Distraction in Commercial Trucks and Buses: Assessing Prevalence and Risk in Conjunction with Crashes and Near-Crashes

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

September 2010

FOREWORD

The purpose of the research presented herein was to analyze naturalistic data collected over a 1-year period. Commercial trucks (3-axle and tractor trailer/tanker) and buses (transit and motor coaches) were the target vehicles in the analyses. These data are intended to provide the Federal Motor Carrier Safety Administration with descriptive data on the adverse consequences of cellular telephone use and other electronic device distractions while driving a commercial motor vehicle. The results of these analyses also provide information on the scope of cellular telephone use and other distractions during safety-critical events (i.e., crashes, near-crashes, and crash-relevant conflicts) in two data sets over a 1-year period.

NOTICE

Technical Report Documentation Page—Form DOT F 1700.7 (8-72)

1. Report No. **FMCSA-RRR-10-049**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **DISTRACTION IN COMMERCIAL TRUCKS AND BUSES: ASSESSING PREVALENCE AND RISK IN CONJUNCTION WITH CRASHES AND NEAR-CRASHES**		5. Report Date **September 2010** 6. Performing Organization Code
7. Author(s) **Jeffrey S. Hickman, Richard J. Hanowski, and Joseph Bocanegra**		8. Performing Organization Report No.
9. Performing Organization Name and Address **Virginia Tech Transportation Institute Center for Truck and Bus Safety 3500 Transportation Research Plaza Blacksburg, VA 24061**		10. Work Unit No. (TRAIS) 11. Contract or Grant No. **DTMC75-09-J-00045**
12. Sponsoring Agency Name and Address **U.S. Department of Transportation Federal Motor Carrier Safety Administration Office of Analysis, Research and Technology 1200 New Jersey Ave., SE Washington, DC 20590**		13. Type of Report and Period Covered **Final Report September 2009–April 2010** 14. Sponsoring Agency Code **FMCSA**

15. Supplementary Notes

This project was funded by the Federal Motor Carrier Safety Administration. The Contracting Officer's Technical Representative was Martin Walker, PhD. The Task Order Manager was Albert Alvarez.

16. Abstract

This research analyzed naturalistic data on commercial trucks (3-axle and tractor trailer/tanker) and buses (transit and motor coaches) over a 1-year period using two data sets: data set A from 207 truck and bus fleets comprising 13,431 vehicles included 1,336 crashes, 15,864 near-crashes, and 173,591 crash-relevant conflicts; and data set B from 183 commercial truck and bus fleets comprising 13,306 vehicles included 1,085 crashes, 8,375 near-crashes, 30,661 crash-relevant conflicts, and 211,171 baseline events (i.e., triggered non-safety critical events). Study results document the prevalence of cellular telephone distractions and the risk associated with performing related tasks while driving. Findings include the odds of involvement in a safety-critical event differed as a function of performing different cell phone-related sub-tasks while driving. More specifically, talking/listening on a cell phone while driving was generally found not to impact significantly the odds of involvement in a safety-critical event (and was even found to decrease the odds significantly in some cases), while other cell phone sub-tasks (e.g., texting, dialing, reaching) were found to increase significantly the odds of involvement in a safety-critical event. Analyses examine the likelihood of commercial drivers to use their cell phone under a fleet cell phone policy and State cell phone law.

17. Key Words **buses, cell phone, cell phone policy, commercial motor vehicle, CMV, crash avoidance, distraction, driver behavior, naturalistic, odds ratio, population attributable risk, trucks**		18. Distribution Statement **No restrictions**	
19. Security Classif. (of this report) **Unclassified**	20. Security Classif. (of this page) **Unclassified**	21. No. of Pages **79**	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized.

SI* (MODERN METRIC) FACTORS CONVERSION

Table of APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	Inches	25.4	millimeters	mm
ft	Feet	0.305	meters	m
yd	Yards	0.914	meters	m
mi	Miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME	Note: Volumes greater than 1000 L shall be shown in m^3	
fl oz	fluid ounces	29.57	milliliters	mL
gal	Gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	Ounces	28.35	grams	g
lb	Pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		TEMPERATURE	Temperature is in exact degrees	
°F	Fahrenheit	5 × (F-32) ÷ 9 or (F-32) ÷ 1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	Poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Table of APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	Millimeters	0.039	inches	in
m	Meters	3.28	feet	ft
m	Meters	1.09	yards	yd
km	Kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	Hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	Liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	Grams	0.035	ounces	oz
kg	Kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2000 lb)	T
		TEMPERATURE	Temperature is in exact degrees	
°C	Celsius	1.8C + 32	Fahrenheit	°F
		ILLUMINATION		
lx	Lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force & Pressure or Stress		
N	Newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009)

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LIST OF ACRONYMS

Acronym	**Definition**
CMV	commercial motor vehicle
DRA	driver risk analyst
FMCSA	Federal Motor Carrier Safety Administration
g	gravity force
GPS	Global Positioning System
IRB	Institutional Review Board
LTCCS	Large Truck Crash Causation Study
LCL	lower confidence limit
NHTSA	National Highway Traffic Safety Administration
NSC	National Safety Council
OBSM	onboard safety monitoring
SMB	small to medium business
UCL	upper confidence limit

EXECUTIVE SUMMARY

Research on distracted driving has increased over the past several years, due, in part, to the increasing number of reported crashes involving cellular telephone (cell phone) use while driving, recent literature reviews that highlighted some key findings (e.g., Kircher, 2007; National Safety Council [NSC], 2010; Regan, Lee, & Young, 2009), and a study that described the magnitude of the problem in light (passenger) vehicles (Klauer et al., 2006). Although this research has shown the adverse safety implications of distracted driving, including cell phone use while driving, it has not focused on commercial motor vehicle (CMV) drivers, per se. As such, there is a knowledge gap regarding the operation of trucks (three-axle or more trucks and tractor trailers/tankers) and buses (including transit and motor coaches, but referred to as "buses" hereafter) in regards to distracted driving and, more specifically, cell phone use and texting while driving. Please note these vehicle types were supplied by the technology vendor, DriveCam, and may or may not conform to Federal definitions for these vehicles types.

SUMMARY OF RESEARCH PROJECT

The aim of this project was to use an existing data set to document the prevalence of distractions while driving a commercial motor vehicle (i.e., truck or bus). New in-vehicle technologies provide objective measures of driver behavior. These technologies collect data continuously on a wide variety of driving behaviors previously unavailable to fleet safety managers. Some of these systems use in-vehicle video technology to record driver behavior. Fleet safety managers may use these video recordings to provide feedback to their drivers on safe and at-risk driving behaviors. As such, existing naturalistic data sets can provide a wealth of data, including driver behavior during crashes, near-crashes, and crash-relevant conflicts, involving thousands of CMVs. DriveCam is a vendor of onboard safety monitoring (OBSM) systems for CMV fleets aimed at reducing risky driving behaviors using in-vehicle video technology. Video and kinematic data snippets, recorded with a kinematic trigger (e.g., hard brake at a pre-set threshold), archived by this vendor were made available for analysis in this study. Note that the authors of this study did not receive any video recordings from the vendor, but rather kinematic data and driver behavior data that did not identify the driver.

The data set did not include continuous data; it only included recorded events that met or exceeded a pre-set kinematic threshold (e.g., greater than or equal to $|0.5\ g|$). These recorded events included safety-critical events (e.g., hard braking in response to another vehicle) and non-safety triggered events (e.g., vehicle traveled over train tracks, which exceeded the kinematic threshold). One of the advantages of continuous data collection is that randomly selected baseline epochs (or control periods of uneventful driving) can be parsed from the continuous data set and be used to assess the risk involved in performing certain behaviors while driving (this approach was used by Olson, Hanowski, Hickman, & Bocanegra, 2009, and Klauer et al., 2006). While the non-safety triggered events (hereafter referred to as baseline events) collected by the technology vendor were not randomly selected, they may be used to evaluate the risk in performing various tertiary tasks while driving. There is bias associated with using these non-safety triggered events (i.e., baseline events), as described in more detail below; however, Dingus et al. (2005) found that randomly selected baselines in the 100-Car Study had a similar kinematic profile as crash-relevant conflicts (the lowest severity safety-critical event). Note that these baseline events were only available in one set of data, as the vendor did not begin to record distractions in these baseline events until later in the collection (data set B).

SUMMARY OF THE DATA SETS

The technology vendor sent to the authors two data sets collected over a consecutive 1-year period, identified as data set A collected during the first 273 days (September 6, 2008 to June 5, 2009), and data set B collected during the last 92 days (June 6, 2009–September 5, 2009). Data set A was derived from 207 different truck and bus fleets comprising a total of 13,431 vehicles deployed by small to medium business (SMB) (32.2 percent), transit (30.4 percent), distribution (25.0 percent), energy (8.5 percent), municipalities (1.5 percent), waste (1.2 percent), utilities/telecommunication (0.9 percent), and construction (0.3 percent) fleets. A total of 1,336 crashes, 15,864 near-crashes, and 173,591 crash-relevant conflicts were captured in data set A. Section 1 includes a detailed description of the two data sets.

Data set B included safety-critical events and baseline events from 183 different truck and bus fleets comprising a total of 13,306 trucks and buses deployed by distribution (33.7 percent), small to medium businesses (SMB; 31.3 percent), transit (27.5 percent), energy (3.7 percent), municipalities (2.0 percent), waste (1 percent), utilities/telecommunication (0.5 percent), and construction (0.3 percent) fleets. Note that the vendor released very limited demographic information to protect the fleets' anonymity. A total of 1,085 crashes, 8,375 near-crashes, 30,661 crash-relevant conflicts, and 211,171 baseline events were captured in data set B. Note that the vendor considers its operational definitions of crashes, near-crashes, and crash-relevant conflicts to be proprietary information. However, Olson et al. (2009) define crashes as any contact with an object, either moving or fixed, at any speed in which kinetic energy was measurably transferred or dissipated; near crashes are defined as any circumstance requiring a rapid, evasive maneuver by the subject vehicle, any other vehicle, pedestrian, cyclist, or animal, to avoid a crash, and crash-relevant conflicts are defined as any circumstance that required a crash avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, cyclist, or animal that was less severe than a rapid evasive maneuver (as defined above), but greater in severity than a "normal maneuver" to avoid a crash.

RESULTS

More detailed results, including additional analyses, are presented in section 3.

Descriptive Analyses

The analyses report the frequency and percentage of tertiary tasks in commercial trucks and buses in each data set. Ablassmeier, Poitschke, Wallhoff, Bengler, and Rigoll (2007) categorized driving tasks as primary, secondary, and tertiary. Primary tasks are those tasks necessary to operate the vehicle (e.g., looking at the forward roadway, steering, etc.), while secondary tasks are related to the driving task, but are not necessary to operate the vehicle (e.g., use turn signals, check speedometer, check mirrors, etc.). Tertiary tasks are not related to driving (e.g., eating, cell phone use, etc.). These descriptive analyses show the proportion of specific tertiary tasks performed by drivers, as well as the prevalence of tertiary tasks across safety-critical events and baseline events. Table 1 shows the frequency and percentage of tertiary tasks across each severity level in data set A. Note that safety-critical events were defined as crashes, near-crashes, and crash-relevant events. However, the vendor did not perform video reduction on the 1,336 crashes in data set A; thus, crashes are not shown in data set A tables. Also note that baseline events are not included in data set A as the vendor did not begin coding tertiary tasks in the baseline events until June 2009. More than one tertiary task could be coded during a safety-critical event in data set A; thus, the column totals in data set A data tables exceed 100 percent.

Tertiary Tasks in Data Set A

As shown in Table 1 most of the safety-critical events did not involve a tertiary task (92.4 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (2.8 percent) and cell phone usage (3.9 percent).

Table 1. Frequency and percentage of tertiary tasks across each severity level in data set A.

Tertiary Tasks	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Total Number (and percent) of Safety-Critical Events (near crashes + crash-relevant conflicts)
Cell Phone Usage	246 (1.55%)	7,278 (4.19%)	7,524 (3.97%)
Consuming Food/Drink	43 (0.27%)	1,367 (0.79%)	1,410 (0.74%)
Other Distraction	723 (4.56%)	4,635 (2.67%)	5,358 (2.83%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	41 (0.26%)	104 (0.06%)	145 (0.08%)
None	14,817 (93.40%)	160,236 (92.31%)	175,053 (92.40%)

Tertiary Tasks in Data Set B

Table 2 shows the frequency and percentage of tertiary tasks across each severity level in data set B. More than one tertiary task could be coded during a baseline or safety-critical event in data set B; thus, the column totals in data set B tables may exceed 100 percent. As shown in Table 2, most of the baseline events and safety-critical events did not involve a tertiary task (97.4 percent and 94.0 percent, respectively). However, of the tertiary tasks recorded during crashes in data set B, all were coded with a cell phone sub-task. More specifically, the crashes involved the driver using a cell phone to text/e-mail/access the Internet while driving (1.02 percent), followed by talking/listening on a hand-held cell phone (0.46 percent), reaching for a cell phone (0.28 percent), and dialing a cell phone (0.18 percent). The most prevalent tertiary tasks during baseline events were talking/listening on a hand-held cell phone (1.1 percent), talking/listening on a hands-free cell phone (0.8 percent), and consuming food/drink (0.6 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (3.0 percent), talking/listening on a hand-held cell phone (1.0 percent), consuming food/drink (0.7 percent), and talking/listening on a hands-free cell phone (0.5 percent).

Table 2. Frequency and percentage of tertiary tasks across each severity level in data set B.

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	256 (0.12%)	2 (0.18%)	3 (0.04%)	160 (0.52%)	165 (0.41%)
Consuming Food/Drink	1,320 (0.63%)	0 (0.00%)	8 (0.10%)	260 (0.85%)	268 (0.67%)
Other Distraction	13 (0.01%)	0 (0.00%)	32 (0.38%)	1,188 (3.87%)	1,220 (3.04%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	30 (0.10%)	30 (0.07%)
Reaching for Headset/Earpiece	168 (0.08%)	0 (0.00%)	0 (0.00%)	104 (0.34%)	104 (0.26%)
Reaching for Cell Phone	178 (0.08%)	3 (0.28%)	3 (0.04%)	116 (0.38%)	122 (0.30%)
Talking/Listening on Hand-Held Cell Phone	2,266 (1.07%)	5 (0.46%)	8 (0.10%)	359 (1.17%)	372 (0.93%)
Talking/Listening on Hands-Free Cell Phone	1,626 (0.77%)	0 (0.00%)	8 (0.10%)	186 (0.61%)	194 (0.48%)
Texting/E-mailing/Accessing the Internet on Phone	3 (0.00%)	11 (1.02%)	2 (0.02%)	77 (0.25%)	90 (0.22%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	205,582 (97.35%)	1,064 (98.06%)	8,314 (99.27%)	28,330 (92.40%)	37,708 (93.99%)

Odds Ratios for Tertiary Tasks

Table 3 shows the odds ratios for each tertiary task in data set B for all safety-critical events. Odds ratios greater than 1.0 where the range from the lower confidence limits (LCL) to the upper confidence limits (UCL) does not include 1.0 indicate the task significantly increases the odds of involvement in a safety-critical event. Conversely, odds ratios less than 1.0 where the range from the LCL to the UCL does not include 1.0 indicate that the task significantly decreases the odds of involvement in a safety-critical event.

Note that odds ratios were only calculated on tertiary tasks in data set B as baseline events were not available in data set A. As shown in Table 3, many of the tertiary tasks in data set B had a significant odds ratio. The odds ratios for other distraction and texting/e-mailing/accessing the Internet were very high. An odds ratio is a measure of association (not unlike a correlation), which can be used under the correct circumstances as an estimate of the rate ratio (Guo & Hankey, 2009). In this situation, the odds ratios for other distraction and texting/e-mailing/accessing the Internet indicate a strong relationship between these tertiary tasks and safety-critical events. As shown by the 95 percent confidence interval for these tertiary tasks, the error associated with these odds ratio estimates was extremely high; thus, it is difficult to report the odds ratio in any meaningful sense other than to report there was a very strong relationship between other distraction and texting/e-mailing/accessing the Internet and involvement in a safety-critical event.

Table 3. Odds ratios for each tertiary task in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage	1.14*	1.06	1.23	895	4,262
Dialing Cell Phone	3.51*	2.89	4.27	165	256
Talking/Listening Hands Free Cell Phone	0.65*	0.56	0.76	194	1,626
Talking/Listening Hand Held Cell Phone	0.89	0.80	1.00	372	2,266
Reaching for Headset/Earpiece	3.38*	2.64	4.31	104	168
Reaching for Cell Phone	3.74*	2.97	4.71	122	178
Texting/E-mailing/ Accessing the Internet	163.59*	51.77	516.73	90	3
Consuming Food/Drink	1.11	0.97	1.26	268	1,320
Other Distraction	511.64*	296.20	883.79	1,220	13
Passenger Distraction	–	–	–	30	0

Note: Asterisk indicates a significant odds ratio.

Odds Ratios for Fleet Cell Phone Policy and State Cell Phone Law

Odds ratios were calculated to approximate the effectiveness of a fleet cell phone policy or a State cell phone law prohibiting cell phone use while driving. These odds ratio did not look at safety-critical events, but rather evaluated the odds of cell phone usage given a fleet cell phone policy or State cell phone law versus the odds of cell phone usage given no fleet cell phone policy or State cell phone law. Table 4 shows the odds ratios for cell phone use while driving in each cell phone policy variable in the entire 365 days (i.e., data set A + data set B) for all safety-critical events and baseline events. As noted, crashes in data set A were not included in this analysis as the vendor did not re-review these crashes.

As shown in Table 4, for truck and bus drivers the odds of using a cell phone while driving under a fleet cell phone policy were .83 times less, compared to no fleet cell phone policy. However, the State cell phone law did not significantly impact drivers' likelihood in using their cell phone while driving compared to a State that did not have a law prohibiting cell phone use (odds ratio = 0.97).

Table 4. Odds ratios for cell phone use while driving in each cell phone policy variable in the 365 day data set (safety-critical events).

Cell Phone Policy	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Cell Phone Use with Policy/Law	Frequency of No Cell Phone Use with Policy/Law
Fleet Cell Phone Policy	0.83*	0.78	0.87	8,787	1,897
State Cell Phone Law	0.97	0.94	1.01	4,526	2,987

Note: Asterisk indicates a significant odds ratio.

DISCUSSION

Naturalistic driving studies record drivers (through video and kinematic sensors) in actual driving situations in order to study driver behavior in driving conditions in the presence of real-world daily pressures. Naturalistic driving studies are difficult to conduct and only a few have analyzed driver distraction (Klauer et al., 2006; Olson et al., 2009; Sayer, Devonshire, & Flanagan, 2007). The results of this study are consistent with these other naturalistic studies.

Several interesting findings invite further discussion. The results in this study were similar to the results found by Olson et al. (2009) regarding safety-critical event risk and performing a tertiary task while driving. Table 5 compares the odds ratios for selected tertiary tasks in this study and those found in Olson et al. Both studies found that talking/listening on a cell phone (hands-free or hand-held) did not increase the odds of involvement in a safety-critical event. More specifically, both found that talking/listening on a hands-free phone significantly decreased the odds of involvement in a safety-critical event (0.65 and 0.44, respectively) and talking/listening on a hand-held phone had no impact on the odds of involvement in a safety-critical event (0.90 and 1.04, respectively). As shown in Table 5, this study also found that reaching for a headset/earpiece or a cell phone significantly increased the odds of involvement in a safety-critical event by 3.4 and 3.7 times, respectively. While Olson et al. did not classify these specific reaching tasks, the authors found that reaching for other electronic devices (which included headsets/earpieces) significantly increased the odds of involvement in a safety-critical event by 6.7 times. The tertiary task, consuming food/drink, was also found to have no impact on the odds of involvement in a safety-critical event in this study and Olson et al.

Table 5. Odds ratios comparison for selected tertiary tasks and Olson et al. (2009).

Tertiary Task	Odds Ratios Across all Vehicles in this Study	Odds Ratios in Olson et al. (2009)
Dialing Cell Phone	3.5*	5.93*
Talking/Listening Hands-Free Cell Phone	0.65*	0.44*
Talking/Listening Hand-Held Cell Phone	0.90	1.04
Reaching for Headset/Earpiece	3.4*	6.72*
Reaching for Cell Phone	3.7*	Included in dialing a cell phone
Texting/E-mailing/Accessing the Internet	163.6*	23.24*
Consuming Food/Drink	1.1	1.01

Note: Asterisk indicates significant odds ratios.

The results clearly indicate that using a cell phone to text, e-mail, or access the Internet while driving is in a category of risk all by itself. Although the odds ratio for this tertiary task was very large in both this study and in Olson et al. (2009), it was also associated with a large amount or error (as shown by the 95 percent confidence interval). Very few instances of this behavior were observed during safety-critical events in this study and Olson et al. (90 and 23, respectively) and even fewer during control events (3 and 3, respectively). An odds ratio is a measure of association (not unlike a correlation) which can be used under the correct circumstances as an estimate of relative risk. In this situation, the odds ratio for texting/e-mailing/accessing the Internet indicates a strong relationship between this tertiary task and involvement in a safety-critical event. It is difficult to report the odds ratio in any meaningful sense other than to report there is a very strong relationship between texting/e-mailing/accessing the Internet while driving and involvement in a safety-critical event. The data suggests that truck and bus drivers who use their cell phone to text, e-mail, or access the Internet *are very likely* be involved in a safety-critical event.

The significant decrease in the odds of involvement in a safety-critical event and/or non-significant results regarding the odds of talking/listening on a cell phone while driving have sparked controversy in the academic community and other traffic safety organizations. There is an extensive amount of published simulator and closed test track studies that have shown performance decrements while talking/listening on a cell phone (both hand-held and hands-free) (see National Safety Council, NCS, 2010 for a review) and many of safety organizations have advocated bans on cell phone use of any kind while driving. Simulator and closed test track studies have shown decrements in driver's reaction time, lane keeping, and scanning ability; however, the question is not whether these performance decrements take place while talking/listening on a cell phone while driving, but do these performance decrements increase crash risk in the real world? When considering cell phone use as a dichotomous variable (yes/no), this study found that cell phone use increased risk by 1.14 (a statistically significant finding). At first glance, this finding seemingly supports the simulator results. However, once the layers are peeled back and specific cell phone sub-tasks are individually considered, the study shows that the risk is not with the conversation (talking/listening sub-task), but the sub-tasks that require the driver to take his/her eyes off the road.

It should not come as a surprise that commercial truck and bus drivers were far less likely to use their cell phone while driving under a fleet cell phone policy as the OBSM system allowed these fleets to monitor their drivers. This makes intuitive sense as the OBSM system afforded safety managers and direct supervisors an opportunity to monitor drivers and implement consequences that would directly impact the driver (e.g., punishment for policy violation).

Some have argued that naturalistic studies are inconclusive as their data sets have relatively few crashes (as crashes are a rare event in the real-world) and risk is calculated using non-crash events (such as near-crashes and safety-critical events) (NSC, 2010). A key feature of this study was that the data set included more than 1,000 crashes; it is noteworthy that these results are consistent with previous naturalistic driving studies that contained far fewer crashes.

Possible Limitations

There are six possible caveats or limitations in interpreting the results of this study. First, the data set involved an active safety intervention; thus, the data sets may be skewed from normative driving data as the safety managers have attempted to directly alter these behaviors. This translates into the results being, potentially, a “best case” scenario. Second, the fact that the truck and bus fleets in this data set purchased an OBSM system reflects a group of safety conscious truck and bus fleets; thus, the prevalence of tertiary tasks may, in fact, be more pronounced in the larger population. Third, the lack of continuous data collection or randomly collected video segments means there were no “true” baseline or control data. Baseline events were used in this study as a proxy measure of control data; however, the similarity in the odds ratios with Olson et al. (2009), which did used true baseline events, suggests this likely had little or no influence on the findings. Fourth, data set B was collected during a time frame when intense media attention focused on the dangers of distracted driving. This intense media attention regarding distracted driving may have influenced safety managers and/or drivers behavior. However, again, this would translate into potentially less risky behavior being recorded in this study which would imply higher tertiary task involvement in the larger population. Fifth, driver exposure was not controlled in this study; thus, extremely unsafe drivers may have contributed far more safety-critical events than baseline events. However, as this study included at least 13,000 drivers (from over 13,000 trucks and buses), the affect of any outliers was minimized. Lastly, the length of the video window during safety-critical events and baseline epochs was longer than in other naturalistic studies (8 seconds before the trigger and 4 seconds after the trigger). It is possible that some tertiary tasks coded as an associative factor during the safety-critical events had no influence on safety-critical event occurrence (if the truck or bus driver engaged in the tertiary task at the very beginning of the video window). However, and as noted previously, the similarity of the odds ratios with the Olson et al. study that used a 6-second window suggests this likely had minimal influence on the results.

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1. BACKGROUND AND SIGNIFICANCE

1.1 INTRODUCTION

The most recent statistics show that the number of crashes and fatalities on our nation's roadways involving large trucks is decreasing. In 2006, there were 42,642 traffic fatalities and 2,575,000 injuries in the United States. Of these, 4,995 were fatal crashes and 106,000 were injury-only crashes resultant from large-truck collisions. These data show a reduction in large truck fatal crashes (4,229) and injury-only crashes (90,000) involving large-truck crashes in 2008 (National Highway Traffic Safety Administration [NHTSA], 2009). These reductions are, in part, due to the success of the Federal Motor Carrier Safety Administration's (FMCSA) mission to reduce the frequency and severity of crashes on our nation's highways. Although these reductions in fatal and injury crashes are encouraging, more work is needed to further reduce large-truck traffic crashes and their associated injuries and fatalities.

Research on distracted driving has increased over the past several years, due, in part, to the increasing number of reported crashes involving cell phone use while driving, and recent literature reviews that have highlighted some of the key findings (e.g., Kircher, 2007; National Safety Council [NSC], 2010; Regan, Lee, & Young, 2009) and a key naturalistic study that described the magnitude of the problem in light (passenger) vehicles (Klauer et al., 2006). Although this research has shown the adverse safety implications of distracted driving, including cell phone use while driving, few of these studies have focused on commercial motor vehicle (CMV) drivers, per se. As such, there is a gap in our knowledge that focuses on truck and bus (including transit and motor coaches, but referred to as "bus" hereafter) drivers in regards to distracted driving and, more specifically, cell phone use and texting while driving.

In 2008 there were numerous high profile media reports of truck and bus crashes involving CMV drivers being distracted by cell phones and texting. For example, on December 11, 2008 it was reported in Commerce City, Colorado that a truck hauling radioactive material rolled over on the interstate; "The state patrol said that the truck driver was distracted by his cell phone when the crash happened" (Web site: http://cbs4denver.com/local/semi.crash.radioactive.2.884299.html). Similarly, it was also reported that a high profile crash in Ocala, Florida in September 2008 occurred when a tractor-trailer driver, using his cell phone, crashed into the rear of a school bus and killed a middle school student (http://www.ocala.com/article/20080928/NEWS/809280295/1402/NEWS?Title=Bus_crash_renews_debate_on_drivers_using_cell_phones). There have also been recently reported crashes involving cell phones and bus drivers, including school bus drivers.

Distracted driving in trucks and buses has become a significant safety issue, in part, because of these high profile crashes and a recently published report, based on an FMCSA-funded study, on the dangers of driving a truck while distracted (Olson, Hanowski, Hickman, & Bocanegra, 2009). These recent media reports and published research findings on the prevalence and dangers of distracted driving resulted in U.S. Transportation Secretary Ray LaHood announcing a summit to address the dangers of text-messaging and other driver distractions behind the wheel. On September 30, 2009 and October 1, 2009, senior transportation officials, elected officials, safety advocates, law enforcement representatives, and academics convened in Washington, D.C. to discuss ideas about how to combat distracted driving.

These high profile truck and bus crashes (and other similar crashes) and numerous research studies have illustrated the dangers of cell phone use while driving (e.g., Beede & Kass, 2006; Klauer et al., 2006; Olson et al., 2009; Patten et al., 2004; Strayer, Drews, & Johnson, 2003) have led many States to prohibit cell phone use while driving. As of April 2010, six States had prohibited hand-held cell phone use while driving: California, Connecticut, New Jersey, New York, Oregon, and Washington (note that Washington, D.C. and the U.S. Virgin Islands also prohibit drivers from using a hand-held cell phone while driving). All these hand-held cell phone laws are primary enforcement (i.e., a police officer may cite a driver for using a hand-held cell phone without other traffic offenses taking place). While no State completely bans all types of cell phone use (i.e., hand-held, hands-free, text messaging), some States prohibit cell phone use by certain drivers, such as novice drivers (24 States and Washington, D.C.) and school bus drivers when passengers are present (17 States and Washington, D.C.). As this report was drafted, 23 States, Washington, D.C., and Guam ban text messaging while driving for all drivers, 9 States prohibit text messaging for novice drivers, and 1 State restricts text messaging for school bus drivers (Governors Highway Safety Association, 2010).

Given the high-profile nature of this topic, many States and Federal agencies are deliberating modifications to existing cell phone laws and/or creating new laws. Readers are encouraged to visit www.distraction.gov for up-to-date information on legislative action regarding this issue and information on distracted driving.

While the original intent of this project was to assess the prevalence of cell phone use in commercial trucks and buses, as indicated in the original title *Cell Phone Distraction in Commercial Trucks and Buses: Assessing Prevalence in Conjunction with Crashes and Near-Crashes*, feedback from FMCSA personnel during the project's kickoff meeting revised the scope of this project to include as many driver distractions as possible. Thus, the study was not limited to cell phone use while driving and includes other distractions drivers engage in while driving (e.g., food/drink, passenger, other electronic device).

1.1.1 Defining Driver Distraction

There are several "types" of driver distraction. Driver distraction can be grouped into one of four separate categories: visual, auditory, biomechanical, and cognitive (Ranney et al., 2000). However, the literature is inconsistent in the operational definition of "driver distraction." Smiley (2005, p. 1) defined it as "misallocated attention," while Ranney et al. (2000, p. 1) indicated that "driver distraction may be characterized as any activity that takes a driver's attention away from the task of driving." Pettitt, Burnett, and Stevens (2005) indicated that a more comprehensive definition of distraction included four components:

- Impact—when a driver is delayed in the recognition of information necessary to safely maintain the lateral and longitudinal control of the vehicle.
- Agent—due to some event, activity, object or person, within or outside the vehicle.

- Mechanism—that compels or tends to induce the driver's shifting attention away from fundamental driving tasks.
- Type—by compromising the driver's auditory, biomechanical, cognitive or visual faculties, or combinations thereof (Pettitt, Burnett, & Stevens, 2005; p. 11).

Hanowski, Perez, and Dingus (2005) used the concepts in Pettitt, Burnett, and Stevens (2005) to develop a definition of distracted driving that could be implemented in the analysis of naturalistic driving data. More specifically, the inattentive behaviors observed in naturalistic driving reflect the Agents and underlying Mechanisms that can distract and lead to a safety-critical event (or Impact). This was the definition followed by Olson et al. (2009) and will be used to define driver distraction in this study

1.1.2 Prior Distraction Studies Involving Trucks and Buses

There is a paucity of published research on the actual risk of distracted driving in commercial trucks and buses. There are only two published studies in this area and both of these studies were conducted with commercial trucks. For example, the Large Truck Crash Causation Study (LTCCS), while not directly a study on distracted driving, assessed the causal factors as well as associated factors in fatal crashes involving large trucks (FMCSA, 2005). Considered the most comprehensive safety database for crashes involving large trucks, the LTCCS collected data on truck crashes at 24 sites across 17 States from 2001 through 2003. Investigators traveled to crash sites to collect crash scene data, conducted thorough interviews with drivers about their conditions before the crash, and inspected the trucks.

The results from the LTCCS indicated that 9 percent of the fatal truck crashes studied were attributed to driver inattention, 8 percent were attributed to an external distraction (i.e., the driver was looking at something outside of his/her truck), and 2 percent were attributed to an internal distraction. It is important to note that these driver errors were determined to be the causal factor in the crash (i.e., had they been absent, the crash could have been avoided), but if these driver errors had also been considered as an associated factor, they would likely result in higher percentages.

Olson et al. (2009) authored a report of driver distraction in CMV operations using data from two large-scale CMV naturalistic truck driving studies (Hanowski et al., 2008; Blanco et al., in press). These data sets represented 203 CMV drivers in seven trucking fleets across 16 fleet locations. In terms of data, the data set used included approximately 3 million miles of continuously collected kinematic and video data, and represents the most comprehensive naturalistic CMV driving set in the world.

The Olson et al. (2009) data set included 4,452 safety-critical events: 21 crashes, 197 near-crashes, 3,019 crash-relevant conflicts, and 1,215 unintentional lane deviations, in addition to 19,888 baseline epochs (non-events). Table 6 displays the percentage of *any* tertiary tasks that were present in all safety-critical events and all safety-critical events where the Vehicle 1 driver (i.e., the participant driver) was judged to be at fault in the safety-critical event. As can be seen in Table 6, tertiary tasks were present in 46.2 percent to 77.5 percent of the safety-critical events (much higher than found in the LTCCS). Note that Ablassmeier et al. (2007) categorized driving tasks as primary, secondary, and tertiary. Primary tasks are those tasks necessary to operate the vehicle (e.g., looking at the forward roadway, steering, etc.), while secondary tasks are related to the driving task, but are not necessary to operate the vehicle (e.g., turn-signal use, check speedometer, etc.). Tertiary tasks are extraneous tasks that are not related to driving (e.g., eating, cell phone use, etc.).

Table 6. Frequency and percentage of any tertiary task in "all" and "vehicle 1 at-fault" events.

Event Type	All Safety-Critical Events	Frequency (and Percent) of All Safety Critical Events	All Vehicle 1 At-Fault Events	Frequency (and Percent) of All Vehicle 1 At-Fault Events
All safety-critical events	59.9%	n = 4,452 (100.0%)	63.9%	n = 3,618 (100.0%)
Crashes	71.4%	n = 21 (0.5%)	40.0%	n = 10 (0.3%)
Near-crashes	46.2%	n = 197 (4.4%)	50.0%	n = 112 (3.1%)
Crash-relevant conflicts	53.6%	n = 3,019 (67.8%)	57.4%	n = 2,281 (63.0%)
Unintentional lane deviations	77.5%	n = 1,215 (27.3%)	77.5%	n = 1,215 (33.6%)
Baseline epochs	56.5%	n = 19,888 (100.0%)	56.5%	n = 19,888 (100.0%)

Note: Adapted from Olson et al. (2009)

In a more detailed examination of the data, odds ratio analyses were calculated by Olson et al. (2009) to identify high-risk tertiary tasks. That is, tertiary tasks that were associated with an increased likelihood of involvement in a safety-critical event compared to non-event, baseline driving. Table 7 shows the results from the analyses that included all safety-critical events. Odds ratios, along with the lower confidence limits (LCL) and upper confidence limits (UCL) are shown in Table 7. Odds ratios greater than 1.0 that have LCL and UCL ranges that do not include "1.0" indicate the task significantly increases the odds of involvement in a safety-critical event. Conversely, odds ratios less than 1.0 that have LCL and UCL ranges that do not include "1.0" indicate that the task significantly decreases the odds of involvement in a safety-critical event. As shown in Table 7, many of the observed tertiary tasks had high odds ratios (e.g., text message on cell phone, interact with/look at dispatching device, write on pad, notebook, etc., use calculator, look at map, dial cell phone, and use/reach for other electronic device). The odds ratios in Table 7 that are marked with an asterisk were significant and did not have a 95 percent confidence interval that contained 1.0.

Table 7. Odds ratios and 95 percent confidence intervals to assess likelihood of a safety-critical event while engaging in tertiary tasks.

Task	Odds Ratio	LCL	UCL
Text message on cell phone	23.24*	9.69	55.73
Other—Complex Tertiary Task (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
Use/reach for other electronic device (e.g., video camera, 2-way radio)	6.72*	2.74	16.44
Dial cell phone	5.93*	4.57	7.69
Other—Moderate Tertiary Task (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
Read book, newspaper, paperwork, etc.	3.97*	3.02	5.22
Put on/remove/adjust sunglasses or reading glasses	3.63*	2.37	5.58
Reach for object in vehicle	3.09*	2.75	3.48
Look back in sleeper berth	2.30*	1.30	4.07
Adjust instrument panel	1.25*	1.06	1.47
Talk or listen to hand-held phone	1.04	0.89	1.22
Eat	1.01	0.83	1.21
Remove/adjust jewelry	1.68	0.44	6.32
Other—Simple Tertiary Task (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
Interact with or look at other occupant(s)	0.35*	0.22	0.55
Talk or listen to hands-free phone	0.44*	0.35	0.55
Bite nails/cuticles	0.45*	0.28	0.73
Look at outside vehicle, animal, person, object, or undetermined	0.54*	0.50	0.60
Talk or listen to CB radio	0.55*	0.41	0.75
Smoking-related behavior—reaching, lighting, extinguishing	0.60*	0.40	0.89
Other personal hygiene	0.67*	0.59	0.75

Note: Adapted from Olson et al., (2009). Asterisk indicates a significant odds ratio.

Olson et al. (2009) also conducted an eye glance analysis to determine, during a 6-second (s) interval (5 s before the event onset and 1 s after), the drivers' mean duration of eyes off forward roadway (i.e., any time the driver's eyes were not on the forward roadway, either from a single glance or multiple glances). CMV drivers' mean duration of eyes off forward roadway was 2.1 s prior to the onset of a crash, 1.7 s prior to the onset of a near-crash, 1.6 s prior to the onset of a crash-relevant conflict, and 1.2 s during the baseline epoch. Table 8 illustrates the odds ratios across all safety-critical events in five different time bins. Not surprisingly, longer glances of more than 1.5 s were associated with a significant increase in the odds of involvement in a safety-critical event (odds ratio = 1.3) and very long glances of more than 2 s had the highest odds of involvement in a safety-critical event (odds ratio = 2.9).

Table 8. Odds Ratios and 95 percent confidence intervals for all events to assess likelihood of a safety-critical event while eyes off forward roadway.

Total Eyes Off Forward Roadway	Odds Ratio	LCL	UCL
Less than or equal to 0.5 s	1.36*	1.16	1.58
Greater than 0.5 s but less than or equal to 1.0 s	0.91	0.80	1.03
Greater than 1.0 s but less than or equal to 1.5 s	1.07	0.94	1.23
Greater than 1.5 s but less than or equal to 2.0 s	1.29*	1.12	1.49
Greater than 2.0 s	2.93*	2.65	3.23

Note: Adapted from Olson et al. (2009). Asterisk indicates a significant odds ratio.

The Olson et al. (2009) study was the first naturalistic study to assess the odds associated with distracted driving in CMV operations. As such, the results have high ecological validity given the data collected in the study came from heavy trucks operating on our nation's roadways as they made their revenue-producing deliveries. However, the results run counter to results published from other researchers using driving simulators that suggest talking and listening on a cell phone is dangerous (Beede & Kass, 2006; Patten et al., 2004; Strayer, Drews, & Johnston, 2003). As shown above in Table 7, the results in the Olson et al. study suggest that talking and listening on a cell phone while driving does not increase risk, and may even provide a safety benefit.

It is important to keep in mind that a driving simulator is not *actual* driving. Therefore, degradations in driving performance shown in simulators may not necessarily translate into actual crashes or near-crashes in the real world. Therefore, the risk posed by driver distractions must be assessed using real-world data. As naturalistic driving studies are still in their infancy, more data sets are needed verify the results found in Olson et al. (2009)

1.1.3 Research Project Summary

The aim of this project was to document the prevalence of distractions while driving a commercial truck or bus using an existing naturalistic data set. New in-vehicle technologies are available that provide objective measures of driver behavior under naturalistic driving conditions. These devices are able to provide continuous measures on a wide variety of driving behaviors previously unavailable to fleet safety managers. Some of these systems use in-vehicle video technology to record driver behavior. The video recordings obtained from these devices may be used by fleet safety managers to provide drivers with feedback on their safe and at-risk driving behaviors. As such, these existing naturalistic data sets can provide a wealth of naturalistic data, including driver behavior during crashes, near-crashes, and crash-relevant conflicts, involving thousands of commercial vehicles (including trucks and buses). DriveCam is a vendor of onboard safety monitoring (OBSM) systems for professional fleets aimed at reducing risky driving behaviors using in-vehicle video technology. Video and kinematic data snippets, recorded with a kinematic trigger (e.g., hard brake at a pre-set threshold), archived by the vendor were made available for analysis in this study. Note that the study authors did not receive any video data from the technology vendor, but rather anonymous, de-identified categorical data formulated from the reduction of videos by the vendor's staff.

The data sets in the study did not include continuous data; they only included recorded events that met or exceeded a kinematic threshold. These recorded events included safety-critical events (e.g., hard braking in response to another vehicle) and non-safety triggered events (e.g., vehicle traveled over train tracks or a pothole and this exceeded the kinematic threshold, driver braked in response to no apparent traffic safety situation, etc.). One of the advantages of continuous data collection is that randomly selected baseline events (or control events) can be parsed from the continuous data set and be used to assess the risk involved in performing certain behaviors while driving (this was the approach used by Olson et al., 2009 and Klauer et al., 2006). While the non-safety triggered events (hereafter referred to as baseline events) collected by the vendor were triggered and not randomly selected events, these baseline events can be used to evaluate the risk in performing various tertiary tasks while driving (section 4 includes a description of the limitations in using such an approach). There is bias associated with using these non-safety triggered events (i.e., baseline events), as described in more detail in section 4; however, Dingus et al. (2005) found that randomly selected baseline events in the 100-Car Study had a similar kinematic profile as crash-relevant conflicts (the lowest severity safety-critical event). Note that these baseline events were only available in data set B as the vendor did not begin to record distractions in these baseline events until June 2009.

1.1.3.1 Analysis Overview

Commercial trucks (3-axle and tractor trailer/tanker) and buses (transit and motor coach) were the target vehicles in the analyses. Please note these vehicle types were supplied by the technology vendor, and may or may not conform to Federal definitions for these vehicles types. Note that safety-critical events included crashes, near-crashes, and crash-relevant conflicts that had been recorded by the system. The primary distraction analyses involved two data sets collected over a consecutive 1-year period: all safety-critical events in the first 273 days (September 6, 2008 to June 5, 2009; hereafter referred to as data set A), and all safety-critical events and baseline events in the last 92 days (i.e., June 6, 2009 to September 5, 2009; hereafter referred to as data set B). In data set B, the technology vendor re-reviewed all safety-critical events and baseline events where cell phone was noted as a distraction to determine the frequency of the following cell-phone sub-tasks: dialing cell phone, reaching for cell phone, reaching for headset/earpiece, talking/listening on hands-free cell phone, talking/listening on hand-held cell phone, and texting/e-mailing/accessing the Internet on cell phone. Note that the vendor's normal data reduction only records cell phone use and does not classify the individual cell phone sub-tasks noted above. The vendor also re-reviewed all crashes in data set B and documented all the distractions that occurred during these crashes. Note that the vendor does not normally perform data reduction on crashes. Data set A was identical to data set B; however, the separate cell phone sub-tasks were not classified and data reduction was not conducted on crashes in data set A. Therefore, data set B was more detailed and broken out further than data set A.

The frequency and percentage of distractions during safety-critical events and baseline events were documented in both data sets. The results of these analyses provide information on the scope of cell phone use, and other distractions, during safety-critical events and baseline epochs within the time periods noted above. This provides the FMCSA with descriptive data on the adverse consequences of cell phone use and other distractions while driving. However, important issues, such as assessing safety risk associated with engaging in distractions while driving, may not be fully understood given the lack of a randomly selected non-event (control) data set. However, the inclusion of baseline events provides information on the direction of these risks (although the actual risk may be greater and/or lesser than indicated). As such, the study can be viewed as using a very large naturalistic data set that will provide important information on the scope of the distracted driving problem in truck and bus operations. Below is a brief overview of the four analyses that were conducted.

- Analysis 1: Descriptive Analyses — the first analysis was a descriptive analysis of the data set. The descriptive analyses reported the frequency and percentage of tertiary tasks across all commercial trucks and buses in each of the two data sets, as well as disaggregated results for each of the three vehicle types (i.e., 3 axle or more trucks, buses, and tractor trailers/tankers) and fleet cell phone policy (i.e., presence and absence). These descriptive analyses showed the proportion of specific tertiary tasks, as well as the prevalence of tertiary tasks across safety-critical events and baseline events.
- Analysis 2: Odds Ratios of Tertiary Tasks — odds ratios were calculated to approximate the rate ratio of safety-critical event risk compared to baseline driving for each tertiary task (using baseline events) in data set B. Analysis 2 reports the odds ratios for each tertiary tasks across all commercial trucks and buses in data set B, as well as disaggregated results for each of the three vehicle types (i.e., 3 axle or more trucks, buses, and tractor trailers/tankers) and fleet cell phone policy (i.e., presence and absence).
- Analysis 3: Population Attributable Risk (PAR) — PAR was calculated on all significant odds ratios greater than 1.0. While odds ratios inform which tasks increase the likelihood of involvement in a safety-critical event, the PAR considers the frequency of occurrence of each task and shows the proportion of safety-critical events that could be avoided by limiting exposure to the risk factor.
- Analysis 4: Odds Ratios of Fleet Cell Phone Policy and State Cell Phone Law — odds ratios were also used to calculate the approximate effectiveness of a fleet cell phone policy and State cell phone law regarding cell phone use while driving. This odds ratio did not look at safety-critical events, but rather evaluated the odds of cell phone usage given a fleet cell phone policy or State cell phone law versus the odds of cell phone usage given no fleet cell phone policy or State cell phone law.

2. METHODS

2.1 CHARACTERIZATION OF THE DATA SET

The data collected in the study was existing data collected by the vendor from September 6, 2008 to September 5, 2009. No new data was collected; however, as indicated above, cell phone safety-critical events and baseline events in data set B (June 6, 2009 to September 5, 2009) were re-reviewed by the technology vendor's personnel to classify discrete cell phone sub-tasks (e.g., dialing a cell phone, talking on a cell phone, reaching for a cell phone, etc.). Crashes in data set B were also re-reviewed by the vendor to classify any and all tertiary tasks during the crash. Below is a description of the procedures for collecting, validating, and reviewing the data. As the study involves the collection of existing data, a brief overview of the data collection process is provided below.

2.1.1 Data Collection Process

The event recorder had two camera views, including:

- Driver face view.
- Forward road-facing view.

Figure 1 and Figure 2 show the event recorder and the two camera views captured by the event recorder, respectively. The event recorder had three accelerometers (y-, x-, and z-axis) that triggered an event to be recorded. If a certain criterion was met or surpassed (e.g., greater than or equal to $|0.5\ g|$) the event recorder saved 12 s of video (i.e., 8 s prior to the criterion being met or surpassed and 4 s after). Note that this criterion was used for all vehicles in the study. Once events had been validated and reduced, the safety-critical events were uploaded to a secure server where fleet safety managers and other fleet personnel with the required access can view them. Fleet personnel used these videos to coach drivers to reduce risky driving behavior and praise appropriate responses to safety situations. Note that a light on the event recorder blinked once an event has been stored; thereby, providing the driver with immediate feedback.

Figure 1. Photo. Event recorder (left) and typical installation of event recorder behind the vehicle's rearview mirror (right).

Figure 2. Photo. Front camera view from the event recorder (left) and driver's face view (right).

Figure 3 shows the basic flow of the review process to gather data in the study. The workflow is numbered with descriptions for each numbered item listed in the workflow. As shown in Figure 3, potential events were captured by the event recorder via a 3-axis accelerometer-based triggering system. More specifically, potential events were captured when the accelerometer threshold was met or exceeded (e.g., hard braking, hard cornering, collision, rough road, etc.). The accelerometers in the event recorders were on 24 hours a day, 7 days a week.

Potential events were typically transmitted at night over a cellular network from the event recorder to the technology vendor. The potential event included the 12-second video/audio for the clip as well as key kinematic data, including: serial number, settings, accelerometer data, Global Positioning System (GPS), speed (calculated via GPS), date/time stamp of recorded events, and event recorder logs. After potential events were transmitted to the technology vendor, a certified Driver Risk Analyst (DRA) reviewed the potential events to determine if the potential event was truly 'risky' and what behaviors contributed to the safety-critical event. DRAs performed event review on safety-critical event video clips and scored these video clips according to operational standards developed by the vendor.

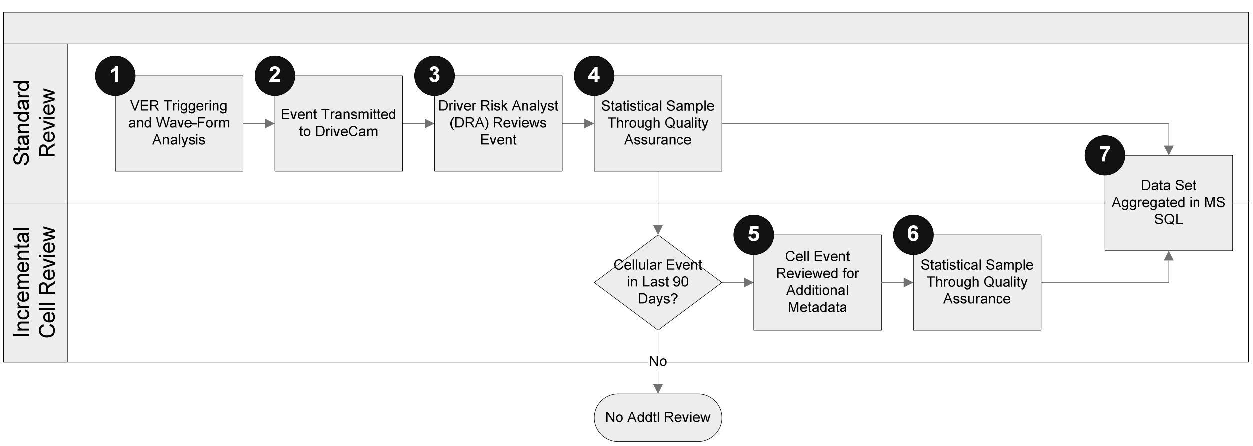


Figure 3. Flowchart. The data capture and review process.

2.1.1.1 DRA Training

DRAs went through a month-long training program prior to reviewing videos unsupervised. The first two weeks of training were instructional and involved the following topics: common safe driving practices/standards according to the Smith System®, safety ride-a-long in an equipped vehicle, utilizing the vendor's behavior definitions, proprietary software/ components, two milestone tests, correctly analyzing videos and writing effective reviewer notes, and the milestone 3 test (DRAs had to score >80 percent to move to the next training module). The following two weeks of on-the-job training include the following: 16 hours working with a mentor, assisting with analysis of various client videos (these events will be randomly selected for quality control), and a final certification test (DRAs must score >90 percent to complete training program).

2.1.1.2 DRA Quality Control

As part of the vendor's standard review process, each DRA went through statistical quality assurance sampling. The vendor had a tool that randomly selected video clips from each DRA to ensure a 97 percent quality rating (based on a 95 percent confidence interval). Quality assurance was completed daily on the safety-critical events reviewed by each DRA. Each day, DRAs received a list of the reviewed safety-critical events with their associated errors and successes. DRAs attended weekly meetings with their manager and quality assurance team to review their overall quality as well as to determine areas where refresher training might be needed. The vendor also tracked the most common mistakes made by all DRAs; this information was used to improve their training guidelines and behavioral definitions. The vendor had a quality rating of 97 percent (<3 percent error rate) against their standards

2.1.1.3 DRA Review

The study included a re-review of all existing safety-critical events and baseline events in data set B that were coded with cell phone in order to classify specific cell phone sub-tasks, including: dialing cell phone, reaching for cell phone, reaching for headset/earpiece, talking/listening on hands-free cell phone, talking/listening on hand-held cell phone, texting/ e-mailing/accessing the Internet on cell phone. Note that all data provided by the vendor was existing data and none of these data were revised except the reclassification of specific cell phone sub-tasks in safety-critical events and baseline events that were already coded with cell phone. The description of the DRA quality control (above) and review (below) illustrates the process in which DRA's reviewed and reduced existing video and kinematic data from commercial trucks and buses.

DRAs were instructed to record or score a tertiary task if the tertiary task contributed to a safety-critical event trigger or significantly increased risk during the safety-critical event. Activities, such as checking a mirror, scanning to the side, or glances in the vehicle (such as looking at the instrument panel) for <1 second were considered normal driving activities and were not considered distractions. DRAs recorded a tertiary task in one of three situations: (a) if the behavior was noticed during the safety-critical event or baseline, (b) if the tertiary task was the cause of the event being triggered (note that if the driver reaction was within 1 second of the risky situation, this was not considered to be the cause of the trigger), and (c) when the duration of the tertiary task exposed the driver to substantially increased risk (i.e., eyes were off the roadway while moving for 2.5 consecutive seconds, >4 seconds in the first or last half of the clip, or a total of 6 seconds or more throughout the 12-second video clip). Table 9 shows the operational definition of each tertiary task scored or recorded by DRAs.

Table 9. Operational definition of each tertiary task coded by DRAs.

Behavior	Description
Cell Phone	Anytime a driver is using a hand-held or hands-free cell phone select this behavior. Under all circumstances, cell phone should be marked as risky when the use of the cell phone and the associated inattention led to an abrupt action. **General guidance if the use of the cell phone is not risky.** **Hand-held:** If driver is holding the cell phone up to the ear **or** he/she is actively using the phone/speaker phone (texting, dialing, obviously in a phone conversation). **Hands-free:** If you can see the driver wearing the device **and** he/she appears to be in a phone conversation. Select Cell Phone Hands-free if you cannot see the device yet the driver is obviously in a phone conversation (clearly responding to a caller). Indications of this can be: the driver has conversational pauses and/or verbal acknowledgements such as uh-huh, hmm, yes, no, etc.
Other Communication Device	If a driver is holding the communication device to listen **or** is actively using it, select this behavior. Examples include Nextel/ chirp devices, CB Radio, 2-way radios/walkie-talkies, etc.
Food and Drink	Anytime a driver is eating/drinking, select this behavior. If you notice that the driver was eating or drinking when the event was triggered, you need to determine whether or not this was a contributing cause and/or unsafe driving behavior.
Electronic Device	An event where the driver was distracted by an electronic device and the associated inattention led to an abrupt action or clearly increased risk. This includes any electronic device other than cell phone, CB radio or walkie-talkie. Examples include: GPS navigation system, laptops.
Passenger	Select this if the driver's visual attention was directed for too long on a passenger rather than on the roadway.
Other Distractions	Select this if some other form of distraction led to a risky event or caused the driver to have his/her eyes off the roadway for a significant amount of time. Some examples may be another vehicle distracts the driver, a pedestrian, changing channels on the radio station, fumbling with a cigarette, etc.

2.1.2 Summary of Data Sets

Two data sets collected over a consecutive 1-year period were provided by the vendor to the authors for this study:

- Data set A (collected during the first 273 days, September 6, 2008–June 5, 2009).
- Data set B (collected during the last 92 days, June 6, 2009– September 5, 2009).

As indicated above, data set A included only safety-critical events, while data set B included safety-critical events and baseline events. Data set B included reclassified cell phone sub-tasks and full reduction on crashes. No new data reduction occurred in this data set (i.e., crashes were not re-reviewed and safety-critical events coded with cell phone were not re-reviewed and classified into specific tasks).

Table 10 shows the distribution of fleets, vehicles, sectors, company cell phone policy, safety-critical events, and baseline events across the three vehicle types (i.e., 3 axle or more truck, bus, tractor trailer/tanker) in data set B. As shown in Table 10, data set B came from 183 different truck and bus fleets comprising 13,306 vehicles. These 13,306 trucks and buses were distributed among distribution (33.7 percent), small to medium businesses (SMB; 31.3 percent), transit (27.5 percent), energy (3.7 percent), municipalities (2.0 percent), waste (1 percent), utilities/telecommunication (0.5 percent), and construction (0.3 percent) fleets. Note that the vendor released very limited demographic information regarding these fleets to protect the fleets' anonymity. A total of 1,085 crashes, 8,375 near-crashes, 30,661 crash-relevant conflicts, and 211,171 baseline events were captured in data set B. Note that the vendor considers the operational definitions of crashes, near-crashes, and crash-relevant conflicts to be proprietary.

Table 10. Summary of data set B.

Vehicle Type	# of Fleets	# of Vehicles	Cell Phone Policy	Sectors	Crashes	Near-Crashes	Crash-Relevant Conflicts	Baseline Events
3 Axle or More Truck	29	2,617	Yes = 15 No = 7 Unknown =7	76% Distribution 14% Energy 6% Municipalities 3% SMB 1% Waste	107	913	5,907	47,769
Bus	90	8,509	Yes = 55 No = 16 Unknown = 19	43% Transit 33% SMB 23% Distribution 1% Municipalities	740	6,145	18,576	99,662
Tractor Trailer/Tanker	64	2,180	Yes = 39 No = 13 Unknown = 12	58% SMB 25% Distribution 6% Energy 5% Waste 3% Utilities/Telecommunication 2% Construction 1% Municipalities	238	1,317	6,178	63,746
Total	183	13,306	Yes = 109 No = 36 Unknown = 38	33.7% Distribution 31.3% SMB 27.5% Transit 3.7% Energy 2.0% Municipalities 1% Waste 0.5% Utilities/Telecommunication 0.3% Construction	1,085	8,375	30,661	211,171

Table 11 shows the distribution of fleets, vehicles, sectors, company cell phone policy, and safety-critical events across the three vehicle types (i.e., 3 axle or more truck, bus, tractor trailer/tanker) in data set A. As shown in Table 11, the data in data set A came from 207 different truck and bus fleets comprising a total of 13,431 vehicles. These 13,431 trucks and buses were distributed among SMB (32.2 percent), transit (30.4 percent), distribution (25.0 percent), energy (8.5 percent), municipalities (1.5 percent), waste (1.2 percent), utilities/telecommunication (0.9 percent), and construction (0.3 percent) fleets. A total of 1,336 crashes, 15,864 near-crashes, and 173,591 crash-relevant conflicts were captured in data set A.

Table 11. Summary of data set A.

Vehicle Type	# of Fleets	# of Vehicles	# w/Cell Phone Policy	Sectors	Crashes	Near-Crashes	Crash-Relevant Conflicts
3 Axle or More Truck	31	2,511	Yes= 16 No = 8 Unknown = 7	59.9% Distribution 29.7% Energy 1.8% Municipalities 7.2% SMB 1.4% Waste	113	1,365	47,112
Bus	105	8,183	Yes = 52 No = 16 Unknown = 37	56.4% Transit 27.2% SMB 15.4% Distribution 1% Municipalities	1,008	12,260	76,445
Tractor Trailer/Tanker	71	2,737	Yes = 34 No = 11 Unknown = 26	56.1% SMB 22.4% Distribution 11.8% Energy 4% Waste 2.7% Utilities/Telecommunication 2.4% Municipalities 0.8% Construction	215	2,239	50,034
Total	207	13,431	Yes = 102 No = 35 Unknown = 70	32.2% SMB 30.4% Transit 25.0% Distribution 8.5% Energy 1.5% Municipalities 1.2% Waste 0.9% Utilities/Telecommunication 0.3% Construction	1,336	15,864	173,591

The distribution of the two data sets shown in Table 11 and Table 10 was similar. Also, there were more crashes and less near-crashes and crash-relevant conflicts than expected in data set B compared to data set A (given the time period in each data set). If the data in data set B was normalized to include the same period of time as in data set A, we would expect to find approximately 120,000 safety-critical events (compared to 190,791 safety-critical events in data set A). While the additional 125 trucks and buses in data set A explains some of this variability, it appears that drivers drove more safely and/or safety managers were more vigilant in their monitoring (and coaching) in data set B.

2.2 RESEARCH QUESTIONS AND ANALYSES

There were four primary research questions in the study. Each of these research questions is described in more detail below.

2.2.1 Analysis 1: Descriptive Analyses

The first analysis was a descriptive analysis of the two data sets. These descriptive analyses report the frequency and percentage of tertiary tasks in commercial trucks and buses in each data set across each vehicle type and fleet cell phone policy. These descriptive analyses show the proportion of specific tertiary tasks, as well as the prevalence of tertiary tasks across safety-critical events and baseline events (in data set B only). Below is a list of the descriptive analyses.

- Frequency and percentage of detailed cell phone tasks and other tertiary tasks in commercial trucks and buses across safety-critical events and baseline events in data set B. These results were also disaggregated by vehicle type and fleet cell phone policy.
- Frequency and percentage of tertiary tasks in commercial trucks and buses across safety-critical events in data set A. These results were also disaggregated by vehicle type and fleet cell phone policy.

Note that the presence of each fleet's cell phone policy (or lack thereof) was only coded in data set B. Thus, this information was cross-referenced with the fleets in data set A to determine which fleets in data set A had a cell phone policy (or conversely did not have a cell phone policy). As this information was not recorded for every fleet in the data set B, it was unknown if these fleets had a cell phone policy. Thus, the fleets where it was unknown if they had a cell phone policy were excluded from all descriptive analyses where the results were disaggregated by fleet cell phone policy (or lack thereof). There were various fleet cell phone policies present in data set B, including no cell phone use of any kind while driving and no hand-held cell phone use while driving (hands-free cell phone use was allowed). Limited sample size restricted the disaggregation by specific fleet cell phone policy; thus, the presence of a fleet cell phone policy in this analysis was defined as "any" fleet cell phone policy (e.g., no cell phone use of any kind while driving, no hand-held cell phone use while driving, etc.).

2.2.2 Analysis 2: Odds Ratios of Tertiary Tasks

Odds ratios were calculated for each tertiary task to approximate the rate ratio of safety-critical event risk compared to normal, baseline driving (using baseline events). An odds ratio compares the odds of some outcome occurring (e.g., a safety-critical event), given the presence of some predictor factor, condition, or classification (e.g., cell phone use). An odds ratio is usually a comparison of the presence of a condition to its absence (e.g., driver cell phone use versus no driver cell phone use). As shown in Table 12, an odds ratio is a measure of association commonly employed in the analysis of 2 × 2 contingency tables (Agresti, 1996).

Table 12. Example of a 2 × 2 contingency table used to calculate odds ratio.

Outcome	Driver Inattention	No Driver Inattention
Incidence Occurrence	n_{11}	n_{12}
No Incidence Occurrence	n_{21}	n_{22}

Odds of occurrence were defined as the probability of safety-critical event occurrence divided by the probability of non-occurrence (baseline). The following formula was used to perform the calculation to determine the odds ratio in order to assess the increase (or decrease) in the probability of having a safety-critical event, compared to a baseline, in the presence of a tertiary task versus no tertiary task: Odds Ratio = $(n_{11})(n_{22})/(n_{21})(n_{12})$.

Odds ratios of "1.0" indicate the outcome is equally likely to occur given the condition. An odds ratio greater than "1.0" indicates the outcome is more likely to occur given the condition, while an odds ratio of less than "1.0" indicates the outcome is less likely to occur (Pedhazur, 1997). To determine whether the odds ratio is significant, the lower confidence limit (LCL) and the upper confidence limit (UCL) are calculated. If 1.0 is not included between the LCL and the UCL, the odds ratio is significant. The hypothetical data presented in Table 13 is used to illustrate how the odds ratio was calculated for dialing a cell phone while driving. In this hypothetical example, assume there were a total of 100 safety-critical events and 100 baseline events in the data set. Drivers were found to be dialing a cell phone while driving during 45 of the safety-critical events, while drivers were dialing a cell phone while driving in 23 of the baseline events.

Table 13. Example of the dialing a cell phone odds ratio calculation.

Outcome	Dialing a Cell Phone	No Dialing a Cell Phone
Safety-critical events	45 (A)	55 (B)
Baseline events	23 (C)	77 (D)

The formula for this calculation was as follows:

$$Odds\ Ratio = \frac{A \times D}{B \times C} \tag{1a}$$

$$Odds\ Ratio = \frac{45 \times 77}{23 \times 55} \tag{1b}$$

$$Odds\ Ratio = 2.74 \tag{1c}$$

In order to determine if the odds ratio of 2.74 was significant, a 95-percent confidence interval was calculated, including the UCLs and LCLs. The formulas to calculate the UCL and LCL are shown below:

$$UCL = Odds\ Ratio \times e^{1.96\sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}} \tag{2a}$$

$$UCL = 2.74 \times e^{1.96\sqrt{\frac{1}{45}+\frac{1}{55}+\frac{1}{23}+\frac{1}{77}}} \tag{2b}$$

$$UCL = 5.04 \tag{2c}$$

$$LCL = OddsRatio \times e^{-1.96\sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}} \tag{3a}$$

$$LCL = 2.74 \times e^{-1.96\sqrt{\frac{1}{45}+\frac{1}{55}+\frac{1}{23}+\frac{1}{77}}} \tag{3b}$$

$$LCL = 1.49 \tag{3c}$$

Since 1.0 is not included between the LCL and the UCL, the odds ratio was significantly different than 1.0. If the study were conducted multiple times, 95 percent of the confidence intervals calculated would contain the true odds ratio. Therefore, in this example using data from Table 13, it can be interpreted that drivers who dial a cell phone while driving significantly increased their odds of involvement in a safety-critical event by 2.74, compared to a baseline, than if they were not dialing a cell phone while driving. Note that the odds ratio analysis follows an epidemiological approach. Odds ratios do not infer causation, they illustrate risk. This is analogous to retrospective research that shows a relationship between smoking cigarettes and cancer in the human population. The results from the odds ratio analyses can be interpreted the same way.

In order to approximate safety-critical event risk, compared to baseline driving, odds ratios were calculated on each tertiary task in data set B (when there was a sufficient sample size of safety-critical events). Odds ratios for each tertiary task were calculated with the absence and presence of that specific tertiary task. The results from these calculations show the odds ratio, LCL, UCL, and frequency of safety-related events and baseline events for each tertiary task. Note that odds ratios were only calculated on tertiary tasks in data set B.

As the study employs a case-control analysis approach (rather than a follow-on cohort approach), the use of odds ratios (rather than relative risk) is appropriate. The quantities obtained from a case-control and cohort approach are not equal. The odds ratio in a case-control approach is calculated with the probability of the risky behavior given a crash; however, the risk in a cohort study is calculated with the conditionality in the other direction. Since the total number of baseline events and safety-critical events is known in the study, exposure risk can be calculated (i.e., the risk of dialing a cell phone given the driving event is a baseline or a safety-critical event). In such situations, odds ratios are not used to approximate the risk ratio. Instead, the odds ratio is used to approximate the rate ratio. For time-variant factors, such as tertiary tasks, a more appropriate measure is rate ratio (i.e., the number of crashes per miles driven with cell phone use). The analysis framework used the odds ratio to approximate the rate ratio, which does not require the rare event assumption (Guo & Hankey, 2009). Analysis 3: Population Attributable Risk

The PAR was also calculated on all significant odds ratios and was defined as the risk of a safety-critical event in the total population (p_t) minus the risk in the unexposed group (p_u) (Sahai & Khurshid, 1996). For each odds ratio with an outcome greater than "1.0", the percentage PAR was calculated. While the odds ratio is measured at the individual level, the PAR is measured at the population level. This analysis provided an assessment of the percentage of safety-critical events that are occurring in the population and that are directly attributable to the specific behavior measured. The PAR percentage is defined as the proportion of the risk to the safety-critical event in the study population that is attributable to the exposure to the distracting task, and thus could be avoided by limiting the exposure to the risk factor (Sahai & Khurshid).

Since this is a retrospective study, the odds ratio approaches the rate ratio (i.e., a ratio of the probability of the event occurring in the exposed group versus a non-exposed group); thus, odds ratios may be substituted for rate ratio and the PAR percentage was calculated as follows:

$$PAR\ percentage = \frac{(P_e(OddsRatio - 1))}{(1 + P_e(OddsRatio - 1))} \times 100 \qquad (4a)$$

Where P_e = population exposure estimate (e.g., number of baseline epochs with complex tertiary task/total number of baseline epochs). This calculation provides a percentage value which can then be generalized to the entire population. For example, drivers who dial a cell phone while driving significantly increase their odds of involvement in a safety-critical event by two times, compared to not dialing a cell phone, but dialing a cell phone while driving is a rare occurrence in the entire population, which is explained by calculating the PAR percentage. Again, using the hypothetical data presented in Table 13, the PAR percentage is calculated below where:

$$P_e = \frac{23\ baseline\ epochs\ with\ dialing\ a\ cell\ phone\ while\ driving\ present}{100\ total\ baseline\ epochs} = 0.23 \qquad (4b)$$

$$Odds\ Ratio = 2.74 \qquad (4c)$$

$$PAR\ percentage = \frac{(0.23(2.74 - 1))}{(1 + 0.23(2.74 - 1))} \times 100 \qquad (4d)$$

$$PAR\ percentage = 18.70 \qquad (4e)$$

In order to interpret the PAR percentage, the estimated sample variance and the UCL and LCL must first be calculated. Table 14 displays the hypothetical data used above in the odds ratio example; these data will be used to explain the 95 percent UCL and LCL calculations shown below.

Table 14. Population attributable risk—confidence limits example.

Outcome	Dialing a Cell Phone	No Dialing a Cell Phone	Row Total
Safety-critical events	45 (A)	55 (B)	100 (m1)
Baseline events	23 (C)	77 (D)	100 (m2)
Column Total	68 (n1)	132 (n2)	(n)

First, it is necessary to calculate the estimated sample variance using the following formula:

$$Var(PAR\ percentage) = \left(\frac{Bm_2}{Dm_1}\right)^2 \left[\frac{A}{Bm_1} + \frac{C}{Dm_2}\right] \times 100 \tag{5a}$$

$$Var(PAR\ percentage) = \left(\frac{55 \times 100}{77 \times 100}\right)^2 \left[\frac{45}{55 \times 100} + \frac{23}{77 \times 100}\right] \times 100 \tag{5b}$$

$$Var(PAR\ percentage) = 0.57 \tag{5c}$$

Next, the 95 percent UCL and LCL is calculated using the estimated sample variance. The formulas are as follows:

$$UCL = PAR\ percentage + 1.96\sqrt{Var(PAR\ percentage)} \tag{6a}$$

$$UCL = 18.70 + 1.96\sqrt{0.57} \tag{6b}$$

$$UCL = 20.18 \tag{6c}$$

$$LCL = PAR\ percentage - 1.96\sqrt{Var(PAR\ percentage)} \tag{7a}$$

$$LCL = 18.70 - 1.96\sqrt{0.57} \tag{7b}$$

$$LCL = 17.22 \tag{7c}$$

Therefore, it can be reported using this hypothetical data that dialing a cell phone while driving significantly increases the probability of involvement in a safety-critical event. Note that PAR percentages were only calculated on tertiary tasks in data set B.

2.2.3 Analysis 4: Odds Ratios of Fleet Policy and State Law

Odds ratios were also used to calculate the approximate effectiveness of a fleet cell policy and State cell phone law regarding cell phone use while driving. Table 15 illustrates the 2 × 2 contingency table employed in these analyses. In order to approximate the likelihood of commercial truck and bus drivers using a cell phone while driving under a fleet cell phone policy and State cell phone law, odds ratios for each cell phone policy were calculated. This odds ratio did not look at safety-critical events, but rather evaluated the odds of cell phone usage given a fleet cell phone policy or State cell phone law versus the odds of cell phone usage given no fleet cell phone policy or State cell phone law. Each of these calculations was performed using the safety-critical events in data sets A and B (i.e., the full 365 days) and baseline events in data set B (i.e., the two data sets were merged). Crashes in data set A were not included in this analysis as the vendor did not re-review these crashes. The results from these calculations show the odds ratios, LCL, UCL, and the frequency of cell phone use while driving and no cell phone use while driving.

Table 15. Example of 2 × 2 contingency table used to calculate the cell phone policy odds ratio.

Outcome	Cell Phone Policy	No Cell Phone Policy
Cell phone use while driving	n_{11}	n_{12}
No cell phone use while driving	n_{21}	n_{22}

Note that the specific cell phone sub-tasks in data set B were re-classified as general “cell phone use” in this analysis in order to be merged with data set A. As indicated above, fleets with an unknown cell phone policy were excluded from this analysis. There were various fleet cell phone policies present in the merged data set, including no cell phone use while driving and no hand-held cell phone use while driving (hands-free cell phone use was allowed). As the merged data set did not classify specific cell phone sub-tasks, the fleet cell phone policy in this analysis was defined as “any” fleet cell phone policy (e.g., no cell phone use while driving, no hand-held cell phone use while driving, etc.). Similarly, the State cell phone law in this analysis was defined as any State cell phone law (e.g., no hand-held cell phone use while driving, no texting while driving, etc.). Also note that baseline events and safety-critical events were not mutually exclusive in these analyses. More specifically, a baseline or safety-critical event that was coded with both a fleet cell phone policy and a State cell phone law was included in both analyses (i.e., fleet cell phone and State cell phone analyses).

3. RESULTS

As indicated, the authors completed four analyses using the two data sets provided by the vendor. These analyses included: descriptive statistics of tertiary tasks in both data sets, odds ratios on each tertiary task in data set B, PAR for each significant odds ratio greater than 1.0, and odds ratios of cell phone use while driving under company cell phone policy and State cell phone law in a merged data set.

3.1 ANALYSIS 1: DESCRIPTIVE ANALYSES

The first analysis was a descriptive analysis of the data set. These descriptive analyses report the frequency and percentage of tertiary tasks in commercial trucks and buses in each data set across the three vehicle types. These descriptive analyses show the proportion of specific tertiary tasks performed by drivers, as well as the prevalence of tertiary tasks across safety-critical events and baseline events.

3.1.1 Tertiary Tasks in Data Set A

Table 16 shows the frequency and percentage of tertiary tasks across each severity level in data set A. Note that safety-critical events were defined as crashes, near-crashes, and critical incidents. More than one tertiary task could be coded during a safety-critical event in data set A; thus, the column totals in the data set A tables may exceed 100 percent.

As shown in Table 16, most of the safety-critical events did not involve a tertiary task (92.4 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (2.8 percent) and cell phone usage (4.0 percent).

Table 16. Frequency and percentage of tertiary tasks across each severity level in data set A.

Tertiary Tasks	Number of Near-Crashes (and percent)	Number of Crash-Relevant Conflicts (and percent)	Number of Safety-Critical Events (near crashes + crash-relevant conflicts) (and percent)
Cell Phone Usage	246 (1.55%)	7,278 (4.19%)	7,524 (3.97%)
Consuming Food/Drink	43 (0.27%)	1,367 (0.79%)	1,410 (0.74%)
Other Distraction	723 (4.56%)	4,635 (2.67%)	5,358 (2.83%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	41 (0.26%)	104 (0.06%)	145 (0.08%)
None	14,817 (93.40%)	160,236 (92.31%)	175,053 (92.40%)

Table 17 shows the frequency and percentage of tertiary tasks across each severity level in data set A for fleets with no cell phone policy. Note that fleets with an unknown cell phone policy were excluded from Table 17 and Table 18; thus, the frequencies in Table 17 and Table 18 will not sum to the frequencies found in Table 16. As shown in Table 17, most of the safety-critical events did not involve a tertiary task (93.3 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were cell phone usage (4.0 percent) and other distraction (2.1 percent).

Table 17. Frequency and percentage of tertiary tasks across each severity level in data set A (no fleet cell phone policy only).

Tertiary Tasks	Number of Near-Crashes (and percent)	Number of Crash-Relevant Conflicts (and percent)	Number of Safety-Critical Events (near crashes + crash-relevant conflicts) (and percent)
Cell Phone Usage	54 (3.71%)	715 (3.97%)	769 (3.95%)
Consuming Food/Drink	9 (0.62%)	129 (0.72%)	138 (0.71%)
Other Distraction	57 (3.91%)	345 (1.92%)	402 (2.07%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	3 (0.21%)	5 (0.03%)	8 (0.04%)
None	1,334 (91.56%)	16,816 (93.39%)	18,150 (93.25%)

Table 18 shows the frequency and percentage of tertiary tasks across each severity level in data set A for fleets with a cell phone policy. As shown in Table 18, most of the safety-critical events did not involve a tertiary task (91.4 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were cell phone usage (4.3 percent) and other distraction (3.4 percent).

Table 18. Frequency and percentage of tertiary tasks across each severity level in data set A (fleet cell phone policy only).

Tertiary Tasks	Number of (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (near crashes and crash-relevant conflicts)
Cell Phone Usage	159 (1.50%)	5,169 (4.58%)	5,328 (4.32%)
Consuming Food/Drink	28 (0.26%)	1,022 (0.91%)	1,050 (0.85%)
Other Distraction	499 (4.70%)	36,93 (3.28%)	4,192 (3.40%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	29 (0.27%)	75 (0.07%)	104 (0.08%)
None	9,915 (93.31%)	102,813 (91.18%)	112,728 (91.37%)

Table 19 shows the frequency and percentage of tertiary tasks in 3 axle or more trucks across each severity level in data set A. As shown in Table 19, most of the safety-critical events in 3 axle or more trucks did not involve a tertiary task (91.9 percent). Of the tertiary tasks in 3 axle or more trucks during the safety-critical events, the most prevalent were other distraction (3.7 percent) and cell phone usage (3.3 percent).

Table 19. Frequency and percentage of tertiary tasks in 3 axle or more trucks across each severity level in data set A.

Tertiary Tasks	Number of (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (near crashes and crash-relevant conflicts)
Cell Phone Usage	21 (1.54%)	1,576 (3.35%)	1,597 (3.29%)
Food/Drink	5 (0.37%)	653 (1.23%)	547 (1.13%)
Other Distraction	106 (7.77%)	1,676 (3.56%)	1,782 (3.68%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	1 (0.07%)	7 (0.01%)	8 (0.02%)
None	1,233 (90.33%)	43,316 (91.94%)	44,549 (91.90%)

Table 20 shows the frequency and percentage of tertiary tasks in buses across severity level in data set A. As shown in Table 20, most of the safety-critical events in buses did not involve a tertiary task (93 percent). Of the tertiary tasks in buses during the safety-critical events, the most prevalent were cell phone usage (3.6 percent) and other distraction (2.8 percent).

Table 20. Frequency and percentage of tertiary tasks in buses across each severity level in data set A.

Tertiary Tasks	Number of (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (near crashes and crash-relevant conflicts)
Cell Phone Usage	157 (1.28%)	3,001 (3.93%)	3,158 (3.56%)
Food/Drink	26 (0.21%)	416 (0.54%)	442 (0.50%)
Other Distraction	485 (3.96%)	1,997 (2.61%)	2,482 (2.80%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	36 (0.29%)	78 (0.10%)	114 (0.13%)
None	11,558 (94.27%)	70,970 (92.84%)	82,528 (93.04%)

Table 21 shows the frequency and percentage of tertiary tasks in tractor trailers/tankers across each severity level in data set A. As shown in Table 21, most of the safety-critical events in tractor trailers/tankers did not involve a tertiary task (91.8 percent). Of the tertiary tasks in tractor trailers/tankers during the safety-critical events, the most prevalent were cell phone usage (5.3 percent) and other distraction (2.1 percent).

Table 21. Frequency and percentage of tertiary tasks in tractor trailers/tankers across each severity level in data set A.

Tertiary Tasks	Number of (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (near crashes and crash-relevant conflicts)
Cell Phone Usage	68 (3.04%)	2,701 (5.40%)	2,769 (5.30%)
Food/Drink	12 (0.54%)	409 (0.82%)	421 (0.81%)
Other Distraction	132 (5.90%)	962 (1.92%)	1,094 (2.09%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)
Passenger Distraction	4 (0.18%)	19 (0.04%)	23 (0.04%)
None	2,026 (90.49%)	45,950 (91.84%)	47,976 (91.78%)

3.1.2 Tertiary Tasks in Data Set B

Table 22 shows the frequency and percentage of tertiary tasks across each severity level in data set B. More than one tertiary task could be coded during a baseline or safety-critical event in the data set B; thus, the column totals in the data set B tables may exceed 100 percent.

As shown in Table 22, most of the baseline events and safety-critical events did not involve a tertiary task (97.4 percent and 94.0 percent, respectively). However, of the tertiary tasks recorded during crashes in data set B, all were coded with a cell phone sub-task. More specifically, the crashes involved the driver using a cell phone to text/e-mail/access the internet while driving (1.02 percent), followed by talking/listening on a hand-held cell phone (0.46 percent), reaching for a cell phone (0.28 percent), and dialing a cell phone (0.18 percent). The most prevalent tertiary tasks during baseline events were talking/listening on a hand-held cell phone (1.1 percent), talking/listening on a hands-free cell phone (0.8 percent), and food/drink (0.6 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (3.0 percent), talking/listening on a hand-held cell phone (1.0 percent), food/drink (0.7 percent), and talking/listening on a hands-free cell phone (0.5 percent).

Table 22. Frequency and percentage of tertiary tasks across each severity level in data set B.

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	256 (0.12%)	2 (0.18%)	3 (0.04%)	160 (0.52%)	165 (0.41%)
Consuming Food/Drink	1,320 (0.63%)	0 (0.00%)	8 (0.10%)	260 (0.85%)	268 (0.67%)
Other Distraction	13 (0.01%)	0 (0.00%)	32 (0.38%)	1,188 (3.87%)	1,220 (3.04%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	30 (0.10%)	30 (0.07%)
Reaching for Headset/Earpiece	168 (0.08%)	0 (0.00%)	0 (0.00%)	104 (0.34%)	104 (0.26%)
Reaching for Cell Phone	178 (0.08%)	3 (0.28%)	3 (0.04%)	116 (0.38%)	122 (0.30%)
Talking/Listening on Hand-Held Cell Phone	22,66 (1.07%)	5 (0.46%)	8 (0.10%)	359 (1.17%)	372 (0.93%)
Talking/Listening on Hands-Free Cell Phone	1,626 (0.77%)	0 (0.00%)	8 (0.10%)	186 (0.61%)	194 (0.48%)
Texting/E-mailing/ Accessing the Internet on Phone	3 (0.00%)	11 (1.02%)	2 (0.02%)	77 (0.25%)	90 (0.22%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	205,582 (97.35%)	1,064 (98.06%)	8,314 (99.27%)	28,330 (92.40%)	37,708 (93.99%)

Table 23 shows the frequency and percentage of tertiary tasks across each severity level in data set B for fleets with no cell phone policy. Note that fleets with an unknown cell phone policy were excluded from Table 23 and Table 24; thus, the frequencies in Table 23 and Table 24 will not sum to the frequencies found in Table 22. As shown in Table 23, most of the baseline events and safety-critical events did not involve a tertiary task (96.1 percent and 92.9 percent, respectively). However, of the tertiary tasks recorded during crashes in s data set B for fleets with no cell phone policy, all were coded with a cell phone sub-task. More specifically, the crashes involved the driver using a cell phone to text/e-mail/access the Internet while driving (2.1 percent), followed by talking/listening on a hand-held cell phone (1.4 percent), reaching for a cell phone (0.28 percent), and dialing a cell phone (0.7 percent). The most prevalent tertiary tasks during baseline events were talking/listening on a hand-held cell phone (2.3 percent), talking/listening on a hands-free cell phone (0.7 percent), and consuming food/drink (0.5 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (2.4 percent), talking/listening on a hand-held cell phone (1.8 percent), and talking/listening on a hands-free cell phone (0.8 percent).

Table 23. Frequency and percentage of tertiary tasks across each severity level in data set B (no fleet cell phone policy).

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	72 (0.26%)	0 (0.00%)	1 (0.10%)	37 (0.98%)	38 (0.78%)
Consuming Food/Drink	144 (0.52%)	0 (0.00%)	0 (0.00%)	28 (0.74%)	28 (0.57%)
Other Distraction	1 (0.00%)	0 (0.00%)	5 (0.52%)	113 (2.99%)	118 (2.42%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (0.19%)	7 (0.14%)
Reaching for Headset/Earpiece	43 (0.15%)	0 (0.00%)	0 (0.00%)	28 (0.74%)	28 (0.57%)
Reaching for Cell Phone	54 (0.19%)	1 (0.71%)	1 (0.10%)	29 (0.77%)	31 (0.63%)
Talking/Listening on Hand-Held Cell Phone	649 (2.33%)	2 (1.43%)	2 (0.21%)	82 (2.17%)	86 (1.76%)
Talking/Listening on Hands-Free Cell Phone	184 (0.66%)	0 (0.00%)	2 (0.21%)	39 (1.03%)	41 (0.84%)
Texting/E-mailing/ Accessing the Internet on Phone	0 (0.00%)	3 (2.14%)	0 (0.00%)	2 (0.05%)	5 (0.10%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	26,730 (96.12%)	134 (95.71%)	956 (98.96%)	3,448 (91.24%)	4,538 (92.90%)

Table 24 shows the frequency and percentage of tertiary tasks across each severity level in data set B for fleets with a cell phone policy. As shown in Table 24, most of the baseline events and safety-critical events did not involve a tertiary task (97.2 percent and 93.4 percent, respectively). However, of the tertiary tasks recorded during crashes in data set B for fleets with a cell phone policy, all were coded with a cell phone sub-task. More specifically, the crashes involved the driver using a cell phone to text/e-mail/access the Internet while driving (1.1 percent), followed by dialing a cell phone (0.3 percent), reaching for a cell phone (0.3 percent), and talking/listening on a hand-held cell phone (0.1 percent). The most prevalent tertiary tasks during baseline events were talking/listening on a hand-held cell phone (1.0 percent), talking/listening on a hands-free cell phone (0.9 percent), and consuming food/drink (0.8 percent). Of the tertiary tasks present during the safety-critical events, the most prevalent were other distraction (3.5 percent), talking/listening on a hand-held cell phone (0.9 percent), and consuming food/drink (0.8 percent).

Table 24. Frequency and percentage of tertiary tasks across each severity level in data set B (fleet cell phone policy).

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	161 (0.12%)	2 (0.27%)	2 (0.03%)	115 (0.53%)	119 (0.42%)
Consuming Food/Drink	1052 (0.76%)	0 (0.00%)	4 (0.07%)	209 (0.96%)	213 (0.75%)
Other Distraction	10 (0.01%)	0 (0.00%)	24 (0.41%)	969 (4.45%)	993 (3.49%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	16 (0.07%)	16 (0.06%)
Reaching for Headset/Earpiece	108 (0.08%)	0 (0.00%)	0 (0.00%)	70 (0.32%)	70 (0.25%)
Reaching for Cell Phone	96 (0.07%)	2 (0.27%)	2 (0.03%)	76 (0.35%)	80 (0.28%)
Talking/Listening on Hand-Held Cell Phone	1,388 (1.00%)	1 (0.14%)	5 (0.08%)	259 (1.19%)	265 (0.93%)
Talking/Listening on Hands-Free Cell Phone	1205 (0.87%)	0 (0.00%)	5 (0.08%)	132 (0.61%)	137 (0.48%)
Text/E-mail/Access the Internet on Phone	3 (0.00%)	8 (1.09%)	2 (0.03%)	74 (0.34%)	84 (0.30%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	135,158 (97.21%)	720 (98.23%)	5,880 (99.29%)	19,948 (91.68%)	26,548 (93.43%)

Table 25 shows the frequency and percentage of tertiary tasks in 3 axle or more trucks across each severity level in data set B. As shown in Table 25, most of the baseline events and safety-critical events in 3 axle or more trucks did not involve a tertiary task (97 percent and 87.5 percent, respectively). The 3 axle or more truck driver was using his/her cell phone to text/e-mail/access the Internet during the one crash where a tertiary task was coded. The most prevalent tertiary tasks in 3 axle or more trucks during baseline events were consuming food/drink (1.4 percent) and talking/listening on a hand-held cell phone (1.1 percent). Of the tertiary tasks in 3 axle or more trucks during the safety-critical events, the most prevalent were other distraction/electronic device (8.1 percent), consuming food/drink (1.6 percent), talking/listening on a hand-held cell phone (1.0 percent), and texting/e-mailing/accessing the Internet (0.8 percent).

Table 25. Frequency and percentage of tertiary tasks in 3 axle or more trucks across each severity level in data set B.

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	40 (0.08%)	0 (0.00%)	0 (0.00%)	31 (0.52%)	31 (0.45%)
Consuming Food/Drink	683 (1.43%)	0 (0.00%)	2 (0.22%)	111 (1.88%)	113 (1.63%)
Other Distraction	1 (0.00%)	0 (0.00%)	11 (1.20%)	547 (9.26%)	558 (8.06%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Reaching for Headset/Earpiece	28 (0.06%)	0 (0.00%)	0 (0.00%)	17 (0.29%)	17 (0.25%)
Reaching for Cell Phone	34 (0.07%)	0 (0.00%)	0 (0.00%)	18 (0.30%)	18 (0.26%)
Talking/Listening on Hand-Held Cell Phone	534 (1.12%)	0 (0.00%)	1 (0.11%)	68 (1.15%)	69 (1.00%)
Talking/Listening on Hands-Free Cell Phone	155 (0.32%)	0 (0.00%)	1 (0.11%)	27 (0.46%)	28 (0.40%)
Texting/E-mailing/Accessing the Internet on Phone	2 (0.00%)	1 (0.93%)	0 (0.00%)	57 (0.96%)	58 (0.84%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	46,326 (96.98%)	106 (99.07%)	898 (98.36%)	5,060 (85.66%)	6,064 (87.54%)

Table 26 shows the frequency and percentage of tertiary tasks in buses across each severity level in data set B. As shown in Table 26, most of the baseline events and safety-critical events in buses did not involve a tertiary task (98.5 percent and 96.4 percent, respectively). However, of the tertiary tasks recorded in bus crashes in data set B, all were coded with a cell phone sub-task. More specifically, the bus crashes involved the driver using a cell phone to text/e-mail/access the Internet while driving (1.0 percent), followed by talking/listening on a hand-held cell phone (0.54 percent), reaching for a cell phone (0.27 percent), and dialing a cell phone (0.27 percent). The most prevalent tertiary tasks in buses during baseline events were talking/listening on a hand-held cell phone (0.7 percent), consuming food/drink (0.3 percent), and talking/listening on a hands-free cell phone (0.3 percent). Of the tertiary tasks in buses during the safety-critical events, the most prevalent were other distraction (1.5 percent) and talking/listening on a hand-held cell phone (0.7 percent).

Table 26. Frequency and percentage of tertiary tasks in buses across each severity level in data set B.

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	137 (0.14%)	2 (0.27%)	2 (0.03%)	80 (0.43%)	84 (0.33%)
Consuming Food/Drink	317 (0.32%)	0 (0.00%)	5 (0.08%)	93 (0.50%)	98 (0.38%)
Other Distraction	7 (0.01%)	0 (0.00%)	11 (0.18%)	379 (2.04%)	390 (1.53%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	24 (0.13%)	24 (0.09%)
Reaching for Headset/Earpiece	78 (0.08%)	0 (0.00%)	0 (0.00%)	55 (0.30%)	55 (0.22%)
Reaching for Cell Phone	92 (0.09%)	2 (0.27%)	1 (0.02%)	55 (0.30%)	58 (0.23%)
Talking/Listening on Hand-Held Cell Phone	724 (0.73%)	4 (0.54%)	4 (0.07%)	177 (0.95%)	185 (0.73%)
Talking/Listening on Hands-Free Cell Phone	247 (0.25%)	0 (0.00%)	2 (0.03%)	81 (0.44%)	83 (0.33%)
Texting/E-mailing/Accessing the Internet on Phone	1 (0.00%)	7 (0.95%)	2 (0.03%)	11 (0.06%)	20 (0.08%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	98,186 (98.52%)	725 (97.97%)	6,120 (99.59%)	17,695 (95.26%)	24,540 (96.38%)

Table 27 shows the frequency and percentage of tertiary tasks in tractor trailers/tankers across each severity level in data set B. As shown in Table 27, most of the baseline events and safety-critical events in tractor trailers/tankers did not involve a tertiary task (95.8 percent and 91.9 percent, respectively). However, of the tertiary tasks recorded in the tractor trailer/tanker crashes in data set B, all were coded with a cell phone sub-task. More specifically, the tractor trailer/tanker crashes involved the driver using a cell phone to text/e-mail/access the Internet while driving (1.3 percent), followed by talking/listening on a hand-held cell phone (0.4 percent), and reaching for a cell phone (0.4 percent). The most prevalent tertiary tasks in tractor trailers/tankers during baseline events were talking/listening on a hands-free cell phone (1.9 percent), talking/listening on a hand-held cell phone (1.6 percent), and consuming food/drink (0.5 percent). Of the tertiary tasks in tractor trailers/tankers during the safety-critical events, the most prevalent were other distraction (3.5 percent), talking/listening on a hand-held cell phone (1.5 percent), and talking/listening on a hands-free cell phone (1.1 percent).

Table 27. Frequency and percentage of tertiary tasks in tractor trailers/tankers across each severity level in data set B.

Tertiary Tasks	Number (and percent) of Baseline Events	Number (and percent) of Crashes	Number (and percent) of Near-Crashes	Number (and percent) of Crash-Relevant Conflicts	Number (and percent) of Safety-Critical Events (crashes + near-crashes +crash-relevant conflicts)
Dialing Cell Phone	79 (0.12%)	0 (0.00%)	1 (0.08%)	49 (0.79%)	50 (0.65%)
Consuming Food/Drink	320 (0.50%)	0 (0.00%)	1 (0.08%)	56 (0.91%)	57 (0.74%)
Other Distraction	5 (0.01%)	0 (0.00%)	10 (0.76%)	262 (4.24%)	272 (3.52%)
Passenger	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (0.10%)	6 (0.08%)
Reaching for Headset/Earpiece	62 (0.10%)	0 (0.00%)	0 (0.00%)	32 (0.52%)	32 (0.41%)
Reaching for Cell Phone	52 (0.08%)	1 (0.42%)	2 (0.15%)	43 (0.70%)	46 (0.59%)
Talking/Listening on Hand-Held Cell Phone	1,008 (1.58%)	1 (0.42%)	3 (0.23%)	114 (1.85%)	118 (1.53%)
Talking/Listening on Hands-Free Cell Phone	1,224 (1.92%)	0 (0.00%)	5 (0.38%)	78 (1.26%)	83 (1.07%)
Texting/E-mailing/Accessing the Internet on Phone	0 (0.00%)	3 (1.26%)	0 (0.00%)	9 (0.15%)	12 (0.16%)
Other Communication Device	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
None	61,070 (95.80%)	233 (97.90%)	1,296 (98.41%)	5,575 (90.24%)	7,104 (91.87%)

3.1.3 Summary

The prevalence rates of tertiary tasks in this study were far below those found in LTCCS (FMCSA, 2005) and in a naturalistic truck study conducted by Olson et al. (2009). Olson et al. found that 59.9 percent and 56.5 percent of the safety-critical events and baseline epochs had at least one tertiary task present, respectively. The LTCCS found that 9 percent of the crashes were attributed to driver inattention, 8 percent were attributed to an external distraction (i.e., the driver was looking at something outside of his/her truck), and 2 percent were attributed to an internal distraction. Note that these driver errors in the LTCCS were determined to be the causal factor in the crash (i.e., had they not been present, the crash would not have happened). If these driver errors had also been considered as an associated factor, rather than a causal factor, they would likely result in much higher percentages.

It is likely that these data sets present a very conservative view of the scope of the distracted driver problem. The prevalence of driver distraction in these data sets was likely influenced by four factors. First, and most importantly, the fleets in the study were able to actively monitor their drivers. The system is an effective safety-management technique aimed at reducing risky driving behaviors. Hickman et al. (in press) found that the system reduced the mean-rate of safety-critical events/10,000 miles by up to 70 percent in a sample of long-haul and short-haul truck drivers. Similarly, McGehee et al. (2007) found that the same system was able to reduce the mean rate of safety-critical events/1,000 miles by up to 70 percent in a sample of novice teen drivers. Second, these reductions were likely compounded (at least in data set B) by the intense media attention regarding distracted driving. Third, the fact that the fleets in the data set purchased and used the system likely reflects a group of safety conscious fleets. Of course, it is possible the converse is true (i.e., fleet with significant safety issues decided they needed the driver monitoring system). Lastly, the available view of the driver from the system was less comprehensive as compared to the video views in Blanco et al. (in press). Figure 4 shows the five camera view available in Blanco et al. This limited view of the driver using the system (as shown in Figure 2), combined with the three other factors noted, may have resulted in fewer distracted driving events being recorded than may be occurring in the larger truck and bus population.

Adapted from Blanco et al. (in press)

Figure 4. Photos. Five screenviews captured by event recorders installed on test vehicle.

3.2 ANALYSIS 2: ODDS RATIOS FOR TERTIARY TASKS

Table 28 shows the odds ratios for each tertiary task in data set B for all safety-critical events. Note that crashes are included in the safety-critical events in data set B. Also, each cell phone safety-critical event and baseline in data set B was re-reviewed to classify specific cell phone sub-tasks.

As shown in Table 28, many of the tertiary tasks in data set B had a significant odds ratio. If 1.0 is not included between the lower confidence limit and the upper confidence limit, the odds ratio is significant. The odds ratios for other distraction and texting/e-mailing/accessingthe Internet were very high. An odds ratio is a measure of association (not unlike a correlation) which can be used under the correct circumstances as an estimate of relative risk. In this situation, the odds ratios for other distraction and texting/e-mailing/accessingthe Internet indicated a strong relationship between these tertiary tasks and safety-critical events. As shown by the large 95 confidence interval for these tertiary tasks, the error associated with these odds ratio estimates was extremely high (there were only 3 and 13 baseline events for texting/e-mailing/accessingthe Internet, and other distraction, respectively); thus, it was difficult to report the odds ratio in any meaningful sense other than to report there was a very strong relationship between other distraction and texting/e-mailing/accessingthe Internet and involvement in a safety-critical event.

Table 28. Odds ratios for each tertiary task in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage	1.14*	1.06	1.23	895	4,262
Dialing Cell Phone	3.51*	2.89	4.27	165	256
Talking/Listening Hands Free Cell Phone	0.65*	0.56	0.76	194	1,626
Talking/Listening Hand Held Cell Phone	0.89	0.80	1.00	372	2,266
Reaching for Headset/Earpiece	3.38*	2.64	4.31	104	168
Reaching for Cell Phone	3.74*	2.97	4.71	122	178
Texting/E-mailing/Accessing the Internet	163.59*	51.77	516.73	90	3
Consuming Food/Drink	1.11	0.97	1.26	268	1,320
Other Distraction	511.64*	296.20	883.79	1,220	13
Passenger Distraction	–	–	–	30	0

Note: Asterisk indicates a significant odds ratio.

Truck and bus drivers reaching for a cell phone while driving were found to increase significantly their odds of involvement in a safety safety-critical event by 3.7 times. Dialing a cell phone while driving significantly increased the odds of involvement in a safety-critical event by 3.5 times, while reaching for a headset/earpiece increased the odds by 3.4 times. The tertiary task, any cell phone usage, includes all the specific cell phone sub-tasks. This is analogous to how cell phone usage was classified in data set A. As shown in Table 28, drivers significantly increased their odds of involvement in a safety-critical event by 1.14 times for any cell phone usage while driving.

One tertiary task was found to decrease significantly the odds of involvement in a safety-critical event. That is, drivers were less likely to be involved in a safety-critical event while talking/listening on a hands-free cell phone. Both consuming food/drink and talking/listening on a hand-held cell phone (odds ratios = 1.11 and 0.89, respectively) had non-significant odds ratios (i.e., no increase and/or decrease in risk).

Table 29 shows the odds ratios for each cell phone sub-task across each fleet cell phone policy in data set B. Note that fleets with an unknown cell phone policy in data set B were excluded from this analysis. Also note that the tertiary tasks, consuming food/drink and other distraction, are not shown as these tertiary tasks would not be affected by the cell phone policy. The tertiary task, texting/e-mailing/accessing the Internet, is not shown as the sample size for this tertiary task does not allow disaggregated analyses.

As shown in Table 29, many of the tertiary tasks in the disaggregated data set B had a significant odds ratio. Regardless of the fleet's cell phone policy, drivers' odds of being involved in a safety-critical event increased significantly while reaching for a cell phone (odds ratios = 4.24 if cell phone policy is in place and 3.38 if the company has no cell phone policy), dialing a cell phone (odds ratios = 3.76 and 3.11, respectively with or without a company policy), and reaching for a headset/earpiece while driving (odds ratios = 3.30 and 3.84, respectively with or without a company policy). The tertiary task, any cell phone usage, includes all the specific cell phone sub-tasks. As shown in Table 29, regardless of fleet cell phone policy, drivers' odds of involvement in a safety-critical event increased significantly for any cell phone usage while driving (odds ratios = 1.16 and 1.22, respectively with or without a company policy).

Two tertiary tasks were found to decrease significantly the odds of involvement in a safety-critical event. Truck and bus drivers significantly decreased their odds of involvement in a safety-critical event while talking/listening on a hands-free cell phone in a fleet with a cell phone policy (odds ratio = 0.58) and while talking/listening on a hand-held cell phone in a fleet with no cell phone policy (odds ratio = 0.78). However, talking/listening on a hands-free cell phone in a fleet with no cell phone policy and talking/listening on a hand-held cell phone in a fleet with a cell phone policy had non-significant odds ratios (odds ratios = 1.3 and 0.97, respectively).

Table 29. Odds ratios for cell phone sub-tasks across each fleet cell phone policy in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage (No Cell Phone Policy)	1.22*	1.04	1.43	194	934
Any Cell Phone Usage (Cell Phone Policy)	1.16*	1.07	1.27	644	2,815
Dialing Cell Phone (No Cell Phone Policy)	3.11*	2.11	4.61	38	72
Dialing Cell Phone (Cell Phone Policy)	3.76*	3.0	4.77	119	161
Talking/Listening Hands Free Cell Phone (No Cell Phone Policy)	1.31	0.93	1.84	41	184
Talking/Listening Hands Free Cell Phone (Cell Phone Policy)	0.58*	0.48	0.70	137	1,205
Talking/Listening Hand Held Cell Phone (No Cell Phone Policy)	0.78*	0.62	0.98	86	649
Talking/Listening Hand Held Cell Phone (Cell Phone Policy)	0.97	0.85	1.11	265	1,388
Reaching for Headset/Earpiece (No Cell Phone Policy)	3.84*	2.38	6.18	28	43
Reaching for Headset/Earpiece (Cell Phone Policy)	3.30*	2.44	4.46	70	108
Reaching for Cell Phone (No Cell Phone Policy)	3.38*	2.17	5.27	31	54
Reaching for Cell Phone (Cell Phone Policy)	4.24*	3.15	5.71	80	96

Note: Asterisk indicates a significant odds ratio.

Table 30 shows the odds ratios for each tertiary task in 3 axle or more trucks in the data set B. As shown in Table 30, many of the tertiary tasks in 3 axle or more trucks in data set B had a significant odds ratio. Three axle or more truck drivers significantly increased their odds of involvement in a safety-critical event by 5.9 times while dialing a cell phone while driving. Reaching for a headset/earpiece while driving a 3 axle or more truck increased risk by 4.6 times, while reaching for a cell phone and consuming food/drink increased the odds by 4.0 times and 1.3 times, respectively.

The tertiary task, any cell phone usage, includes all the specific cell phone sub-tasks. As shown in Table 30, 3 axle or more truck drivers significantly increased their odds of involvement in a safety-critical event by 1.9 times for any cell phone usage while driving. Both talking/listening on a hands-free cell phone and talking/listening on a hand-held cell phone (odds ratios = 1.4 and 1.0, respectively) had non-significant odds ratios.

Table 30. Odds ratios for each tertiary task in 3 axle or more trucks in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage	1.93*	1.64	2.27	192	759
Dialing Cell Phone	5.92*	3.70	9.47	31	40
Talking/Listening Hands-Free Cell Phone	1.38	0.92	2.06	28	155
Talking/Listening Hand-Held Cell Phone	0.98	0.77	1.27	69	534
Reaching for Headset/Earpiece	4.64*	2.53	8.48	17	28
Reaching for Cell Phone	4.04*	2.28	7.17	18	34
Consuming Food/Drink	1.26*	1.03	1.55	113	683

Note: Asterisk indicates a significant odds ratio.

Table 31 shows the odds ratios for each tertiary task in buses data set B. As shown in Table 31, many of the tertiary tasks in buses in data set B had a significant odds ratio. Bus drivers significantly increased their odds of involvement in a safety-critical event by 2.8 times while reaching for a headset/earpiece while driving. Reaching for a cell phone while driving a bus significantly increased the odds of involvement in a safety-critical event by 2.5 times. Dialing a cell phone and talking/listening on a hands-free cell phone increased the odds by 2.5 and 1.3 times, respectively.

The tertiary task, any cell phone usage, includes all the specific cell phone sub-tasks. As shown in Table 31, bus drivers significantly increased their odds of involvement in a safety-critical event by 1.4 times for any cell phone usage while driving. Talking/Listening on a hand-held cell phone and consuming food/drink had a non-significant odds ratios (odds ratios = 1.1 and 1.24, respectively).

Table 31. Odds ratios for each tertiary task in buses in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage	1.42*	1.27	1.59	409	1,152
Dialing Cell Phone	2.45*	1.87	3.22	84	137
Talking/Listening Hands-Free Cell Phone	1.34*	1.05	1.72	83	247
Talking/Listening Hand-Held Cell Phone	1.02	0.87	1.20	185	724
Reaching for Headset/Earpiece	2.82*	2.00	3.99	55	78
Reaching for Cell Phone	2.52*	1.81	3.50	58	92
Consuming Food/Drink	1.24	0.98	1.55	98	317

Note: Asterisk indicates a significant odds ratio.

Table 32 shows the odds ratios for each tertiary task in tractor trailers/tankers in data set B. As shown in Table 32, many of the tertiary tasks in tractor trailers/tankers in data set B had a significant odds ratio. Tractor trailer/tanker drivers significantly increased their odds of involvement in a safety-critical event by 7.6 times while reaching for a cell phone while driving. Dialing a cell phone while driving a tractor trailer/tanker increased risk by 5.4 times, while reaching for a headset/earpiece device and consuming food/drink increased risk by 4.4 and 1.5 times, respectively.

One tertiary task was found to decrease significantly the risk of involvement in a safety-critical event. That is, drivers were less likely to be involved in a safety-critical event while talking/listening on a hands-free cell phone (odds ratio = 0.58). The tertiary task, any cell phone usage, includes all the specific cell phone sub-tasks. As shown in Table 32, both any cell phone usage and talking/listening on a hand-held cell phone had a non-significant odds ratios (odds ratios = 1.1 and 1.1, respectively).

Table 32. Odds ratios for each tertiary task in tractor trailers/tankers in data set B.

Tertiary Task	Odds Ratio	Lower Confidence Limit	Upper Confidence Limit	Frequency of Safety Critical Events	Frequency of Baseline Events
Any Cell Phone Usage	1.08	0.95	1.22	294	2,351
Dialing Cell Phone	5.44*	3.81	7.76	50	79
Talking/Listening Hands-Free Cell Phone	0.58*	0.47	0.73	83	1224
Talking/Listening Hand-Held Cell Phone	1.01	0.83	1.22	118	1,008
Reaching for Headset/Earpiece	4.43*	2.89	6.80	32	62
Reaching for Cell Phone	7.60*	5.11	11.31	46	52
Consuming Food/Drink	1.53*	1.15	2.03	57	320

Note: Asterisk indicates a significant odds ratio.

3.2.1 Summary

The odds ratio for other distraction was extremely high. While there was a very strong relationship between other distraction and involvement in a safety-critical event, the operational definition for this tertiary task was nebulous (included anything not listed in Table 9); thus, making any meaningful interpretation on this tertiary task was not possible.

The odds ratios for each vehicle type (e.g., 3 axle or more truck, bus, and tractor trailer/tanker) found some interesting trends. Although the magnitude of the odds ratios varied, the tertiary tasks, dialing a cell phone, reaching for a cell phone, and reaching for a headset/earpiece all increased the risk of involvement in a safety-critical event in 3 axle or more trucks, buses, and tractor trailers/tankers. The tertiary task, talking/listening on a hand-held cell phone, was consistently found to have no impact on the odds of involvement in a safety-critical event in each vehicle type. However, differences in risk between each vehicle type were found when evaluating the tertiary tasks, talking/listening on a hands-free cell phone and consuming food/drink. For example, talking/listening on a hands-free phone was found to increase the odds of involvement in a safety-critical event in buses (odds ratio = 1.3), decrease the odds in tractor trailers/tankers (odds ratio = 0.60), and have no impact on the odds in 3 axle or more trucks (odds ratio = 1.4). Consuming food/drink was found to increase significantly the odds of involvement in a safety-critical event in tractor trailers/tankers and 3 axle or more trucks (odds ratios = 1.5 and 1.3, respectively), but have no impact on the odds in buses (odds ratio = 1.2).

It is also important to note this was an observational study that evaluated associations between various tertiary tasks and safety-critical event occurrence. The study did not evaluate cause and effect (i.e., cell phone use *caused* a safety-critical event), but rather showed which tertiary tasks increased commercial truck and bus drivers odds of being involved in safety-critical event if they engaged in those tertiary tasks while driving. As indicated above, the data sets may not reflect the actual prevalence of driver distractions in 3 or more axle trucks, buses, and tractor trailers/tankers. However, the presence of an OBSM system, such as DriveCam, does not change the riskiness of engaging in tertiary tasks while driving, it only affects the prevalence of drivers who engage in those tasks while driving, which in turn may alter the odds ratios.

3.3 ANALYSIS 3: POPULATION ATTRIBUTABLE RISK

In analysis 3, PAR percentages were calculated on all significant odds ratios greater than 1.0 in data set B. The PAR provides an assessment of the percentage of safety-critical events that occurred in the population and that were directly attributable to the specific tertiary tasks measured. Table 33 shows the PAR and 95 percent confidence interval for all odds ratios greater than 1.0 in data set B for all safety-critical events and each fleet cell phone policy. Note that a very large rate ratio estimate will result in a higher PAR estimate. Given how many safety-critical events and baseline events were in the data set and how rare some of the tertiary tasks were explains why some of the PAR estimates were rather low and contained a negative confidence interval (thereby uninterruptable); however, the rate ratio estimates for other distraction and texting/e-mailing/accessing the Internet were so large that it did not matter how frequently these tertiary tasks occurred. As indicated above, the error for other distraction and texting/e-mailing/accessing the Internet does not allow an interpretable PAR."

Table 33. PAR and 95 percent confidence intervals for each tertiary task in data set B for all safety-critical events and each fleet cell phone policy.

Tertiary Tasks	PAR	Lower Confidence Limit	Upper Confidence Limit
Any Cell Phone Usage	0.30	-0.32	0.92
Any Cell Phone Usage (No Cell Phone Policy)	0.77	-0.48	2.02
Any Cell Phone Usage (Cell Phone Policy)	0.34	-0.39	1.07
Dialing Cell Phone	0.43	-0.13	0.99
Dialing Cell Phone (No Cell Phone Policy)	0.73	-0.53	2.00
Dialing Cell Phone (Cell Phone Policy)	0.48	-0.16	1.11
Reaching for Headset/Earpiece	0.26	-0.46	0.99
Reaching for Headset/Earpiece (No Cell Phone Policy)	0.64	-0.61	1.88
Reaching for Headset/Earpiece (Cell Phone Policy)	0.25	-0.66	1.16
Reaching for Cell Phone	0.34	-0.28	0.95
Reaching for Cell Phone (No Cell Phone Policy)	0.64	-0.67	1.95
Reaching for Cell Phone (Cell Phone Policy)	0.35	-0.35	1.05
Texting/E-mailing/Accessing the Internet	5.84	5.78	5.92
Other Distraction	72.02	72.01	77.04

3.4 ANALYSIS 4: ODDS RATIOS FOR FLEET POLICY AND STATE LAW

In analysis 4, odds ratios were calculated to approximate the effectiveness of a fleet cell phone policy and State cell phone law regarding cell phone use while driving. As indicated above, these odds ratio did not look at how cell phone use while driving affected involvement in a safety-critical event, but rather evaluated the odds of cell phone usage given a fleet cell phone policy or State cell phone law versus the odds of cell phone usage given no fleet cell phone policy or State cell phone law. Table 34 shows the odds ratios for cell use while driving in each cell phone policy in the entire days data set (i.e., data set A + B) for all safety-critical events and baseline events. As shown in Table 34, for truck and bus drivers the odds of using a cell phone while driving under a fleet cell phone policy were .83 times less, compared to no fleet cell phone policy. However, the data shows that a State cell phone law did not significantly impact drivers' likelihood in using their cell phone while driving compared to a State that did not have a law prohibiting cell phone use (odds ratio = 0.97). The results from the study suggest that these laws may not be effective because drivers may be ignoring or unaware of them.

Table 34. Odds ratios for cell phone use while driving in each cell phone policy in the 365 day data set (safety-critical events).

Cell Phone Policy	Odds Ratio	LCL	UCL	Frequency of Cell Phone Use with Policy/Law	Frequency of No Cell Phone Use with Policy/Law
Fleet Cell Phone Policy	0.83*	0.78	0.87	8,787	1,897
State Cell Phone Law	0.97	0.94	1.01	4,526	2,987

Note: Asterisk indicates a significant odds ratio.

4. DISCUSSION

4.1 SUMMARY

The introduction of naturalistic driving studies that record drivers (through video and kinematic sensors) in actual driving situations has created a scientific method to study driver behavior in real-world driving conditions in the presence of real-world daily pressures. If the primary intention of transportation safety research is to understand driver behavior in the real-world, then naturalistic studies, conducted in the real-world, must be considered the gold standard. However, conducting large-scale naturalistic driving studies is complex and there have only been a few published naturalistic studies that have assessed driver distraction (Klauer et al., 2006; Olson et al., 2009; Sayer, Devonshire, & Flanagan, 2007). More naturalistic research is needed across different settings and research sites to validate the results found in these studies.

The aim of this project was to document the prevalence of distractions while driving a commercial truck and bus using an existing naturalistic data set. Commercial trucks (3 axle and tractor trailer/tanker) and buses (transit and motor coaches) were the target vehicles in the analyses. Two large and diverse data sets were used in the study. The data in data set B came from 183 different truck and bus fleets comprising a total of 13,306 vehicles. A total of 1,085 crashes, 8,375 near-crashes, 30,661 crash-relevant conflicts, and 211,171 baseline events were captured from these 13,306 vehicles in data set B. The data in data set A came from 207 different truck and bus fleets comprising a total of 13,431 vehicles. A total of 1,336 crashes, 15,864 near-crashes, and 173.591 crash-relevant conflicts were captured from these 13,431 vehicles in data set A.

All safety-critical events and baseline events are in data set B (i.e., June 6, 2009–September 5, 2009) and all safety-critical events are in data set A (September 6, 2008–June 5, 2009). In data set B, the vendor re-reviewed all safety-critical events and baseline events where cell phone was noted as a distraction to determine the frequency of the following cell-phone tasks: dialing cell phone, reaching for cell phone, reaching for headset/earpiece, talking/listening on hands-free cell phone, talking/listening on hand-held cell phone, and texting/e-mailing/accessing the Internet on cell phone. Note that the vendor's normal data reduction only records cell phone use and does not classify the individual cell phone tasks noted above. The vendor also re-reviewed all crashes in data set B and documented all the distractions that occurred. Note that the vendor does not normally perform data reduction on crashes. Data set A was identical to data set B; except the separate cell phone tasks were not classified and data reduction was not conducted on crashes in data set A. Note that the results (above) and conclusions (below) only deal with professional drivers in a commercial motor vehicle mode and do not represent other drivers in other transportation modes.

4.2 CONCLUSIONS

There were several interesting findings in the data that require further discussion. First, while the OBSM system certainly influenced the prevalence of tertiary tasks, it should not influence the risk in performing these tasks while driving. However, some fleets with a cell phone policy were more stringent in their monitoring and modification of cell phone use than others. Under these circumstances risk would be affected as cell phone use in a fleet with a strict cell phone policy might be coded as a safety-critical event, while the identical cell phone use might be coded as a baseline in a fleet with a more liberal cell phone policy. More specifically, a fleet with the strict cell phone policy may have instructed the vendor to code any cell phone use as safety event, while a fleet with the liberal cell phone policy may have instructed the vendor to code cell phone use as a safety event only if it occurred in conjunction with a traffic safety event.

This was not seen as a limitation as the study was able to control for this by disaggregating the results by fleet cell phone policy. The cell phone results for fleets with no cell phone policy should be viewed as the most accurate assessment of risk; thus, the conclusions below regarding cell phone use generally describe the results for these disaggregated results (i.e., fleets with no cell phone policy). Surprisingly, the odds of involvement in a safety-critical event associated with each non-talking/listening cell phone sub-task were very similar in fleets with and without a cell phone policy. Differences were shown with regard to talking/listening on hand-held and hands-free cell phone. For example, talking/listening on a hands-free phone was shown to decrease significantly the odds of involvement in a safety-critical event in fleets with a fleet cell phone policy (odds ratio = 0.58), while the same cell phone sub-task was shown not to have any impact on involvement in safety-critical events for fleets without a cell phone policy (odds ratio = 1.31; not significant). The converse was found with talking/listening on a hand-held phone (i.e., talking/listening on a hands-free phone was shown to not have any impact on risk for fleets with a fleet cell phone policy, while the same cell phone sub-task was shown to be protective for fleets without a fleet cell phone policy). However, it is important to stress that in either case, talking/listening was not associated with an increase in the odds of involvement in a safety-critical event (i.e., either a non-significant odds ratio or a significant decrease in the odds). Thus, in this study and in Olson et al. (2009), talking/listening on a hands-free cell phone was not associated with increased odds of involvement in a safety-critical event.

Second, the results in this study were very similar to the results found by Olson et al. (2009) regarding safety-critical event risk and performing a tertiary task while driving. Table 35 shows a comparison of the odds ratios for selected tertiary tasks in this study and those found in Olson et al. Both studies found a very strong relationship between texting/e-mailing/accessing the Internet and involvement in a safety-critical event. This study found that reaching for a headset/earpiece or a cell phone significantly increased the odds of involvement in a safety-critical event by 3.4 and 3.8 times, respectively, in fleets with no cell phone policy. While Olson et al. did not classify these specific reaching tasks, the authors found that reaching for other electronic devices (which included headsets/earpieces) significantly increased the odds of involvement in a safety-critical event by 6.7 times. The tertiary task, consuming food/drink, was also found to have a non-significant odds of involvement in a safety-critical event in this study and Olson et al. There were differences between the two studies regarding the odds of involvement in a safety-critical event while talking/listening on a cell phone while driving. As shown in Table 35, this study found that talking/listening on a hand-held cell phone significantly decreased the odds of involvement in a safety-critical event in fleets with no cell phone policy (odds ratio = 0.78), while Olson et al. found that talking/listening on a hand-held cell phone did not impact the odds of involvement in a safety-critical event (odds ratio = 1.0). The converse was found when comparing talking/listening on a hands-free cell phone (i.e., the study found no significant impact on the odds of involvement in a safety-critical event while talking/listening on a hands-free phone in fleets with no cell phone policy, while Olson et al. found the same cell phone sub-task to significantly decrease the odds of involvement in a safety-critical event. This study also found that truck and bus drivers significantly increased their odds of involvement in a safety-critical event if they engaged in any cell phone use while driving, while Olson et al. found any cell phone use to not significantly increase drivers' odds of involvement in a safety-critical event. The reason for this discrepancy is the robust decrease in the odds of involvement in a safety-critical event for the cell phone sub-tasks, talking/listening on a hands-free device, in the Olson et al. study. Note that all trucks in the Olson et al. study were tractor-trailers.

Table 35. Odds ratios comparison for selected tertiary tasks in this study and Olson et al. (2009).

Tertiary Task	Odds Ratios Across all Vehicles with no Fleet Cell Phone Policy in this Study	Odds Ratios for Tractor Trailers/Tankers Only in this Study	Odds Ratios in Olson et al. (2009)
Any Cell Phone Use	1.22*	1.08	1.04
Dialing Cell Phone	3.1*	5.44*	5.93*
Talking/Listening Hands-Free Cell Phone	1.31	0.58*	0.44*
Talking/Listening Hand-Held Cell Phone	0.78*	1.01	1.04
Reaching for Headset/Earpiece	3.4*	4.43*	6.72*
Reaching for Cell Phone	3.8*	7.60*	Included in dialing cell phone
Texting/E-mailing/Accessing the Internet	163.6*	–	23.24*
Consuming Food/Drink	1.1	1.53*	1.01

Note: Asterisk indicates a significant odds ratio.

The results reported in the previous paragraph include all vehicle types. The Olson et al. (2009) study only included tractor-trailers; thus, the inclusion of 3 axle or more trucks and buses in this comparison might obscure any differences related to those specific vehicle types. As shown in Table 35, the odds ratios for selected tertiary tasks in tractor trailers/tankers are also shown. The odds ratios for selected tertiary tasks in tractor trailers/tankers in this study were very similar to the odds ratios for tractor trailers found in Olson et al. Notably, the tertiary task, consuming food/drink, was found to significantly increase the odds of involvement in a safety-critical event in this study, while Olson et al. found that consuming food/drink did not have an impact on the odds of involvement in a safety-critical event.

Third, it appears using a cell phone to text, e-mail, or access the Internet while driving is in a category of risk all by itself. Although the odds ratios for this tertiary task were very large in both this study and in Olson et al. (2009), it was also associated with a large amount or error (as shown by the large 95 percent confidence interval). There were very few instances of this behavior observed during safety-critical events in this study and Olson et al. (90 and 23, respectively) and even fewer during control events (3 and 3, respectively). As indicated above, an odds ratio is a measure of association (not unlike a correlation) which can be used under the correct circumstances as an estimate of rate ratio. In this situation, the odds ratio for texting/

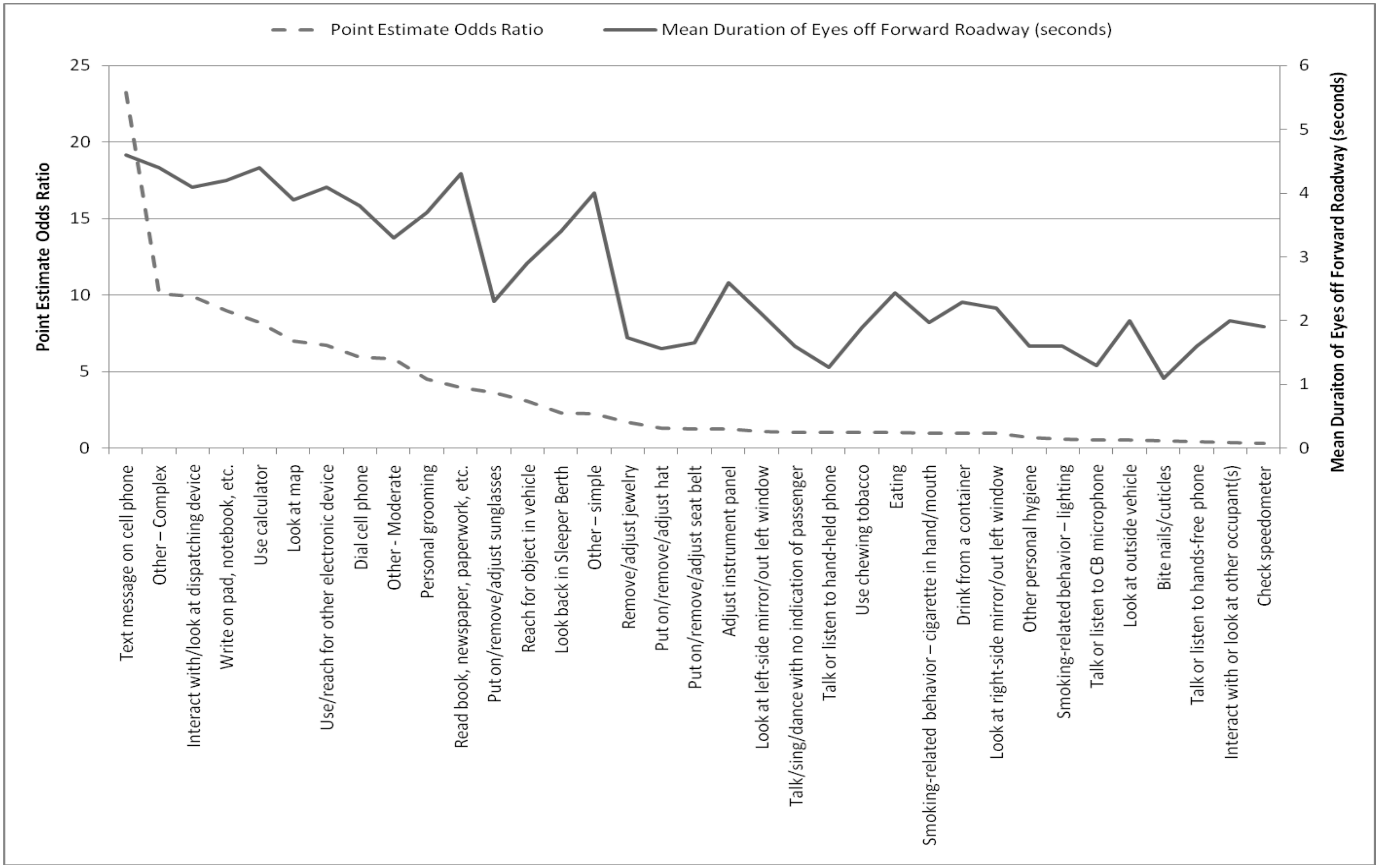
e-mailing/accessing the Internet indicates a strong relationship between this tertiary task and involvement in a safety-critical event. It is difficult to report the odds ratio in any meaningful sense other than to report there is a very strong relationship between texting/e-mailing/accessing the Internet while driving and involvement in a safety-critical event. The data suggests that truck and bus drivers who use their cell phone to text, e-mail, or access the Internet *are very likely* be involved in a safety-critical event.

Fourth, the finding that talking/listening on a cell phone while driving does not increase the odds of involvement in a safety-critical event was not restricted to commercial truck and bus drivers (but only for hand-held cell phone in bus drivers). Klauer et al. (2006) found that talking or listening on a hand-held phone did not statistically elevate the odds of being involved in a safety-critical event in a naturalistic study with light vehicle drivers. Similarly, a naturalistic study by Sayer, Devonshire, and Flanagan (2007) found that light vehicle drivers improved their speed variance when using a cell phone while driving and maintained their eyes on the forward roadway. However, the results from these naturalistic studies are in opposition to results found in simulator studies that suggest talking/listening on a cell phone while driving does increase risk (e.g., Beede & Kass, 2006; Patten et al., 2004; Strayer & Johnston, 2001; Strayer, Drews, & Johnston, 2003), although this could be due how cell phone use is considered a dichotomous variable in some studies.

The Olson et al. (2009) study was the first published naturalistic study to quantify the role of visual distraction while commercial truck drivers engaged in various tertiary tasks. Olson et al. and Hanowski et al. (in press) suggest a strong relationship between the odds ratios for tertiary tasks and mean duration of eyes off the forward roadway. Figure 5, adapted from Hanowski et al. (in press), shows a plot of odds ratios and mean durations of eyes of forward roadway times for each tertiary task in Olson et al. (For numeric values see Table 36.) The plot in Figure 5 shows a strong linear relationship between the odds ratios (dashed blue line using the left y-axis) and the mean duration of eyes off the forward roadway (solid red line using the right y-axis). For example, texting was associated with the highest odds ratio and longest mean eyes off the forward roadway time (4.6/6.0 seconds). As the odds ratios decrease, so does the mean eyes off the forward roadway times, such as reaching for other electronic device (4.10/6.0 seconds), dialing a cell phone (3.8/6.0 seconds), talking/listening on hands-free cell phone (1.60/6.0 seconds), and talking/listening on a hand-held phone (1.27/6.0 seconds) (Olson et al.).

In this study those tertiary tasks associated with the greatest visual attention had the greatest risk (e.g., texting/e-mailing/accessing the Internet, dialing a cell phone, reaching for cell phone, and reaching for a headset/earpiece), while those tertiary tasks associated with the least visual attention had no impact on the odds of being involved in a safety-critical event, in fact, one of these tasks was shown to decrease the odds of involvement in a safety-critical event (e.g., talking/listening on a hand-held and hands-free phone). It appears the primary difference between these high-risk and low-risk tertiary tasks involves the amount of visual distraction (as all tasks have a cognitive component). Although no eye glance analysis was performed in this study, the results lend support to the contention by Olson et al. (2009) and Hanowski et al. (in press) that tertiary tasks associated with significant visual attention regarding have the highest odds of involvement in a safety-critical event.

A curious finding in the study was when the driver groups were disaggregated by vehicle type, bus drivers significantly increased their odds of involvement in a safety-critical event while talking/listening on a hands-free cell phone (but not an increased risk for hand-held). This finding was an anomaly when considering the results in the talking/listening sub-tasks in all other vehicle types. And, when all vehicle types (including buses) were collapsed (i.e., considered together), the talking/listening on a hands-free cell phone had a significant decrease in the odds of involvement in a safety-critical event. With the exception of bus drivers listening/talking on a hands-free cell phone, the results for all other disaggregated vehicle types showed no increase in the odds of involvement in a safety-critical event or had a significant decrease in the odds of involvement in a safety-critical event for talking/listening. As such, this result contradicts the preponderance of findings from the other analyses conducted in this study and the results from other naturalistic studies that show talking/listening on a cell phone does not increase the odds of involvement in a safety-critical event. Limited sample size prevented the disaggregation of bus data by fleet cell phone policy; thus, it is unknown if the fleet cell phone policy in buses would affect the direction of this result. Also, the 95 percent confidence interval for bus drivers talking/listening on a hands-free cell phone was 1.05 to 1.71, so a small amount of variability could impact the odds ratio. Nonetheless, because limited research has been directed at bus drivers specifically, it is a finding that should prompt further investigation. It may turn out to be a spurious finding, the result of outliers, or a statistical anomaly, but it nonetheless requires further research investigation, particularly in this unique group of commercial drivers.



Adapted from Hanowski et al. (in press).

Figure 5. Chart. Plot of the odds ratios and values for mean duration of eyes off the forward roadway for each tertiary task.

Table 36. Odds ratios and values for mean duration of eyes off the forward roadway for each tertiary task (numeric values from Figure 5).

Tertiary Task	Point Estimate Odds Ratio (range 0–25 points)	Mean Duration of Eyes off Forward Roadway (seconds)
Text message on cell phone	23.24*	4.60
Other—Complex Tertiary Task	10.07*	4.40
Interact with/look at dispatching device	9.93*	4.10
Write on pad, notebook, etc.	8.98*	4.20
Use calculator	8.21*	4.40
Look at map	7.02*	3.90
Use/reach for other electronic device	6.72*	4.10
Dial cell phone	5.93*	3.80
Other—Moderate Tertiary Task	5.86*	3.80
Personal grooming	4.48*	3.70
Read book, newspaper, paperwork, etc.	3.97*	4.30
Put on/remove/adjust sunglasses	3.63*	2.30
Reach for object in vehicle	3.09*	2.90
Look back in Sleeper Berth	2.30*	3.40
Other—Simple Tertiary Task	2.23	4.00
Remove/adjust jewelry	1.68	1.73
Put on/remove/adjust hat	1.31	1.56
Put on/remove/adjust seat belt	1.26	1.66
Adjust instrument panel	1.25*	2.60
Look at left-side mirror/out left window	1.09	2.10
Talk/sing/dance with no indication of passenger	1.05	1.60
Talk or listen to hand-held phone	1.04	1.27
Use chewing tobacco	1.02	1.89
Eating	1.01	2.43
Smoking-related behavior—cigarette in hand/mouth	0.97	1.97
Drink from a container	0.97	2.29
Look at right-side mirror/out left window	0.95	2.20
Other personal hygiene	0.67	1.60
Smoking-related behavior—lighting	0.60	1.60
Talk or listen to CB microphone	0.55	1.30
Look outside vehicle	0.54	2.00
Bite nails/cuticles	0.45	1.10
Talk or listen to hands-free phone	0.44	1.6
Interact with or look at other occupant(s)	0.35	2.00
Check speedometer	0.32	1.90

* Asterisk indicates a significant odds ratio

Distracted driving is an important safety issue, and many State and Federal organizations have passed and/or proposed bans on using cell phones while driving. So, the real question is whether it is safe to use a cell phone while driving? The answer depends on what is meant by the term “cell phone use.” If cell phone use implies use of the cell phone in any manner, then the data in this study suggest that cell phone use significantly increases the odds of involvement in a safety-critical event by 1.22 times (in fleets with no cell phone policy). However, if cell phone use is classified into specific cell phone tasks or sub-tasks (Hanowski et al., in press), then certain cell phone sub-tasks are shown to increase significantly the odds of involvement in a safety-critical event (e.g., texting/e-mailing/accessing the Internet, dialing a cell phone, reaching for cell phone, and reaching for a headset/earpiece), while others are not, and may, in fact, significantly decrease the odds of involvement in a safety-critical event (e.g., talking/listening on a hand-held and hands-free phone). Given the differences in odds ratios associated with the specific cell phone sub-tasks, researchers studying distracted driving should consider cell phone use as a series of specific sub-tasks, rather than one task, that are not associated with an equivalent degree of risk. Research that defines and records cell-phone use as one higher-level task and either ignores the specific cell phone sub-tasks will result in a skewed understanding of this issue.

Fifth, the odds ratio calculations revealed differences between each vehicle type. While most of the odds ratios were in the same direction, the magnitude of the odds ratios differed. This highlights the need to conduct naturalistic driving research in as many vehicle types (transport modes) and settings as possible as each are exposed to different work demands and driving situations. Unfortunately, the data set was not detailed enough to highlight these inter-modal (or vehicle type) difference.

Sixth, it should not come as a surprise that commercial truck and bus drivers were far less likely to use their cell phone while driving under a fleet cell phone policy as the OBSM system allowed these fleets to accurately monitor their drivers. This make intuitive sense as the OBSM system afforded safety managers and direct supervisors an opportunity to monitor drivers and implement consequences that would directly impact the driver (e.g., punishment for policy violation).

Seventh, as data set A only included 2 days in which media attention may have influenced the data, the data in data set B controls for this event and may document the influence of the media attention on distracted driving (i.e., the only difference between the two data sets was the wide-spread media attention). It appears the increased media attention may have influenced safety managers' and/or drivers' behavior. Overall, commercial truck and bus drivers in data set A used their cell phone in 4.0 percent of the safety-critical events, while the commercial truck and bus drivers in data set B used their cell phone in 2.6 percent of the total safety-critical events (a 35 percent reduction). However, the driving force beyond this difference was clearly shown when the results are disaggregated by fleet cell phone policy. Commercial truck and bus drivers in fleets with no cell phone policy in data set A used their cell phone in 4.3 percent of the safety-critical events, while the commercial truck and bus drivers in fleets with no cell phone policy in the data set B used their cell phone in 4.7 percent of the total safety-critical events (a 8.5 percent increase). However, commercial truck and bus drivers in fleets with a cell phone policy in data set A used their cell phone in 4.0 percent of the safety-critical events, while the commercial truck and bus drivers in fleets with a cell phone policy in the data set B used their cell phone in 2.7 percent of the total safety-critical events (a 32.5 percent decrease). Although interesting and in the correct direction, the possible media effect on the prevalence of cell phone use while driving in the two data sets cannot be precisely evaluated as the data set A did not contain baseline events. Nonetheless, and although further assessment is required, the data suggest that awareness of the distracted driving problem may have had an effect on curbing cell phone use while driving (at least temporarily).

Eighth, the significant decrease in the odds of involvement in a safety-critical event and/or non-significant results regarding the odds of involvement in a safety-critical event while talking/listening on a cell phone while driving have sparked controversy in the academic community and other traffic safety organizations. An extensive amount of published simulator and closed test track studies have shown performance decrements while talking/listening on a cell phone—both hand-held and hands-free (NSC, 2010)—and many safety organizations have advocated bans on cell phone use of any kind while driving. Simulator and closed test track studies have shown decrements in driver's reaction time, lane keeping, and scanning ability; however, some of these same simulator studies have also found that drivers' reduced their speed and/or following distance to a lead vehicle when talking on a cell phone while driving (Haigney, Taylor, & Westerman, 2000; Rakauskas, Gugerty, & Ward, 2004; Strayer, Drews, & Crouch, 2006; Strayer, Drews, & Johnson, 2004). The question is not whether these performance decrements take place while talking/listening on a cell phone while driving, but do these performance decrements increase crash risk in the real world? As shown in this analysis, if cell phone use is treated as a dichotomous variable (yes/no), the results in the study support the results found in simulator studies that cell phone use significantly increases the odds of involvement in a safety-critical event. The study found that any cell phone use significantly increased the odds of involvement in a safety-critical event by 1.22 (in fleets with no cell phone policy); however, when the cell phone task is examined at a sub-task level, it is clear that not all cell phone sub-tasks are associated with an equal degree of risk. More specifically, those sub-tasks that require the driver to take his eyes off of the forward roadway (by reaching, dialing, texting) have significantly increased risk. Of equal importance is that talking/listening tasks, where the driver's eyes can be maintained on the forward roadway, were generally associated with no significant increase in the odds of involvement in a safety-critical event. Therefore, future research on this topic must examine the cell phone task as a set of sub-tasks. If not, then the conclusions from such studies will be incorrect and misleading.

Finally, some have argued that naturalistic studies are limited as there are few crashes in these data sets (as crashes are a rare event in the real-world) and risk is calculated on non-crash safety events (such as near-crashes and safety-critical events) (NSC, 2010). A key feature of this study was that the data set that was used included over 1,000 crashes; and it is noteworthy that these results are consistent with previous naturalistic driving studies that used far fewer crashes.

4.3 POSSIBLE LIMITATIONS

The authors acknowledge six caveats when interpreting the results. First, the DriveCam data set involves an active safety intervention (via behavioral coaching through review of video clips by safety managers). More specifically, the frequency and distribution of tertiary tasks in the DriveCam data set was likely skewed from normative driving data as the safety managers attempted to directly alter these behaviors. Moreover, some commercial truck and bus fleets were likely to be more stringent in their modification of certain driver behaviors (e.g., cell phone use while driving) than other commercial truck and bus fleets in the two data sets. Hickman and Hanowski (in press) found that the DriveCam system could reduce the mean rate of safety-critical events/10,000 miles in large trucks by up to 70 percent, while McGehee et al. (2007) found similar results in novice teen drivers. Thus, the data found in the study likely reflects a “best case” scenario and the prevalence of driver distractions in the general population of commercial trucks and buses is likely to be higher.

Second, the fact that the truck and bus fleets in the study purchased an OBSM monitoring system reflects a group of safety conscious truck and bus fleets. As with the first caveat noted above, the data was likely skewed from normal truck and bus fleets as the truck and bus fleets included in the study likely were more proactive regarding safety. As such, and consistent with the previous caveat, the prevalence of driver distractions in the study may be an underestimate of the normal commercial truck and bus driving population.

Third, the lack of continuous data collection or randomly collected video segments means there were no “true” baseline or control data (i.e., randomly selected baseline events). This limits most of the analyses to frequency distributions. However, DriveCam did reduce spurious trigger epochs that were not considered safety related. For example, a truck or bus could trigger an epoch by driving over a pot hole. While not safety related, DriveCam reviewed these epochs and recorded the ongoing tertiary tasks (if present). These non-safety-related epochs served as baseline events in the analyses. However, these baseline events were not truly random; thus, increasing possible biasing to certain situations that triggered the baseline (e.g., pot hole, train track, hard brake not in response to safety event, etc.). For that reason, these baseline events will not contain periods of driving where the driver was driving and nothing occurred in the roadway. This is considered a minor limitation as including these baseline events allows the assessment of risk estimates for tertiary tasks that will greatly increase our understanding of risk as compared to limiting the analyses to frequency counts (which do little to assess risk). The similarity of the results in this study with those found in Olson et al (2009), which used true baseline events, suggests this had little or no influence on the findings.

Fourth, data set B included safety-critical events and baseline events from June 6, 2009 to September 5, 2009. This was notable as the FMCSA hosted a webinar on June 3, 2009 to discuss the preliminary results from the Olson et al. (2009) study. This webinar was followed by intense media coverage and documentation regarding the dangers of driving while distracted. This intense media attention regarding distracted driving may have influenced safety managers to focus on reducing these behaviors more intently than before the media attention. Thus, as with the first limitation noted above, the prevalence of tertiary tasks in data set B may not reflect the actual prevalence of these tertiary tasks in commercial trucks and buses that do not have these systems installed in their vehicles. However, as data set A only included 2 days in which media attention may have influenced the data, the data in data set B controls for this event and actually documents the influence of the media attention on distracted driving (i.e., the only difference between the two data sets was the wide-spread media attention). Unfortunately, it is difficult to adequately evaluate this effect as data set A does not contain baseline events (i.e., the comparison was prevalence rates of safety-critical events between the two data sets). However, this would translate into potentially less risky behavior being recorded in the study, which would imply higher tertiary task involvement in the larger population of commercial trucks and buses.

Fifth, driver exposure was not controlled in the study; thus, extremely unsafe drivers may have contributed far more safety-critical events than baseline events (or conversely, extremely safe drivers). However, as the study included at least 13,000 drivers (from over 13,000 trucks and buses), the effect of any outliers was minimized. More specifically, the affect of any one driver was minimized given the large number of drivers in the study.

Lastly, the length of the video window during safety-critical events and baseline epochs was longer than other naturalistic studies (8 seconds before the trigger and 4 seconds after the trigger). Olson et al. (2009) used a much shorter video window, 5 seconds prior to the trigger and 1 second after the trigger. It is possible that some tertiary tasks coded as an associative factor during the safety-critical events had no influence on safety-critical event occurrence (if the truck or bus driver engaged in the tertiary task at the very beginning of the video window). As noted previously, the similarity of the odds ratios with the Olson et al study that used a 6-second window suggests this likely had minimal influence on the results

4.4 FUTURE RESEARCH

There were many important findings in the research project that informed our understanding of driver distraction in commercial trucks and buses. Most notably, this study used a diverse naturalistic data set to replicate and support findings from other naturalistic driving research (Klauer et al., 2006; Olson et al., 2009). While the goal of the study was to document the prevalence (and risk) of distracted driving in commercial trucks and buses using an existing naturalistic data set (to compare to Olson et al.), this study can also be viewed as a springboard for future studies using these existing naturalistic data sets. The following is a list of future research recommendations for studies that intend to use naturalistic data collected by OBSM technology vendors.

- Assess the risk of tertiary tasks on crash risk. Currently, naturalistic data sets are not large enough to perform any detailed analyses on crashes. While safety-critical events provide valuable information, almost all of the safety-critical events are non-crashes. Data set A had a total of 1,336 crashes. If these crashes could be re-reviewed and merged with data sets from other OBSM vendors (e.g., SmartDrive), then researchers could evaluate the crash risk of engaging in tertiary tasks while driving.
- A prospective study using OBSM vendors is needed to avoid the use of baseline events. This was a retrospective observational study that relied on non-random control events (baseline events) to evaluate risk. To address the possible bias in using these non-random events as control events, a prospective study with OBSM vendors that collect non-continuous data could be conducted where the OBSM system randomly records the driver while driving. It appears this would be possible by programming the OBSM device to randomly record the driver at intermittent time intervals while the truck or bus was moving. Note that the ongoing FMCSA-funded 250 truck study is collecting continuous data.
- The study did not perform an eye glance analysis. Future studies should perform an eye glance analysis, if possible, to investigate the eye glance findings in Olson et al. (2009). Currently, the Olson et al. study is the only published naturalistic study that evaluated visual distraction in commercial truck drivers. Other naturalistic studies involving commercial truck and bus drivers need to conduct eye glance analysis to confirm, or refute, the results found in Olson et al.

- The tertiary task, other distraction, was found to be highly correlated with involvement in a safety-critical event. However, the operational definition for this tertiary task was so nebulous (essentially a catch-all) the interpretation of this result lacked any real meaning. Safety-critical events and baseline events coded with the tertiary task, other distraction, should be re-reviewed and classified using the data directory in Olson et al. (2009).
- Future naturalistic driving studies should be conducted with various transport modes (e.g., buses, rail, air, etc.). It is clear that driver/operator distraction is an important issue that is not limited to passenger cars and heavy trucks. As with the recent FMCSA-funded naturalistic research conducted with heavy trucks (Olson et al., 2009), the goal of such investigations would include assessing the scope of the problem within the particular transport mode and identifying countermeasures that would ultimately lead to fewer crashes.

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