smoking-related behavior—cigarette in hand or mouth	0.97	0.82	1.14
Drink from a container	0.97	0.72	1.30
Other personal hygiene	**0.67***	0.59	0.75
Bite nails/cuticles	**0.45***	0.28	0.73
Interact with or look at other occupant(s)	**0.35***	0.22	0.55
Secondary Task			
Look at left-side mirror/out left window	**1.09***	1.01	1.17
Look at right-side mirror/out right window	0.95	0.86	1.05
Check speedometer	**0.32***	0.28	0.38

Appendix 2. Approved key informant interview script used in phase 1 of mixed method data collection.

Approved: October 25, 2012 **IRB No.**: 4494

Key informant interview script; PI: Pollack, IRB No. 4494
Version 1, October 15, 2012

Introduction

Thank you for agreeing to participate in this interview. The goal of this interview is to describe factors that may affect distracted driving in commercial truck drivers. After I go through the consent process, we will begin.

Oral Consent Process

[Read oral consent document]
Do you have any questions?

Description of Distracted Driving

I'd like to start with talking about the phrase "distracted driving." When you hear someone say "distracted driving," what does that make you think of?
[Elicit answers from interview subject]
Thank you. Those are good answers. For the rest of the interview I'd like to use a standardized definition of distracted driving. So from here on, when I refer to distracted driving it is **any secondary activity that takes the drivers hands, eyes, or concentration away from the primary task of driving.**

Behaviors

I am going to list some potentially distracting activities that truck drivers might face while driving. Using what you know, I'd like to know whether or not you think these are actual distractions for truck drivers. Please describe the level of distraction to be from 1 (not at all distracting) to 5 (very distracting).

- Dialing a cell phone
- Talking on a hand-held cell phone or two-way radio
- Talking on a hands-free phone (or such as Bluetooth or other headset)
- Writing a text message or other message on a cell phone
- Reading a message on a cell phone
- Reading a map or Global Positioning System (GPS) device
- Interacting with or looking at a dispatch device/computer
- Writing notes or a log
- Looking at objects in the vehicle
- Looking at objects outside the vehicle
- Reaching for objects inside the vehicle, such as the radio
- Smoking and smoking-related activities, such as lighting a cigarette
- Interacting with other occupants
- Personal grooming, such as putting on make-up, shaving, biting finger nails
- Eating or drinking
- Singing along with or talking to the radio
-

Attitudes

So from the list of behaviors that we have just gone over, I'd like to talk about the pros and cons of some of them. What are some benefits from doing [example #1]? [elicit responses] What are the drawbacks to doing [example #1]? [elicit responses]

repeat for examples 2 and 3

***Items will be selected if the subject gives them a score of 4 or 5 in the Behaviors responses. In later interviews if all respondents are giving similar answers, I will select from examples that haven't been discussed at that point. If a subject gives a score of "5" for 4 Behaviors, then I will attempt to do the following steps for all 4. If it is 5 or more, then I will likely have to skip one or two of them. If one those high-scoring Behaviors has been described by a previous interview subject, then that one will not be followed-up in favor of a Behavior that has not yet been explored. ***

Norms

Now I'd like to talk about who would affect drivers' decisions on whether or not to do these distracted driving behaviors. When thinking about whether or not a driver should [insert example #1] while driving on the job, whose opinion matters most? Who else's opinion would matter when thinking about whether or not a driver should [insert example #1]?

***If not mentioned, specifically probe – what about supervisors/management? Would their opinion matter? Also the following:

- spouse, partner, or significant other
- children
- other truck drivers, co-workers
- other friends

***Repeat for behaviors 2 and 3

Perceived Behavioral Control

Now let's talk about how much personal control drivers have over the situation. When deciding to do [behavior #1] while on the job, what would make it easy to do? What else makes it easy to do? What would make it hard to do? What else would make it hard to do?

Finally, do you feel that people generally have control over whether or not they do [example 1]? Is there anything you can think of that would give people greater personal control over whether or not they [example 1]?

Repeat questioning for examples 2 and 3.

Distracted driving outcomes

In the media and the general public distracted driving is perceived as dangerous. What have you heard about DD on the job for those who drive for a living? Do you know anyone who has had a DD crash or near miss on the job? Can you tell us what happened? Do you think professional drivers are generally better able to react to a dangerous situation if they're driving distracted?

The reason for this final section is that distraction related crashes for truck drivers are rare, so it is possible that we might be able to identify "near misses" or "safety critical events" that commonly occur when commercial drivers come close to crashing, yet perform an avoidance maneuver (such as hard breaking, or sudden swerving) to avoid a crash.

Appendix 3. Online survey administered to IBT drivers.

***What you should know about this study**

- You are being asked to join a research study.
- This consent form explains the research study and your part in the study.
- Please read it carefully and take as much time as you need.
- You are a volunteer. You can choose not to take part and if you join, you may stop at any time. There will be no penalty if you decide to quit the study.
- During the study, we will tell you if we learn any new information that might affect whether you wish to continue to be in the study.
- This project has been developed with leadership at IBT in Washington. They have been here every step of the way to insure the maximum benefit and the minimum risk to drivers.

Purpose of research project

You are being invited to take part in a research study with a purpose of gaining a better understanding of distractions facing commercial truck drivers. To do this, we are surveying members of the International Brotherhood of Teamsters about distractions that they face on the job.

Why you are being asked to participate

You have been asked to participate because you are a member of the International Brotherhood of Teamsters, drive a truck professionally, you also understand English, and are over 18-years-old.

Procedures

After you agree to this consent form, you will begin the survey. The questions that will be asked are about what distractions that you may face while driving, management support, and consequences of driving distracted. The survey should take no more than 10 minutes.

Risks/Discomforts

There are no physical risks associated with participating in this project. All of the information you share with us will be stored in locked file cabinets and/or password protected computer files. Data will not be shared with anyone outside the study staff. Any reports or papers we write based on this work will not include your name. The information you give will be analyzed with other responses, so the data will not be directly attributable to you. Talking about issues related to distracted driving may make you uncomfortable, but as previously mentioned, you can refuse to answer any questions that would rather not answer.

Benefits

There are no direct benefits to participants from participating in this research.

Payment
All participants will have the opportunity to enter a raffle for an iPad.

Protecting confidentiality
To protect your confidentiality, we will not ask you for your name. However, we would need a way to contact you if you are the winner of the raffle. To do so, we are asking that you enter an email address at the end of the survey if you would like to enter into the drawing. If you choose not to enter the drawing, you don't have to provide an email address.

Protecting subject privacy during data collection
At one point during the survey, we will ask about crashes or near crashes due to distracted driving. As some types of distracted driving is not legal activity in many states, we encourage you to be as honest as you can. We are not asking for your name, nor do we want to know what company you drive for.

Who do I call if I have questions or problems?

- **Call the study coordinator, David Swedler, 630-254-5560, or Principal Investigator, Dr. Keshia Pollack, 410-502-6272, if you have questions or complaints about being in this study.**
- **Call or contact the Johns Hopkins Bloomberg School of Public Health IRB Office if you have questions about your rights as a study participant. Contact the IRB if you feel you have not been treated fairly or if you have other concerns. The IRB contact information is:**

Address: Johns Hopkins Bloomberg School of Public Health
615 N. Wolfe Street, Suite E1100
Baltimore, MD 21205
Telephone: 410-955-3193
Toll Free: 1-888-262-3242
Fax: 410-502-0584
E-mail: irboffice@jhsph.edu

○ Agree
○ Do not agree

***What type of vehicle do you drive for the majority of your work? Examples of the truck types are below.**

- ◯ Semi-truck
- ◯ Tank truck
- ◯ Car hauler
- ◯ Dump truck (including grain or gravel haulers)
- ◯ Package car
- ◯ I don't drive any of these type the majority of the time

Semi-truck

Tank truck

Carhaul

Dump truck

Package car

What is your gender?

- ◯ Male
- ◯ Female

How old are you?

____

For how many years have you been a professional truck driver?

____

Approximately how many hours per week do you drive a truck for your job?

____

This section refers to texting while driving. Texting includes reading, writing, or sending a text message. That text message could be to any person who you would text.

Texting while driving on the job is:

Very unpleasant			Neutral			Very pleasant
○	○	○	○	○	○	○

Texting while driving on the job is:

Very harmful			Neutral			Very beneficial
○	○	○	○	○	○	○

Texting while driving on the job is:

Very bad			Neutral			Very good
○	○	○	○	○	○	○

My supervisor thinks that I SHOULD or SHOULD NOT text while driving on the job.

Definitely should			Neutral			Definitely should not
○	○	○	○	○	○	○

How important is it to you is your supervisor's opinion about texting while driving on the job?

Very unimportant			Neutral			Very important
○	○	○	○	○	○	○

I believe that I can avoid texting while driving on the job for the next 3 months:

I cannot avoid texting			Neutral			I can avoid texting
○	○	○	○	○	○	○

If it were entirely up to me, I would not text while driving on the job in the next 3 months:

I would not text			Neutral			I would text
○	○	○	○	○	○	○

How confident are you that you will avoid texting while driving on the job in the next 3 months?

I will not avoid texting			Neutral			I will avoid texting
○	○	○	○	○	○	○

How easy or hard is it for you not to text while driving on the job?

Very hard not to text			Neutral			Very easy not to text
○	○	○	○	○	○	○

I intend to avoid texting while driving on the job in the next 3 months:

Definitely will text			Neutral			Definitely will not text
○	○	○	○	○	○	○

My job involves the use of a dispatch device. Below are examples of two different types of dispatch devices.

◯ Yes

◯ No

In-cab dispatch device, usually mounted on the dash of the vehicle

Hand-held, portable computer connected to dispatch

Reading the dispatch device while driving on the job is:

Very unpleasant			Neutral			Very pleasant
○	○	○	○	○	○	○

Reading the dispatch device while driving on the job is:

Very harmful			Neutral			Very beneficial
○	○	○	○	○	○	○

Reading the dispatch device while driving on the job is:

Very bad			Neutral			Very good
○	○	○	○	○	○	○

My supervisor thinks that I SHOULD or SHOULD NOT read the dispatch while driving on the job.

Definitely should			Neutral			Definitely should not
○	○	○	○	○	○	○

How important is it to you is your supervisor's opinion about reading the dispatch device while driving on the job?

Very unimportant			Neutral			Very important
○	○	○	○	○	○	○

I believe that I can avoid reading the dispatch device while driving on the job for the next 3 months:

I cannot avoid reading the dispatch device			Neutral			I can avoid reading the dispatch device
○	○	○	○	○	○	○

If it were entirely up to me, I would not read the dispatch device while driving on the job in the next 3 months:

I would not read the dispatch device			Neutral			I would read the dispatch device
○	○	○	○	○	○	○

How confident are you that you will avoid reading the dispatch device while driving on the job in the next 3 months?

I will not avoid reading the dispatch device			Neutral			I will avoid reading the dispatch device
○	○	○	○	○	○	○

How easy or hard is it for you not to read the dispatch device while driving on the job?

Very hard not to read the dispatch device			Neutral			Very easy not to read the dispatch device
○	○	○	○	○	○	○

I intend to avoid reading the dispatch device while driving on the job in the next 3 months:

Definitely will read the dispatch device			Neutral			Definitely will not read the dispatch device
○	○	○	○	○	○	○

Changes in working procedures and their effects on safety are effectively communicated to workers

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees are consulted when changes to driver safety practices are suggested

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees are told when changes are made to the working environment such as the vehicle, maintenance or garaging procedures

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Safety policies relating to the use of motor vehicles are effectively communicated to workers

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Safety procedures relating to the use of motor vehicles are complete and comprehensive

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

An effective documentation management system ensures the availability of safety procedures relating to the use of motor vehicles

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Safety problems are openly discussed between employees and managers/supervisors

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Safety procedures relating to the use of motor vehicles match the way tasks are done in practice

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees can discuss important driver safety policy issues

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees are consulted for suggested vehicle/driver safety improvements

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees can easily identify the relevant procedure for each job

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees can express views about safety problems

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Employees are encouraged to support and look out for each other

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Time schedules for completing work projects are realistic

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

There is sufficient 'thinking time' to enable employees to plan and carry out their work to an adequate standard

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Workload is reasonably balanced

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

There are enough employees/drivers to carry out the required work

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Changes in workload, which have been made at short notice, can be dealt with in a way that does not affect driver safety

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

When driving employees have enough time to carry out their tasks

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Problems that arise outside of employees' control can be dealt with in a way that does not affect driver safety

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Management are committed to driver safety

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Management are committed to motor vehicle safety

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Driver safety is central to management's values and philosophies

Strongly agree ○ ○ ○ Neutral ○ ○ ○ Strongly disagree ○

Driver safety is seen as an important part of fleet management in this organization

Strongly agree			Neutral			Strongly disagree
○	○	○	○	○	○	○

Good working relationships exist in this organization

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Employees are confident about their future with the organization

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Morale is good

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Employees trust management

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Management trust employees

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Potential risks and consequences are identified in driver training

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Driver training is provided on skills specific to the type of vehicle driven for work

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Motor vehicle training is carried out by people with relevant experience

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Safety rules relating to the use of motor vehicles can be followed without conflicting with work practices

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Safety rules relating to the use of motor vehicles are followed when a job is rushed

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

Safety rules relating to the use of motor vehicles are always practical

Strongly agree — Neutral — Strongly disagree

○ ○ ○ ○ ○ ○ ○

In this section we talk about distracted driving. When we say distracted driving, we mean ANY activity that takes the driver's hands, eyes, or concentration away from the primary task of driving.

I have ever had a crash while driving on the job.

- ◯ Yes
- ◯ No

I have ever had a crash while driving distracted on the job.

- ◯ Yes
- ◯ No

I have ever had to break hard while I was distracted on the job

- ◯ Yes
- ◯ No

I have ever had to swerve or jerk the wheel to get back into my lane while distracted on the job

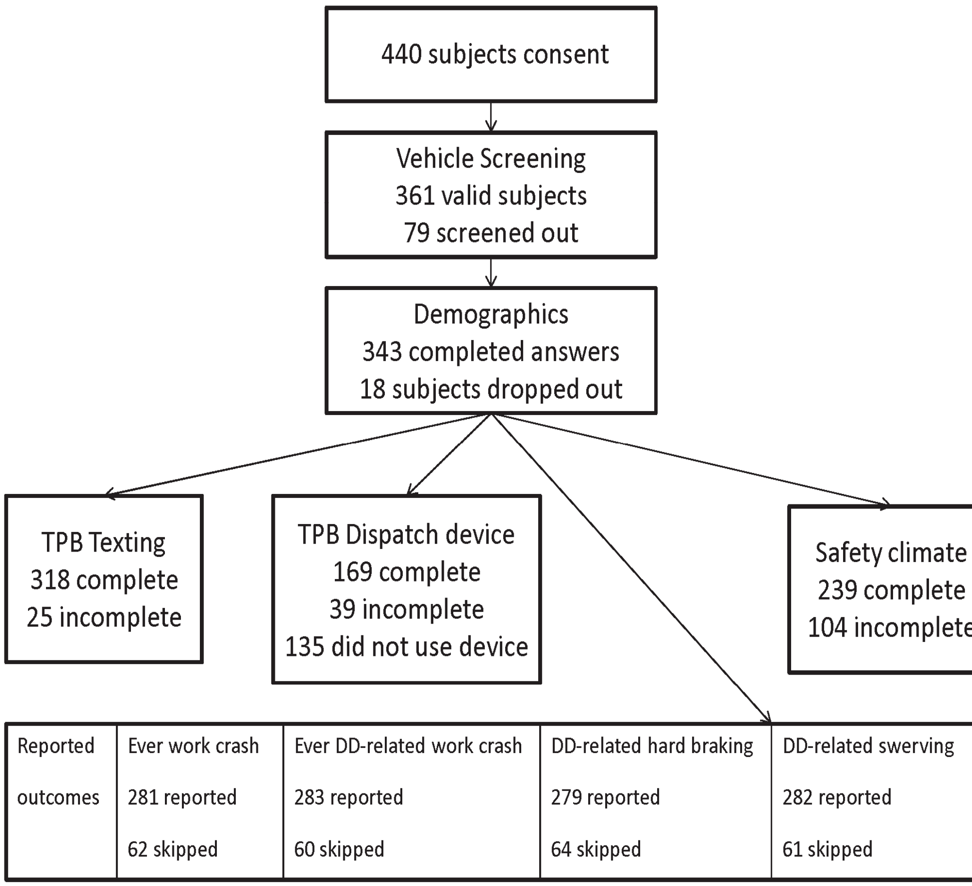
- ◯ Yes
- ◯ No

Appendix 4. Codebook from key informant interviews.

Category	Subgroups	Definition	Notes
Distracted Driving	DD- Definition	Eliciting the subject's definition of distracted driving and comparing it to the definition given by the interviewer	
	DD- Types	In describing DD, interview subjects referenced specific distractions	
Safety Climate	SC- Definition	Describing safety climate, workplace climate, safety culture or company culture	
	SC- Effects	How the SC encourages or discourages drivers to undertake DD while on-the-job	
	SC- Actors	Who generates the safety climate within a company	This is very similar to the TPB Social norms
Theory of Planned Behavior	TPB- Pros	Reasons that drivers would undertake distracting activities; what benefits they could reap from doing a secondary task while driving	Both this subgroup and TPB- Cons would fit under the "Beliefs" node in the Theory of Planned Behavior.
	TPB- Cons	Reasons that drivers would not want to undertake distracting activities while driving.	
	TPB- Social Norms	How do social norms affect DD decision making	
	TPB- Social Referents	Individuals who would affect drivers' decision-making surrounding the use of distractions while driving. Ex. management, family, friends, coworkers	When creating the survey, it was obvious that management had the biggest impact on driver decision-making
	TPB- Personal control	How much control do drivers have over choosing to undertake DD or not?	
Crashes	Completed crashes	Descriptions of distraction-related crashes that interview subjects knew of.	
	Near-misses	Descriptions of near-miss or safety critical events involving distracted truck drivers that interview subjects knew about	

Appendix 5- Results of the online survey. This Appendix describes how I arrived at the populations for both the TPB and safety climate analyses. Answers to individual SCQ and TPB questions are also presented.

Figure 1. The below flow-chart shows how the subjects answered the various sections of questions. A detailed description is given below.



443 subjects started the survey. 440 agreed to the Informed Consent. When asked to describe what type of truck they drive, 79 (18%) subjects were screened out as not driving the appropriate type of vehicle. 361 subjects began entering demographic data on age, gender, driving experience, and weekly driving hours. 18 subjects dropped out of the study before entering demographic data, giving us 343 subjects with demographic data.

Of these 343 subjects, 318 completed the questions on the TPB for texting, and 25 did not complete this section. 135 subjects indicated that they did not use a dispatch device while driving, so they skipped the TPB dispatch section. 169 subjects completed questions on TPB and the dispatch device and 39 did not complete that section. 239 subjects completed all 35 SCQ questions and 104 did not completely answer that section.

Of the 343 subjects who completed the demographic data, 283 answered at least one of the 4 outcome questions; 277 responded to all 4 outcomes. The exact number of respondents to each outcome were as follows: 281 reported if they had ever been in a crash on the job; 283 reported if they had ever had a distracted driving-related crash on the job; 279 reported whether or not they had ever had to undertake distraction-related hard or emergency braking on the job; and 282 reported whether or not they had to swerve due to distraction while on the job.

Demographic data

Table 1 displays the results of the demographic data for the total sample of 343 subjects that answered the demographic questions; those who completed the TPB sections on texting and dispatch device use (presented separately); and those who completed the safety climate questions. Using t-tests, all four groups reported in the table are statistically similar for each demographic variable.

Table 1.

All demographic data (n=343)			
Gender	328 male	9 female	6 unknown
	Mean	SD	Range
Age (years)	47.6	8.8	21 – 69
Driving experience (years)	22.2	10.1	1 – 45
Weekly driving (hours)	47.6	11.8	6 – 70
Theory of Planned Behavior- Texting (n=277)			
Gender	265 male	9 female	6 unknown
	Mean	SD	Minimum-Maximum
Age (years)	48.0	8.8	21 – 69
Driving experience (years)	22.8	10.1	1 – 45
Weekly driving (hours)	47.6	11.6	6 – 70
Theory of Planned Behavior- Dispatch device (n=153)			
Gender	146 male	5 female	2 unknown
	Mean	SD	Minimum-Maximum
Age (years)	46.4	8.4	21 – 69
Driving experience (years)	21.2	9.3	1 – 44
Weekly driving (hours)	47.6	11.3	6 – 70
Safety climate questionnaire (n=239)			
Gender	229 male	7 female	3 unknown
	Mean	SD	Minimum-Maximum
Age (years)	48.0	8.9	21 – 69
Driving experience (years)	22.7	10.1	1 – 45
Weekly driving (hours)	47.6	11.4	6 – 70

Vehicles Driven by Survey Respondents

Table 2 shows the vehicle type that respondents stated was their primary vehicle in the screening question at the beginning of the survey (Appendix 3). Responses are listed for all subjects who began the survey, the population of drivers in Manuscript 2 (SCQ), and the texting and dispatch device populations from Manuscript 3. A Pearson's χ^2 found that the 4 populations are statistically similar (p=0.4).

Table 2. Distribution of vehicle driven by survey respondents.

	Semi-truck	Tank truck	Carhaul	Dump truck	Package Van
Began survey (n=358)	205	9	21	28	95
SCQ (n=239)	145	4	15	15	60
Texting (n=277)	166	6	16	17	72
Dispatch device (n=153)	88	3	4	4	54

Safety Climate Results

Table 3 shows the distribution for the answers to all the SCQ-MD questions used in the analysis. The mean and standard deviation of the factors are described in the safety climate manuscript.

Table 3. Distribution of answers to all SCQ-MD questions

	1- Strongly Agree	2- Mostly agree	3- Agree	4- Neutral	5- Disagree	6- Mostly disagree	7- Strongly Disagree
Changes in working procedures and their effects on safety are effectively communicated to workers	62	41	33	33	17	20	33
Employees are consulted when changes to driver safety practices are suggested	55	34	17	27	23	18	65
Employees are told when changes are made to the working environment such as the vehicle, maintenance or garaging procedures	45	38	32	29	20	28	47
Safety policies relating to the use of motor vehicles are effectively communicated to the workers	67	45	36	31	13	21	26
Safety procedures relating to the use of motor vehicles are complete and comprehensive	64	44	31	34	26	15	25
An effective documentation management system ensures the availability of safety procedures relating to the use of motor vehicles	71	39	32	34	19	25	19
Safety problems are openly discussed between employees and management/supervisors	59	40	28	35	17	22	38
Safety procedures relating to the use of motor vehicles match the way tasks are done in practice	41	36	26	50	23	21	42
Employees can discuss important driver safety policy issues	70	57	34	26	15	11	26
Employees are consulted for suggested vehicle/driver safety improvements	39	30	24	29	21	30	66
Employees can identify relevant procedures for each job	63	64	28	43	18	6	17

Employees can express views about safety problems	86	52	23	30	15	13	20
Time schedules for completing work projects are realistic	31	28	29	34	20	27	70
There is sufficient 'thinking time' to enable employees to plan and carry out their work to an adequate standard	37	32	35	34	19	30	52
Workload is reasonably balanced	32	36	24	37	24	29	57
There are enough employees/drivers to carry out the required work	22	30	23	35	28	27	74
Changes in workload, which have been made on short notice, can be dealt with in a way that does not affect driver safety	30	32	22	37	29	30	59
When driving employees have enough time to carry out their tasks	35	38	28	44	33	22	39
Problems that arise outside of employees' control can be dealt with in a way that does not affect driver safety	36	38	41	51	21	28	24
Management are committed to driver safety	35	36	29	46	23	27	43
Management are committed to motor vehicle safety	44	35	33	36	26	22	43
Driver safety is central to managements' values and philosophies	38	30	35	40	24	27	45
Driver safety is seen as an important part of fleet management in this organization	46	34	38	35	23	31	32

Theory of Planned Behavior

Table 4 shows the distribution for all the answers to the TPB questions for texting-while-driving on the job. 277 subjects completed this section.

Table 4.

	Response on Likert scale						
	1	2	3	4	5	6	7
Texting on the job is-very unpleasant/very pleasant	208	34	11	19	3	1	1
Texting on the job is-very harmful/very beneficial	232	29	8	6	1	0	1
Texting on the job is-very bad/very good	241	19	6	6	4	1	0
My supervisor thinks I SHOULD or SHOULD NOT text while driving on the job	3	2	4	10	3	11	244
How important is your supervisor's opinion about texting while driving on the job?	39	13	5	49	13	28	130

I believe that I can avoid texting while driving on the job for the next 3 months	5	3	3	9	7	19	231
If it were entirely up to me, I would not text while driving on the job for the next 3 months	236	5	7	7	6	3	7
How easy or hard is it for you to not text while driving on the job?	9	5	9	16	11	24	203
I intend to avoid texting while driving on the job in the next 3 months	9	2	5	9	8	25	219

Table 5 shows the distribution for all the answers to the TPB questions for reading the dispatch device while driving on the job. 153 subjects completed this section.

Table 5.

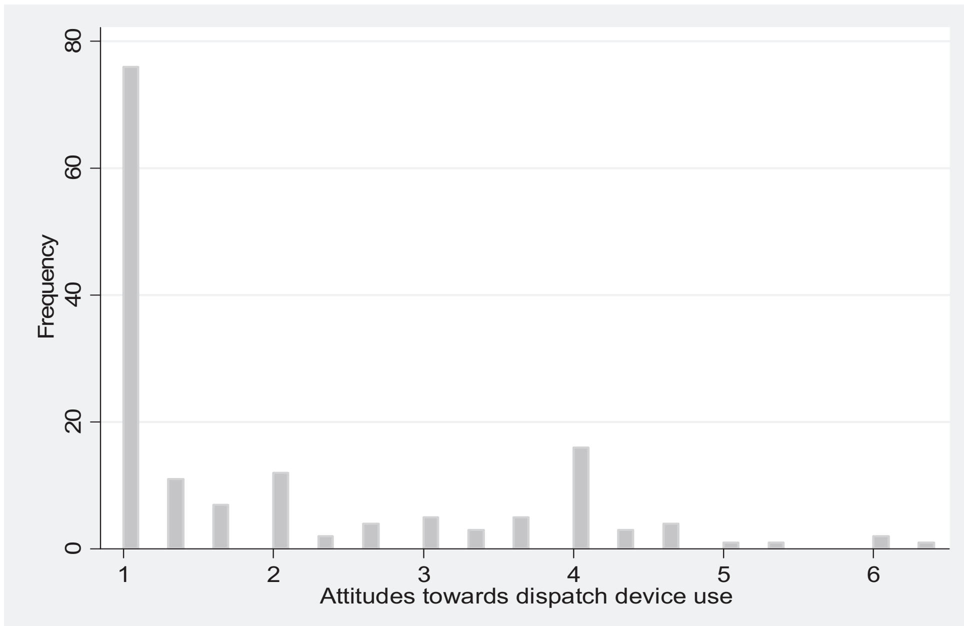
	Response on Likert scale						
	1	2	3	4	5	6	7
Reading the dispatch device on the job is- very unpleasant/very pleasant	82	19	8	32	4	5	3
Reading the dispatch device on the job is- very harmful/very beneficial	101	12	6	17	9	4	4
Reading the dispatch device on the job is- very bad/very good	100	20	8	16	5	4	0
My supervisor thinks I SHOULD or SHOULD NOT read the dispatch device while driving on the job	12	6	15	21	3	5	91
How important is your supervisor's opinion about reading the dispatch device while driving on the job?	27	6	4	30	12	13	61
I believe that I can avoid reading the dispatch device while driving on the job for the next 3 months	27	11	7	9	6	10	83
If it were entirely up to me, I would not read the dispatch device while driving on the job	104	13	3	11	10	1	11

for the next 3 months							
How easy or hard is it for you to not read the dispatch device while driving on the job?	32	11	10	17	5	8	70
I intend to avoid reading the dispatch device while driving on the job in the next 3 months	26	8	5	16	10	11	77

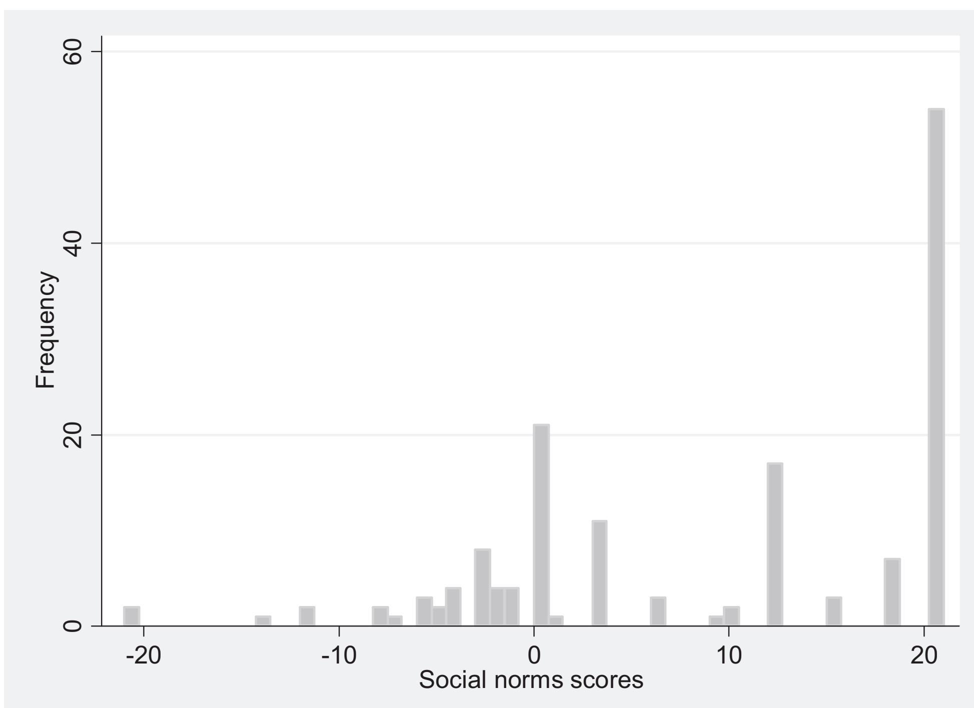
Appendix 6. Additional quantitative results from Manuscript 3.

Distribution of scores for the dispatch device use TPB constructs in Manuscript 3. Histograms generated using Stata v12.1.

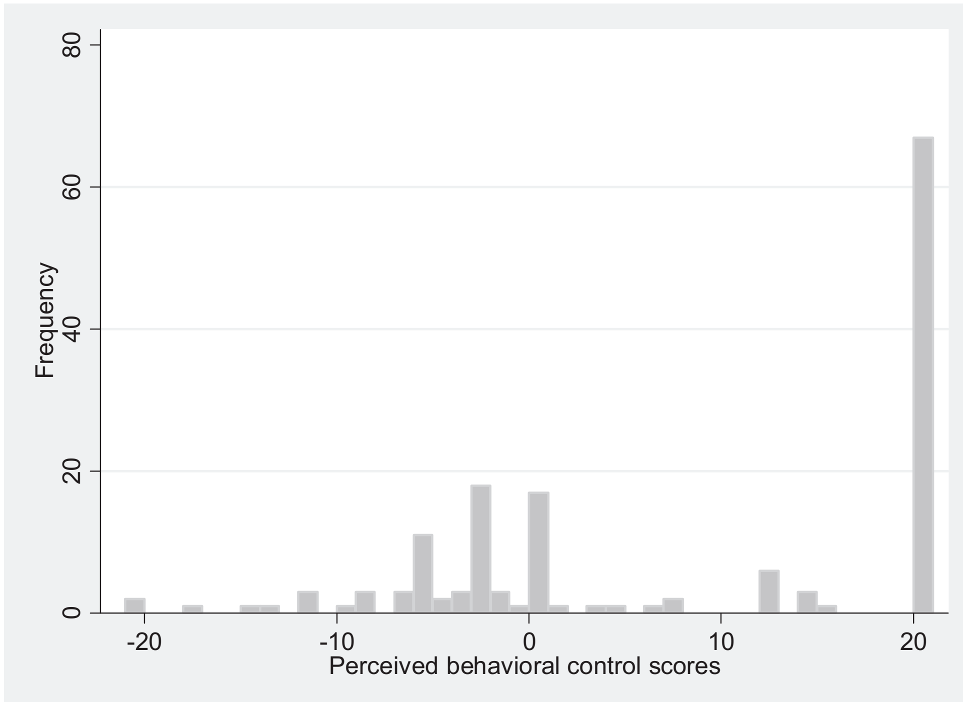
Attitudes



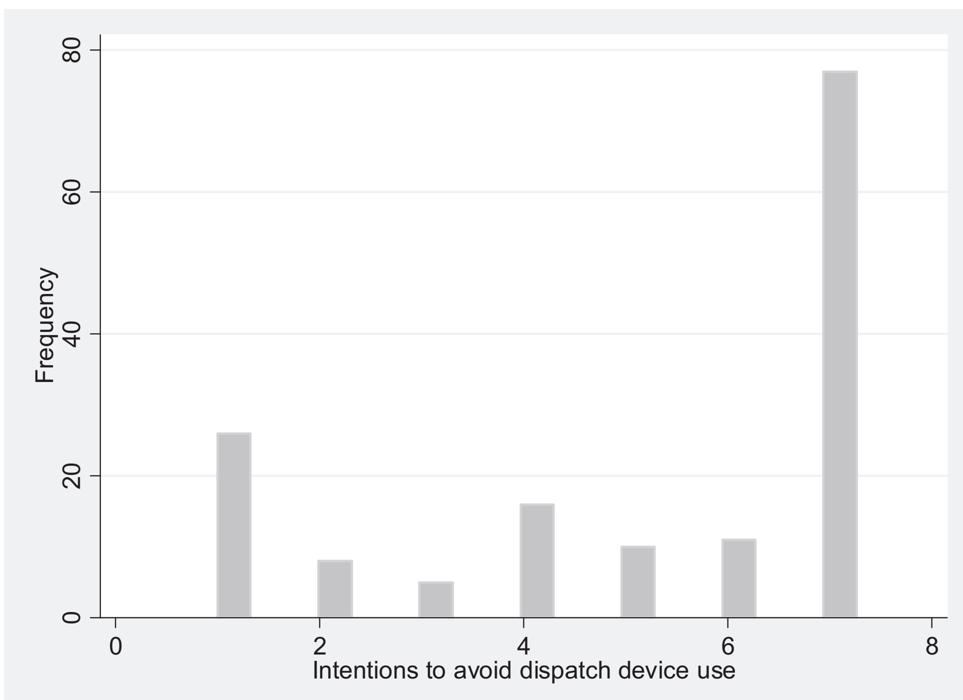
Social Norms



Perceived Behavioral Control



Intentions



Univariate regression results.

Univariate regression of demographic factors and the TPB components on crash or near crash for texting while driving or reading the dispatch device. Odds ratios (ORs) are expressed with subjects who never experienced a given event as the baseline. Bold ORs are significant at p≤0.10 and were entered into multivariate regression.

Texting while driving (n=277)	Ever experience a crash on the job		Ever experience a distraction-related crash on the job		Ever undertake hard braking while distracted on the job		Ever had to swerve while distracted on the job	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender*	**0.10**	**0.01-0.76**	2.38	0.57-9.87	0.93	0.24-3.55	2.67	0.65-10.92
Age	1.02	0.99-1.04	**1.06**	**1.02-1.10**	0.99	0.96-1.02	1.02	0.99-1.05
Driving experience	**1.02**	**1.00-1.05**	**1.05**	**1.01-1.08**	1.00	0.98-1.02	1.01	0.99-1.04
Weekly driving	1.00	0.98-1.02	1.02	0.99-1.05	**0.98**	**0.96-1.00**	1.00	0.98-1.02
Texting Attitudes	1.02	0.60-1.76	0.55	0.25-1.20	1.26	0.75-2.16	1.46	0.86-2.49
Texting Norms	**1.59**	**0.98-2.57**	1.22	0.66-2.28	1.37	0.85-2.21	**1.88**	**1.16-3.05**
Texting PBC	1.36	0.81-2.30	0.61	0.30-1.27	**2.32**	**1.37-3.92**	**2.03**	**1.20-3.41**
Texting Intentions	1.11	0.62-1.99	0.82	0.37-1.81	**2.71**	**1.48-4.97**	**2.81**	**1.54-5.13**

*Odds ratios for Gender are odds for women divided by odds for men.

Univariate regression of demographic factors and the TPB components on crash or near crash for dispatch device use while driving or reading the dispatch device. Odds ratios (ORs) are expressed with subjects who never experienced a given event as the baseline. The values for categorical Norms and Attitudes variables are listed for each level. Bold ORs are significant at p≤0.10 and were entered into multivariate regression.

Reading the dispatch device (n=153)		Ever experience a crash on the job		Ever experience a distraction-related crash on the job		Ever undertake hard braking while distracted on the job		Ever had to swerve while distracted on the job	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender*		--†		1.43	0.15-13.41	0.24	0.03-2.17	1.92	0.31-11.80
Age		1.03	0.98-1.06	1.02	0.97-1.08	1.00	0.96-1.04	1.02	0.99-1.06
Driving experience		**1.04**	**1.00-1.07**	**1.03**	**0.98-1.09**	1.01	0.98-1.05	1.02	0.99-1.06
Weekly driving		1.00	0.98-1.03	1.06	1.00-1.12	1.00	0.97-1.03	1.01	0.98-1.04
Attitudes	Very negative attitudes			Reference		Reference		Reference	
	Negative attitudes	1.26	0.59-2.65	**3.56**	**1.31-9.71**	**2.42**	**1.16-5.05**	**2.10**	**1.01-4.37**
	Neutral and positive attitudes	0.69	0.29-1.65	1.18	0.28-4.93	**2.37**	**0.98-5.75**	1.49	0.62-3.57
Norms	Supervisors strongly oppose use and strong motivation to comply	Reference		Reference		Reference		Reference	
	Supervisors opposed and strong motivation to comply	0.93	0.42-2.06	2.62	0.62-11.12	1.49	0.67-3.33	**2.52**	**1.07-5.95**
	Neutral motivation to comply regardless of supervisor's opinion	0.82	0.30-2.25	**10.46**	**2.43-45.05**	**3.40**	**1.18-9.84**	**5.13**	**1.74-15.09**
	No motivation to comply regardless of supervisor's opinion	1.90	0.74-4.86	3.78	0.88-16.30	**3.40**	**1.37-8.45**	**6.30**	**2.43-16.40**
PBC		1.13	0.59-2.17	**3.22**	**1.24-8.35**	**3.21**	**1.65-6.25**	**2.34**	**1.22-4.50**
Intentions		1.28	0.65-2.52	**2.21**	**0.90-5.41**	**2.63**	**1.33-5.23**	**1.89**	**0.97-3.70**

* Odds ratios for Gender are odds for women divided by odds for men.
†Regression for Gender on crashes was un able to produce significant results.

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Curriculum Vitae
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Education

2006	Master of Public Health, General Epidemiology University of Michigan Ann Arbor, Michigan
2004	Bachelor of Science, Liberal Arts and Sciences Concentration in Microbiology University of Illinois, Urbana-Champaign Urbana, Illinois

Professional Certification

2011	Certificate in Injury Control Center for Injury Research and Policy Bloomberg School of Public Health Johns Hopkins University Baltimore, MD

Post-graduate Education

Fellowships

2009 – 2013	National Institute of Occupational Safety and Health Occupational Injury Epidemiology and Prevention fellowship Johns Hopkins School of Public Health Baltimore, MD 21205

Internships

2007 – 2009	Oak Ridge Institute for Science and Education Epidemiology Intern at US Army Center for Health Promotion and Preventive Medicine (now US Army Institute of Public Health) Directorate of Epidemiology and Disease Surveillance Aberdeen Proving Ground, MD 21010

2005 Cook County Department of Public Health
Infection Control Intern
Communicable Disease Department
Oak Park, IL 60301

Academic Positions

2012 – 2013 Department of Biostatistics
Teaching Assistant
-*Statistical Methods in Public Health I*
-*Statistical Methods in Public Health II*
-*Statistical Methods in Public Health III*
Bloomberg School of Public Health

2011– 2013 Department of Health Policy and Management
Teaching Assistant
-*Graduate Seminar in Injury Research*
Bloomberg School of Public Health

2010 Department of Health Policy and Management
Teaching Assistant
-*Politics, Policy and Transportation Safety*
Bloomberg School of Public Health

2005 Program in Biology
Graduate Student Instructor
-*AIDS and Other Health Crises*
University of Michigan

Research Positions

2010 – 2012 Center for Injury Research and Policy
Research Assistant
Bloomberg School of Public Health
Johns Hopkins University
Baltimore, MD 21205

2010 – 2012 Mine Safety and Health Administration
Research Assistant
Department of Labor
Arlington, VA 22209

2003 – 2004 Spatial Epidemiology Laboratory
Undergraduate Research Assistant
School of Veterinary Medicine
University of Illinois
Urbana, IL 61820

Professional Leadership Positions

2010 – 2011	Co-Chair, Student Coordinating Committee Department of Health Policy and Management Bloomberg School of Public Health Johns Hopkins University Baltimore, MD
2005	Co-Chair, Public Health Student Association School of Public Health University of Michigan Ann Arbor, MI

Professional and Academic Societies

2012 – present	Association for the Advancement for Automotive Medicine Student Member
2012 – present	Society for Advancement of Violence and Injury Research
2011 – present	Mixed Methods Interest Group Bloomberg School of Public Health
2011 – 2012	American Public Health Association Student Member
2010 – 2012	Student Coordinating Committee Department of Health Policy and Management Bloomberg School of Public Health
2004 – 2006	Public Health Student Association School of Public Health University of Michigan
2002 – 2003	Microbiology Club University of Illinois, Urbana-Champaign

Professional and Academic Awards

2006	Outstanding Contributors Award Military Physical Training Footwear Study USACHPPM Aberdeen Proving Ground, MD
2004	Graduation with distinction, with concentration in Microbiology University of Illinois, Urbana-Champaign Urbana, IL
2001	Dean’s List, College of Liberal Arts and Sciences University of Illinois, Urbana-Champaign

Urbana, IL

Professional/Continuing Education

2009	Human Research Curriculum Collaborative Institutional Training Initiative University of Miami Miami, FL
2007 – 2009	HIPAA- Security 101: Introduction to HIPAA Security Military Health Sciences (online)
2007	Introduction to GIS using Arcview® 9.2 Geographic Information Systems Branch, DCSIM Aberdeen Proving Ground, MD

Security Clearance

Secret level government security clearance granted through USACHPPM (now USAIPH), October 29, 2008.

Manuscript Peer Reviewer

2012	*International Journal of Sports Medicine*, Thieme
2011	*Public Health*, Elsevier
2011	*American Journal of Industrial Medicine*, Wiley
2011	*Journal of Orthopeadic Research*, Wiley

Research Grants

Analysis of Felonious Homicide of Law Enforcement Officers,
ERC Pilot Project Training Award ; Environmental Research Center for Occupational Safety and Health, Department of Environmental Health Sciences, Bloomberg School of Public Health, Johns Hopkins University- $7,500.00.
2011– 2012

A Mixed Methods Examination of Distracted Driving in Commercial Truck Drivers
ERC Pilot Project Training Award; Environmental Research Center for Occupational Safety and Health, Department of Environmental Health Sciences, Bloomberg School of Public Health, Johns Hopkins University- $4,000.00.
2012 – 2013

Peer Reviewed Publications

1) **Swedler DI**, Kercher C, Simmons MM, Pollack KM. Occupational homicide of law enforcement officers in the U.S., 1996 – 2010. Inj Prev, *ePub*, 2013.

2) Kercher C, **Swedler DI**, Pollack KM, Webster DW. Homicides of law enforcement officers responding to domestic disturbance calls. Inj Prev, *ePub*, 2013.

3) Tiesman HM, **Swedler DI**, Srinivas K, Pollack KM. Fatal occupational injuries among U.S. law enforcement officers: A comparison of national surveillance systems. Am J Ind Med, 56(6): 693-700, 2013.

4) **Swedler DI**, Bowman SM, Baker SP. Gender and age differences among teen drivers in fatal crashes. Ann Adv Automot Med, 56, 97-108, 2012.

5) Galvangno S, Thomas S, Baker S, **Swedler D**, Stephens C, Floccare D, Provonost P, Haut E. Helicopter emergency medical services for adults with major trauma. Cochrane Review (protocol stage) Published Online: August, 2011.

6) Knapik JJ, Grier T, Spiess A, **Swedler DI**, Hauret KG, Graham B, Yoder J, Jones BH. Injury Rates and Injury Risk Factors Among Federal Bureau of Investigation New Agent Trainees. Biomed Centr Public Health, 11:920-935, 2011.

7) **Swedler DI**, Knapik JJ, Williams KW, Grier TL, Jones BH. Risk factors for medical discharge from US Army basic combat training. Milit Med, 176(10): 1104-1110, 2011.

8) Knapik JJ, Spiess A, **Swedler DI**, Grier T, Hauret KG, Yoder J, Jones BH. Retrospective examination of injuries and physical fitness during Federal Bureau of Investigation New Agent Training. J Occup Med Toxicol, 6(1): 26, 2011.

9) Grier T, Knapik JJ, **Swedler DI**, Jones BH. Footwear in the United States Army Band: Injury incidence and risk factors associated with foot pain. Foot (Edinb), 21(2): 60-65, 2011.

10) Knapik JJ, Trone DW, **Swedler DI**, Villasenor A, Brockelman T, Schmied E, Bullock SH, Han P, Jones BH. Injury reduction effectiveness of assigning running shoes based on plantar shape in Marine Corps basic training. Am J Sports Med, 38(9): 1759-1767, 2011.

11) **Swedler DI**, Knapik JJ, Grier TL, Jones BH. Validity of plantar surface visual assessment as an estimate of foot arch height. Med Sci Sport Exerc, 42(2): 375-380, 2010.

12) Knapik JJ, Spiess A, **Swedler DI**, Grier T, Darakjy SS, Jones BH. Systematic review of the parachute ankle brace: injury reduction and cost-effectiveness. Am J Prev Med, 38(s1): s182-s188, 2010.

13) Knapik JJ, Brosch LC, Venuto M, **Swedler DI**, Bullock SH, Gaines LS, Murphy RJ, Tchandja J, Jones BH. Effect on Injuries of Assigning Shoes Based on Foot Shape in Air Force Basic Training. Am J Prev Med, 38(s1): s197-s211, 2010.

14) Knapik JJ, **Swedler DI**, Grier TL, Hauret KG, Bullock SH, Williams KW, Darakjy SS, Lester ME, Tobler SK, Jones BH. Injury reduction effectiveness of

selecting running shoes based on plantar shape. J Strength Conditioning Res, 23(3):685-697, 2009.

15) Knapik JJ, Spiess A, **Swedler D**, Grier T, Darakjy S, Amoroso P, Jones BH. Injury Risk Factors in Parachuting and Acceptability of the Parachute Ankle Brace. Aviat Space Environ Med, 79 (7): 689-694, 2008.

16) Knapik JJ, Darakjy S, **Swedler D**, Manning F, Hauret KG, Amoroso P, Jones BH. Parachute Ankle Brace and Extrinsic Injury Risk Factors during Parachuting. Aviat Space Environ Med, 79 (4): 408-415, 2008.

Technical/Government Reports

1) Grier T, Knapik JJ, **Swedler D**, Jones BH. Influence of a Viseolastic Insole on Foot, Knee and Back Pain among Members of the United States Army Band. US Army Public Health Command, Aberdeen Proving Ground, MD; Technical Report No. 12-HF-97G010-09, 2010.

2) Knapik JJ, Grier T, Spiess A, **Swedler DI**, Hauret KG, Graham B, Jones BH. Prospective Investigation of Injury Rates and Injury Risk Factors among Federal Bureau of Investigation New Agent Trainees, Quantico, Virginia, 2009-2010. US Army Public Health Command (Prov), Aberdeen Proving Ground, MD; Technical Report 12-HF-97HRF1A-10, 2010.

3) Knapik JJ, Spiess A, **Swedler D**, Grier T, Hauret KG, Yoder J, Jones BH. Retrospective Investigation of Injury Rates and Physical Fitness among Federal Bureau of Investigation New Agent Trainees, Quantico Virginia, 1999-2008. US Army Public Health Command (Prov), Aberdeen Proving Ground, MD; Technical Report No. 12-HF-97HRF1-09, 2010.

4) Grier T, Knapik JJ, **Swedler D**, Spiess A, Jones BH. Injury prevention effectiveness of modifications of shoe type on injuries and risk factors associated with pain and discomfort in the US Army Band 2007-2008. U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD; USACHPPM Report No. 12-HF-05WC-07, 2009.

5) Knapik JJ, Trone DW, **Swedler DI**, Bockelman T, Villasenor A, Schmied E, Bullock S, Han P, Jones BH. Injury reduction effectiveness of assigning running shoes based on plantar shape in Marine Corps Basic Training, San Diego, CA, and Parris Island, SC March-October 2007. U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground MD; USACHPPM Report No. 12-HF-05SBA-07C, 2009.

6) Knapik JJ, Spiess A, Grier TL, Lester ME, Sharp MA, Tobler SK, **Swedler DI**, Jones BH. Injuries and Physical Fitness Before and After Deployments of the 10th Mountain Division to Afghanistan and the 1st Cavalry Division to Iraq, September 2005 – October 2008. US Army Center for Health Promotion and Preventive

Medicine, Aberdeen Proving Ground, MD; USACHPPM Report No. 12-HF-05SR-05, 2009.

7) Knapik JJ, Brosch LC, Venuto M, **Swedler D**, Bullock SH, Gaines L, Murphy R, Canada S, Hoedebecke E, Tobler S, Tchandja J, Jones BH. Injury Reduction Effectiveness of Prescribing Running Shoes Based on Foot Shape in Air Force Basic Military Training. US Army Center for Health Promotion and Preventative Medicine, Aberdeen Proving Ground, MD; USACHPPM Report No. 12-MA-05SBA-08A, 2008.

8) Knapik JJ, **Swedler D**, Grier T, Hauret KG, Bullock SH, Williams K, Darakjy S, Lester M, Tobler S, Clemmons N, Jones BH. Injury Reduction Effectiveness of Prescribing Running Shoes Based on Foot Shape in Basic Combat Training. US Army Center for Health Promotion and Preventative Medicine, APG, MD; USACHPPM Report No. 12-MA-05SB-08, 2008.

9) Knapik J, Spiess A, Darakjy S, Grier T, Manning F, Livingston E, **Swedler D**, Amoroso P, Jones BH. A Survey of Parachute Ankle Brace Breakages. US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD. USACHPPM Report No. 12-MA01Q2A-08. 2008.

10) Knapik JJ, Darakjy S, **Swedler D**, Manning F, Hauret KG, Amoroso P, Jones BH. The Parachute Ankle Brace: Entanglements and Injuries after Controlling for Extrinsic Risk Factors. U.S. Army Center for Health Promotion and Preventative Medicine, Aberdeen Proving Ground, MD; USACHPPM Report No. 12-MA01Q2-07, 2007.

11) Knapik JJ, Spiess A, Darakjy S, Grier T, Manning F, Livingston E, **Swedler D**, Amoroso P, Jones BH. Risk Factors for Parachute Injuries and Airborne Student Operations on the parachute Ankle Brace. U.S. Army Center for Health Promotion and Preventative Medicine, Aberdeen Proving Ground, MD; USACHPPM Report No. 12-MA-01Q2-08B, 2007.

12) Cook County Department of Public Health. West Nile Virus Prevention and Response Plan. Ed, **Swedler, D**, 3rd Edition, 2005.

Conference Presentations

1) Roberts ET, DuGoff EH, Canudas-Romo V, Heins S, **Swedler D**, Feldman D, Wegner S, Castillo RC. Clinical practice guidelines and claims data: "Making the best of bad data." June 25, 2013. Academy Health, Annual Research Meeting, Balimore, MD

2) **Swedler DI**, Bowman SM, Baker SP. Gender and age differences among teen drivers in fatal crashes. October 15, 2012. Association for the Advancement of Automotive Medicine, 56th Annual Conference, Seattle, WA.

3) Weeks J, **Swedler D**, Pollack KM, Agnew J. Risk factors for fatalities in small underground coal mines in the U.S. October 3, 2012. Safety 2012 (World Injury Conference), Wellington, New Zeleand.

4) **Swedler DI**, Simmons MM, Kercher C, Pollack KM. Occupational homicide of law enforcement officers in the United States, 1996-2009. November 2, 2011. American Public Health Association, Washington, DC.

5) Knapik JJ, Spiess A, **Swedler D**, Grier T, Hauret K, Yoder J, Jones BH. Association between injuries and physical fitness among Federal Bureau of Investigation New Agent Trainees. June 3, 2011. American College of Sports Medicine, Denver, CO.

6) Grier T, **Swedler D**, Jones BH. Effect of Body Mass Index and Aerobic Fitness on Injury Risks in U.S. Army Trainees. June 1, 2011. American College of Sports Medicine, Denver, CO (poster).

7) Grier T, Knapik JJ, **Swedler D**, Jones BH. Association of fitness and injuries in military basic training. June 3, 2010. American College of Sports Medicine, Baltimore, MD (poster).

8) **Swedler DI**, Knapik JJ. Historical analysis of injury risk factors in U.S. Army basic combat training. August 20, 2009. Force Health Protection Conference, Albuquerque, NM.

9) **Swedler DI**, Knapik JJ, FASCM, Grier TL, Lester M, Williams KW, Bullock SH, Jones BH, FASCM. Longitudinal Foot Arch and Risk of Injury in US Army Basic Combat Training. May 30, 2009. American College of Sports Medicine, Seattle, WA (poster).

10) Knapik JJ, FASCM, **Swedler DI**, Grier TL, Bullock SH, Williams KW, Darakjy S, Lester ME, Jones BH, FASCM. Injury Reduction Effectiveness of Selecting Running Shoes Based on Plantar Shape. May 28, 2009. American College of Sports Medicine, Seattle, WA.

11) **Swedler DI**, Knapik JJ, Williams K, Bullock SH, Darakjy S, Grier T, Jones BH. Risk Factors Associated with Medical Discharges from United States Army Basic Combat Training. Force Health Protection Conference. August 15, 2008. Albuquerque, NM.

12) Grier T, Knapik JJ, **Swedler D**, Hauret KG, Williams K, Bullock SH, Darakjy S, Lester M, Clemmons N, Jones BH. Effects of Age and Smoking Prior to Basic Combat Training (BCT) on Initial Fitness Levels on Entry to BCT. August 14, 2008. Force Health Protection Conference. Albuquerque, NM .

13) Knapik JJ, **Swedler DI**, Grier T, Hauret KG, Williams K, Bullock SH, Darakjy S, Lester M, Clemmons N, Brown J, Jones BH. Injury Risk in Basic Combat Training Following Prescription of Athletic Shoes On the Basis of Plantar Foot Surface Shape. Force Health Protection Conference. August 13, 2008. Albuquerque, NM (poster).

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Guest Lectures

1) Mixed Methods Interest Group. "A Mixed Methods Examination of Distracted Driving in Commercial Truck Drivers." **Dave Swedler**, MPH. Johns Hopkins Bloomberg School of Public Health. Baltimore, MD, April 11, 2013.

2) Public Health Grand Rounds. "Multi-tasking Behind the Wheel: New Hazards and Public Health Solutions." **David I. Swedler**, MPH, Meg Gobrecht Miller. Mid-Atlantic Public Health Training Center. Baltimore, MD, March 20, 2013.

3) Graduate Seminar in Injury Research and Policy. "Fatalities in Crashes Involving Distracted Driving in Truck Drivers in the United States, 2000 – 2010." **Dave Swedler**, MPH. Johns Hopkins Bloomberg School of Public Health, February 11, 2013.

4) Graduate Seminar in Injury Research and Policy. "Hot Topics in Doctoral Research." Michael Kim, MPH and **David Swedler**, MPH. Johns Hopkins Bloomberg School of Public Health, February 21, 2012.

Popular/Magazine Articles

1) Hauret K and **Swedler D**. All Gain, No Pain. *Knowledge*. v3: 8-9, April 2009.

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1) "Try to prevent the worst from happening." **David Swedler**. *Daily Herald*. January 10, 2010.

Media

1) "Most police murders involve guns, study finds." NBC News (online) May 30, 2013

MPH Capstone Thesis
Analysis of the 2005 West Nile virus outbreak in suburban Cook County, IL. University of Michigan, School of Public Health, Department of Epidemiology, Ann Arbor, MI. April 2006.

Senior Thesis
Relation of the vector of Lyme disease, *Ixodes scapularis*, and the reservoir of Lyme disease, *Peromyscus leucopus*, to the presence of *Borrelia burgdorferi*. University of Illinois at Urbana-Champaign, College of Life Sciences, Urbana, IL. May 2004.

Preliminary Oral Examination
Completed February 23, 2012
Faculty Committee: Andrea Gielen (Chair), Karen Bandeen-Roche, Jacqueline Agnew, Stephen Bowman, Keshia M. Pollack (Mentor)