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Investigation of Distracted Driving Activities At Highway-Rail Grade Crossings (HRGC)

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16. Abstract
Safety at highway-rail grade crossings (HRGCs) is a major concern for various agencies due to the high probability of severe injuries and fatalities associated with such locations. In the year 2010, 2,055 crashes and 227 fatalities were reported at grade crossings in the U.S. Of these, 97 crashes were reported at or adjacent to HRGCs in the state of Nebraska, including 43 crashes involving distracted driving. Distracted driving behaviors at HRGCs may increase driver susceptibility to the hazards common to grade crossings, and should therefore be carefully considered in efforts to maintain and improve safety at HRGCs. The objectives of this research were to report on the frequency and sources of distracted driving at HRGCs in Nebraska and to empirically identify factors that may be associated with distracted driving. Data on distracted driving activities were collected at two Nebraska HRGCs. Analyses indicated that, overall, female drivers were more likely to be distracted than male drivers. Drivers of commercial vehicles exhibited higher distraction rates than non-commercial drivers. Driver, vehicle, and environmental characteristics contributed differently to varying levels of driver distractions. The presence of passengers and weather conditions (e.g., clear and dry pavement) were two major contributors to increased instances of distracted driving at HRGCs. Certain aspects of distracted driving at HRGCs that would benefit from further investigation are recommended.

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Abstract

Safety at highway-rail grade crossings (HRGCs) is a major concern for various agencies due to the high probability of severe injuries and fatalities when crashes occur at these locations. In the year 2010, 2,055 crashes and 227 fatalities were reported at grade crossings in the U.S. Of these, 97 crashes were reported at or adjacent to HRGCs in the state of Nebraska, including 43 crashes involving distracted driving. Distracted driving at HRGCs may increase driver susceptibility to crashes at grade crossings and should therefore be carefully considered in efforts to maintain and improve safety at HRGCs. The objectives of this research were to report on the frequency and sources of distracted driving activities in the state of Nebraska, and to empirically identify factors that may be associated with distracting activities. Data on distracted driving activities were collected at two Nebraska HRGCs. Analyses indicated that, overall, female drivers (29% of female drivers) were more likely to be distracted than were male drivers (26% of male drivers). Commercial drivers, regardless of gender, exhibited higher distraction ratios than did non-commercial drivers. Driver, vehicle, and environmental characteristics each contributed differently to levels of driver distraction. Generally, the presences of passengers, as well as prevailing weather conditions (e.g., clear and dry pavement) were two major contributors to increased distraction rates. Overall, this study elaborated basic concepts pertaining to the effects of specific factors on observed distracted driving behavior. Certain aspects of distracted driving at HRGCs that would benefit from further investigation are recommended.

Chapter 1 Introduction

Distracted driving joined the ranks of driving under the influence and speeding as one of three primary causes of fatal and severe injury accidents in the United States. According to (2010) traffic accident statistics obtained from the National Highway Traffic Safety Administration (NHTSA), 10 percent of drivers involved in injury crashes reported across all types of transportation facilities (e.g., highways, local roads, and highway-rail grade crossings) were engaged in secondary tasks while driving; this accounts for 387,000 persons involved in accidents [1]. Of these 387,000 individuals, 3,331 were killed. Additionally, NHTSA reports that nearly one in five injury crashes in 2010 involved distracted driving, and one in six fatal crashes was the result of distracted driving. The National Safety Council (NSU) [2] estimated that approximately 20 percent of all crashes in 2010 involved talking on cellphones—accounting for approximately one million crashes that year. The National Occupant Protection Use Survey (NOPUS) also conducted a survey on work-related motor vehicle distractions, reporting that cell phone use and texting contributed to approximately 30,000 work-related crashes in 2011—a figure that has since increased at a rate of 1 percent annually [3]. Wilson and Stimpson reported that fatalities resulting from distracted driving increased dramatically after 2005, rising by approximately 28 percent from 2005 to 2008 [4]. Due to this increase in injuries and fatalities resulting from distracted driving, awareness of the consequences of distracted driving has been rising rapidly in recent years, especially pertaining to one particularly dangerous and critical type of transportation facility—highway-rail grade crossings (HRGC). Federal Railroad Administration (FRA) statistics have additionally revealed that approximately 30 percent of grade crossing crashes involve a vehicle colliding with a train already present at the crossing. Texting, use of cell phones, or other sources of driver distraction are a factor in such crashes. In comparison to the high fatality rates attributed to accidents occurring at HRGCs, fatal accidents accounted for only one percent of reported accidents occurring across other transportation modes in 2012 [5]. Thus, distracted driving behaviors at HRGCs may exhibit a particular susceptibility to the characteristic hazards of at grade crossings, and should be carefully considered as part of an effort to maintain and improve safety at HRGCs.

1.1 Problem Statement

Crashes at HRGCs continue to be the leading cause of fatalities and injuries in the highway/railroad industry. A considerable portion of these crashes are the result of distracted driving by motorists. Inattentive driving at HRGCs degrades driving performance and can potentially lead to serious safety consequences. Distracted drivers may not recognize the presence of an approaching train, or may fail to account for other highway vehicles that may be involved in evasive maneuvers. At present, limited information is available regarding the frequency of distracted driving at HRGCs, the characteristics of distracted motorists at HRGCs, and additional related factors. Nearly all previous studies in this research area have focused on analyzing the sources and frequency of distracted driving, in addition to the characteristics of the most vulnerable driver populations on highway and roadway systems. Therefore, an examination of the characteristics associated with distracted driving at HRGCs is needed to help reduce the occurrence of distracted driving at crossings.

1.2 Research Objectives

The main focus of the research was to empirically identify factors associated with distracted driving at HRGCs, which involved an investigation of the occurrence of distracted driving at HRGCs and an attempt to identify driver, roadway, environmental, and crossing characteristics associated with distracted driving at HRGCs. This study features an in-depth safety analysis of factors associated with distracted driving at HRGCs, with a particular focus on identifying groups of interest that are characteristically associated with different forms of distracted driving.

1.3 Research Approach

Distraction-related data were collected at two HRGCs to assess different forms of distracted driving. The frequency of distracted driving at HRGCs, the characteristics of distracted motorists at HRGCs, and other associated factors were observed at two designated study sites. The main variables of interest included sources of distracted driving based on field observation. The sources of distraction were adapted from NHTSA reports. In all, seven sources of distraction were used in this study. To diagnose factors associated with distracted driving, variables that typified certain characteristics (e.g., environmental characteristics, infrastructure/physical characteristics) were examined for their effects on distracted driving related activities. An attempt was made to collect data on as many factors listed in table 2.1 as possible, subject to time and budgetary constraints.

1.4 Report Organization

Following this chapter, chapter 2 presents a review of the published literature related to distracted driving. Development of data collection schemes at the study site are described in chapter 3. Analyses of the collected data are described in chapter 4. Conclusions are detailed in chapter 5.

Chapter 2 Literature Review

The following literature review covers the categorization of distracted driving activities and a selection of data collection methodology employed in the current study. A summary of this review appears at the end of the chapter.

2.1 Driver Distraction

It is common for drivers to engage in secondary tasks while driving, even when the driving task requires significant attention due to the inherent complexity of the driving situation. Inattentive driving, regardless of the duration or frequency of inattention, degrades driving performance and can lead to serious safety consequences [1], [2]. NHTSA estimates that distracted driving contributes to approximately 20% of police-reported crashes annually [6]. This percentage was estimated based on investigator (i.e., law enforcement) accident reports. Table 2.1 provides statistics gathered by the NHTSA related to crashes involving distracted drivers observed from 2006 to 2010.

Table 2.1 Police-reported crashes and crashes involving distraction, 2006-2010

Year	Number of Police-Reported Crashes	Police-Reported Crashes Involving a Distracted Driver	Distraction-Related Crashes Involving an Integrated Control/Device*	Distraction-Related Crashes Involving an Electronic Device*
2006	5,964,000	1,019,000 (17%)	18,000 (2%)	24,000 (2%)
2007	6,016,000	1,001,000 (17%)	23,000 (2%)	48,000 (5%)
2008	5,801,000	967,000 (17%)	21,000 (2%)	48,000 (5%)
2009	5,498,000	957,000 (17%)	22,000 (2%)	46,000 (5%)
2010	5,409,000	899,000 (17%)	26,000 (3%)	47,000 (5%)

*National Highway Traffic Safety Administration [1]

To enhance traffic safety, forms and sources of distractions should first be identified. NHTSA has determined three primary forms of distracted driving:

1) Visual Distraction: A driver's attention is diverted from the driving task by secondary tasks, resulting in the driver taking their eyes off of the road (e.g., passing through a work zone, roadside billboards, use of navigation equipment).

2) Manual Distraction: A driver takes a hand off of the steering wheel to manipulate a device (e.g., texting, using in-vehicle radio, etc.). This type of distraction has resulted in a significant number of accidents in recent years.

3) Cognitive Distraction: Drivers divert their mental attention from driving to secondary tasks. Common secondary tasks reported in the literature include conversations between drivers and passengers and talking on cell phones.

Although these three forms of distraction are classified separately, they are not mutually exclusive. For instance, operating a navigation device could engage a driver in two forms of distraction simultaneously, i.e., visual distraction caused by taking eyes off of the road to use a navigation screen, or manual distraction caused by handling the navigation screen to update or change destinations. NHTSA recognizes 13 additional sources of distraction, as follows [7]:

1. Eating or drinking
2. Outside person, object, or event
3. Adjusting radio or CD player
4. Other occupants in the vehicle
5. Moving objects inside the vehicle
6. Smoking
7. Talking or listening on a cellphone
8. Using devices/objects brought into the vehicle
9. Using devices/controls integral to the vehicle

10. Other distractions

In order to accurately record distracted driving data, numerous data collection techniques have been employed in previous literature. Accurate data collection is an essential element in the assessment of the impacts of distracted driving activities. A well-developed data collection technique is key to investigating the incidence of distracting activities among drivers, and to providing researchers with information on the contribution of distracting activities to crash causation. Thus, literature on distracted driving is reviewed below.

2.2 Data Collection Technique

Accurate distracted driving data are the most important element used to analyze the effects of distracted driving activities. Researchers have utilized numerous techniques and various equipment to collect distracted driving data. In essence, two types of techniques—equipment-based and non-equipment-based—have commonly been employed in the collection of distraction-related data. Equipment-based studies rely upon equipment such as cameras and video storage devices to collect data. Non-equipment-based techniques commonly refer to data collected through surveys or other non-equipment-based methods. Generally, fixed-site, naturalistic, and simulator based techniques are classified as equipment-based. These are reviewed in the following sections.

The principle of the fixed-site technique is to observe and record driving activities and distracted driving activities at a fixed location, which can include roadways or HRGCs. Field data can be collected either by assigning observers to or installing surveillance systems at sites of interest. By employing the fixed-location technique, not only can basic traffic characteristics be observed, but researchers can record distracted driving activities such as cell phone use, smoking, eating, etc. It should be noted that a few researches have stated that the fixed-location technique can be limited by the “fixed-site” aspect of the study, available time, and the fidelity of distraction determinations made by observers as vehicles move past the experiment sites [8]. However, the fixed-site technique provides extremely useful insight regarding driver activities in real world driving situations. Additionally, the fidelity of the distraction determination process can be improved upon with the adoption of a surveillance system. In this case, “suspicious” activities that could not be determined at the scene could be further discerned by reviewing recorded footage.

Another method of data collection is the in-vehicle naturalistic technique. Normally, test vehicles are instrumented with sensors and video cameras to record in-vehicle driving activities. Long-term observation is required to facilitate this method of study. Vehicles instrumented with multiple-channel cameras and vehicle kinematics are provided to volunteers for a period of time. Several studies have previously adopted the naturalistic technique to monitor and record various types of data surrounding driver behavior and performance. A research team from the Virginia Tech Transportation Institute conducted an in-depth distracted driving analysis using data collected in the 100-Car Naturalistic Driving Study [7], [9], [10]. The primary goal of the naturalistic driving study was to provide the vital exposure and pre-crash data necessary to determine the causes of crashes. However, data on driving activities such as distracted driving were also recorded. Such data reveal that distraction while driving is a common occurrence. The same research team also conducted comparisons between distractions occurring during normal driving and distractions present during crashes and near-crashes [7]. The results of this comparison suggested that drivers may frequently face more critical situations (i.e., crashes or near-crashes) while being distracted by other tasks.

Ngamdung and daSilva [11] performed the naturalistic technique for an analysis of heavy trucks. Video and data recorders were instrumented in participating heavy trucks. The analysis focused primarily on driving activities at HRGCs. Distractions were cross-compared for driver age, gender, and driving experience. The authors reported that the most frequent distraction was talking or listening to phones. The data also indicated that more experienced drivers more often engaged in secondary tasks. However, driver gender was not a statistically significant variable, as had been initially supposed.

Several other studies [12], [13], [14], [15], [16] have applied the naturalistic technique in order to collect data on distracted driving activities, followed by the development of countermeasures to mitigate unsafe driving behaviors. However, limitations associated with the naturalistic technique include the cost of instrumented vehicles and the potential for test subjects to exhibit unnatural driving behaviors. Such elements are impediments to the collection of substantial and unbiased data. Another limitation is that the vast portion of everyday driving behavior is uneventful; thus, the cost of continuously recording and examining all driver activity relative to a certain number of resulting crashes is high, given the low probability that a given driver will be involved in a crash in a given year [17]. The result is that, when using the naturalistic technique for data collection, numerous drivers are required in order to obtain a useful crash sample size.

In addition to the fixed location and naturalistic techniques, an experimental study had been designed to simulate driving behaviors in the laboratory. Simulator experiments can be classified under low- and high-fidelity simulation environments, depending upon the fidelity of the simulated driving environment in comparison to the real-world driving environment. Both levels of a simulator can be used to simulate existing or projected driving scenarios; however, differences in simulator fidelity have a profound effect on actual scenario rendering, and, in turn, on the equivalence of such scenarios when run on different simulators[18]. When focusing on the analysis of distracted driving, simulators primarily measure the level of influence of different sources of administered distraction on driving behavior. Participants are typically given instructions concerning when and how often to engage in secondary tasks while driving. Simulator studies do not incorporate motivational factors that influence drivers' willingness to engage in secondary tasks during real-world driving [17]. The real-world risk associated with secondary tasks relates to the priority given by a driver to the task, as well as the driving situations in which a driver is willing to engage in the secondary task. Difficulties involving the characterization of factors that contribute to drivers' willingness to engage in secondary tasks have raised questions regarding researchers' ability to generalize experimental results to a real-world driving scenario. Hence, simulator results could potentially be biased against real-world driving performance.

When comparing strengths and weaknesses among equipment-based data collection techniques, the fixed-location technique appears to have certain advantages over the naturalistic technique. The fixed-location technique provides more accurate and reliable distracted driving data from real-world driving scenarios. In contrast to the fixed-location technique, the results of the naturalistic technique may be biased, since research subjects may be aware of the existence of in-vehicle cameras and therefore behave unnaturally. Additionally, this method necessitates continuous recording over a long period of time in order to collect sufficient and realistic data on distracted driving. As for the simulator technique, experimental results may or may not reflect real-world driving behaviors due to the limitations of the simulated environment. Hence, considering the accuracy and cost-effectiveness of the resulting data, the fixed-location method appeared to be a reasonable selection to be utilized in the current research. Additional data collection preparations are discussed in detail in a subsequent chapter.

2.3 Summary of Literature Review

This chapter presented a review and discussion of literature on distracted driving, as well as a discussion of the sources of distracted driving. The literature review revealed a lack of publications dealing specifically with distracted driving activities at HRGCs. In addition to reviewing sources of distracted driving related activities, previous literature has focused on the various methods of data collection commonly utilized to collect distraction-related data. A review of these data collection techniques revealed the appropriateness of the fixed-location technique for use in the current study. The application of the fixed-location technique not only allows for the observation of natural driver characteristics and behaviors in the field, but can also allow for the direct recording of distracted driving activities without concern for the previously described weaknesses of the previously described alternative data collection techniques. A detailed discussion of the data collection methodology utilized in the current study is described in the following chapter.

Chapter 3 Data Collection

Distraction-related data were collected using surveillance cameras, and were stored in a Network Video Recorder (NVR). A sample “basic area-of-interest” designated for the collection of distracted driving field data and the observation of driver activities at each HRGC is illustrated in Figure 3.1. The observation of driver activities began prior to vehicles reaching the railway tracks, and continued until vehicles passed the tracks. The following section demonstrates the protocols applied for the collection of the required datasets.

Figure 3.1 Basic area-of-interest at an HRGC (sample: Fremont HRGC)

Distracted driving activities were collected at two HRGCs. The first was located in the city of Lincoln, Nebraska; the other in the city of Fremont, Nebraska. Data were collected using the fixed-location technique, which utilized surveillance Axis IP cameras that were installed to record video footage at the test sites. The equipment configuration at the two sites differed slightly depending primarily on accessibility and the availability of space at or near each HRGC.

At the Fremont site, three consecutive crossings were spaced within a distance of 450 feet (from track to track), as shown in figure 3.2. The crossing located in the center, as denoted by the red line appearing in figure 3.2, had the highest train volume per day; the resulting possibility of higher risk distinguished this site from the others as a candidate study site. The studied crossing (FRA crossing# *074662E*) consisted of two sets of tracks crossing two lanes of a roadway, and was protected by dual quadrant gates. The crossing was equipped with flashing lights, crossbuck signs, and audible bells. Due to limited space at the Fremont HRGC and in consideration of the railway right-of-way restriction, the Axis IP surveillance camera was mounted at a power pole located 150 feet downstream (south) of the railroad crossing, where it recorded driving activity. Figure 3.3 illustrates the placement of the surveillance camera relative to the crossing.

The equipment configuration installed at the Lincoln site differed from that of the Fremont site. The subject crossing (FRA crossing# *074406N*) consisted of two sets of tracks crossing two lanes of a roadway, protected by dual quadrant gates (Figure 3.4). The crossing was equipped with flashing lights, crossbuck signs, and audible bells. Due to the

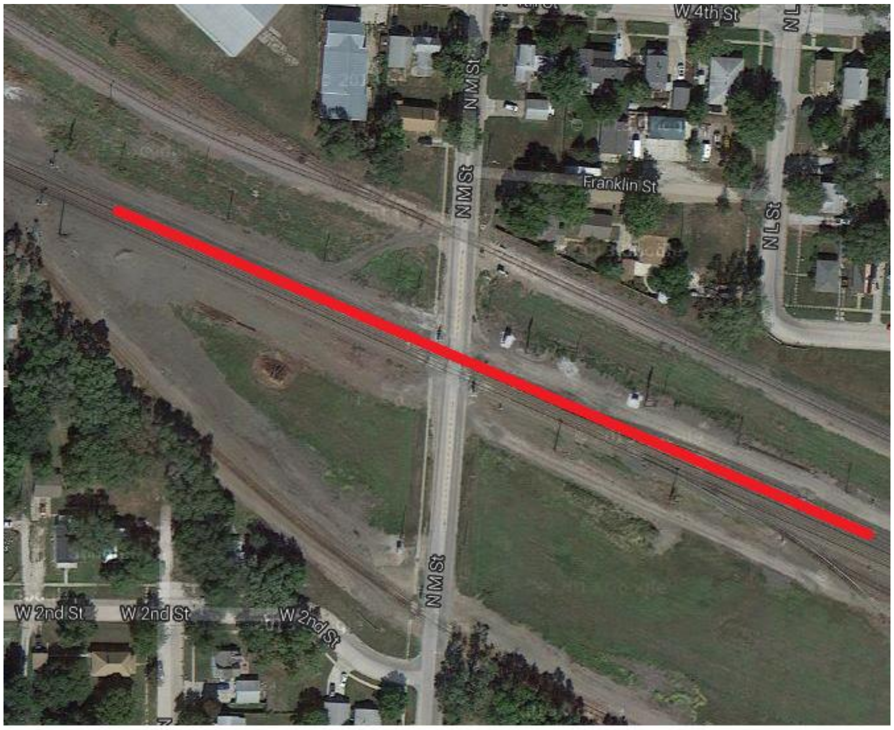


Figure 3.1 HRGC at M St. in Fremont, NE (source: Google Maps)

Figure 3.2 Configuration of data collection equipment at Fremont site

presence of a sidewalk, which provided a safe space for data collection near the crossing, a data collection trailer equipped with two Axis IP cameras and an NVR was anchored on the sidewalk (i.e., the red box in fig 3.4) to simultaneously record driver activities from two different fields of view, as shown in figure 3.5; this occurred in order to ensure high fidelity of the recorded distracted activity. One camera was installed perpendicularly to record driver activities from the driver side window (shown on the right in fig 3.6). The other camera was designated primarily to record the activities of trains/gates/flashers at the crossings (shown on the left in fig 3.6).

Figure 3.3 HRGC at Old Cheney Rd in Lincoln, NE (source: Google Maps)

Figure 3.4 Configuration of data collection equipment in Lincoln

Figure 3.5 Fields-of-view at tested HRGCs (Sample: Old Cheney Rd & Jamaica HRGC)

3.1 Variables and Coding Scheme

Video footage recorded at the two sites was then extracted and coded by trained personnel using the data recording template shown in Appendix A. The data recording template incorporated the characteristics of the roadway environment, vehicle characteristics, driver characteristics and behaviors, environmental factors, and crossing violations. In the category of driver characteristics, seven sources of common distracted driving activities were listed in the data record template, and were recorded from the field. If the person who reviewed the footage noticed the occurrence of distracted driving, one or more observed distracted activities were recorded and coded. Snapshots of distracted activities were also captured from the video footage. Examples of texting while driving, eating/drinking, and talking to other passengers are shown in Figure 3.7, from left to right, respectively.

Figure 3.6 Examples of distracted driving activities

In all, 24 variables associated with each crossing event were observed from the video footage and coded in the spreadsheet. For categorical variables such as weather conditions, subsequent analyses were dummy coded separately for each type of weather condition. For instance, for the dummy condition “snow,” the presence of the variable snow was coded as “1” while the absence of snow was coded as “0.” The same concept was applied to all other categorical variables recorded in the study. It should be noted that the variable “light condition” disregarded nighttime conditions due to relatively low visibility, which hindered trained personnel from determining or identifying inappropriate driving behaviors. Table 3.1 displays the study variables in conjunction with their corresponding coding schemes.

Once distraction data was extracted from the video footage, distractions were cross-compared with the characteristics of the roadway environment, vehicle characteristics, driver characteristics, and environmental factors. The following chapter presents a discussion of distracted activities observed at the studied HRGCs.

Table 3.1 Variables and coding scheme

Aspect	Variable	Label	Coding
Roadway Environment	ID	FRA Crossing ID	ID
	Device	Warning device	1 if equipped and 0 if otherwise
	Track	Number of railroad tracks	Integer
	Lane	Number of traffic lane	Integer
	Intersect	Intersecting road within 250' of the crossing	1 if Yes and 0 if otherwise
	Act	Activities are found nearby the study site (e.g., accident, work zone, unattended vehicle)	1 if Yes and 0 if otherwise
	Function	Crossing warning activation for train	1 if Yes and 0 if otherwise
Vehicle Characteristics	Usage	Vehicle usage	1 if Personal and 0 if otherwise
	Model	Vehicle model	0 if passenger, 1 if pickup, 2 if SUV/minivan, 3 if single unit, 4 if semi-truck, 5 if motorcycle, 6 if farming tractor, and 7 if school bus
Driver Characteristics	Gender	Driver gender	1 if male and 0 if female
	Look	Look behavior while approaching crossing	0 if looked straight, 1 if looked to one side (right or left) and 2 if looked to both sides

	Passenger	Passenger accompanied in the front seat	1 if Yes and 0 if otherwise
	Dist.	Secondary activities engaged by subjected driver	0 if no secondary tasks, 1 if talk to passenger, 2 if eat/drink, 3 if cellphone use, 4 if smoking, 5 if reaching object, 6 if look to the side, and 7 if others (grooming)
Environment Characteristics	Weather	Weather condition	1 if clear, 2 if cloudy, and 3 if rain,
	Light	Light condition	1 if daytime, 2 if dawn, 3 if dusk, and 4 if other
	Pave	Pavement condition	1 if dry and 2 if wet
Violation Characteristics	Vio	Grade crossing violation involvement	1 if Yes and 0 if otherwise
	VioType	Violation type	1 if passing between the activation of train warning and the gate descending (denoted as V0) 2 if passing under descending gates (V1) 3 if passing around fully lowered gates (V2) 4 if passing around fully lower gates between train (V3) 5 if Passing under ascending gates (V4)

Chapter 4 Data Analysis

The analysis described in this section focused on motorist crossing events. Other transportation modes (e.g., bicycle or pedestrian) were not considered in this study. The analysis of driver behavior data at HRGCs focused on the identification of driver behaviors and the distribution of types of distracted driving activities and grade crossing violations, if any were present. Examples of driver behavioral characteristics included looking behavior (looked one way, looked either ways, or neither) and the presence of distraction (phone, eating, talking to passenger, etc.).

4.1 Grade Crossing Event Basic Statistics

Grade crossing event data were collected at two separate geographic locations. In terms of crossing control and geometry, both crossings physically consisted of two sets of tracks crossing two lanes of a roadway, with protection by dual quadrant gates. Subsequently, an analysis could not be conducted on the basis of different physical crossing features, but rather on driver demographics or other characteristics (e.g., environmental characteristics). That is, crossing events were grouped by unique characteristics (e.g., gender) in this study, and further analyses focused on major sources of distractions and their corresponding effects on different groups of drivers. Additionally, a preliminary analysis consisting of the calculation of frequencies, means, and variances for the different variables listed in table 3.1 are presented in the current chapter.

4.2 Crossing by Driver Characteristics

The statistics presented here grouped recorded crossing events by driver gender. Basic statistics focused on the variables associated with driver characteristics such as gender, passenger accompanied in the front seat, and looking behavior. Of the data, a total of 858 and 643 vehicle crossings were recorded at the Old Cheney and Fremont crossings, respectively. Out of a total of 1,501 events, 492 events occurred among female drivers, and 1,009 among male drivers. In terms of accompanying front seat passengers, which were treated as a primary source of distraction, 225 events characterized by male drivers included a passenger in the front seat, while 95 events with female operators included a passenger in the front seat. The final variable classified in terms of driver characteristics was looking behavior. Looking behavior was measured by the amount of head movement as a driver approached the crossing. Since a high percentage of HRGC accidents have been the result of drivers failing to recognize the presence of an approaching train, looking behavior may be used as a criterion to evaluate crossing safety. Looking behavior was captured by the on-site cameras, which were positioned to enable observation of the driver-side window. All activities at grade crossing were examined to determine whether drivers looked one way (to the left or to the right), both ways, or straight ahead. Examination of the collected data suggested that male drivers did not move their heads 81.6% of the time as they approached a highway-rail grade crossing. Only 18.4% of male drivers looked in either one or both directions. In comparison to male drivers, 90.4% of female drivers did not turn their head to one or both sides; only 9.6% of female drivers turned their heads. Analysis of t-statistics conducted at a 0.05 level of significance further proved that male and female driver groups exhibited statistically significant differences in terms of looking behavior. Related statistics are presented in table 4.1.

Table 4.1 Crossing by driver characteristics

Gender	Driver (unit: events)	Passenger accompanied (unit: events)	Looking behavior# (straight) (unit: events (percentage))	Looking behavior# (looked one way, looked both ways) (unit: events (percentage))
Male	1009	215	824 (81.6%)	185 (18.4%)
Female	492	95	445 (90.4%)	47 (9.6%)

4.3 Crossing by Vehicle Characteristics

The following basic statistics focused on the distribution of variables associated with vehicle characteristics, such as vehicle model and use (i.e., commercial or non-commercial use), grouped by driver gender. Vehicle use was examined based on the fact that work-related injuries resulting from distracted driving have been steadily increasing by 1% annually. There exists a need to specifically examine distraction-related performance for different vehicle use types. As for data collection for different vehicle use types, with the exception of cases that could easily be determined by vehicle exterior features or profiles (e.g., school buses), determinations were made based on license plate types. License plates designated for commercial/farm/work purposes differ from those of regular vehicles (see fig 4.1). Analysis of the collected data suggested that 18.8% of male drivers operated commercial vehicles, whereas only 2.7% of female drivers operated commercial vehicles during the analysis period.

Figure 4.1 Different schemes on license plates with different vehicle use characteristics

The distribution of vehicle types among non-commercial (e.g., personal use) and commercial vehicles was also calculated. Columns 4-11 (left to right) in table 4.2 display the counts for seven types of commercial and non-commercial vehicles. The values shown in parentheses represent vehicles used for commercial (commercial/farm/work) purposes. Further, cross-comparisons were made to analyze the distribution of vehicle types exclusively for commercial vehicles, as shown in figure 4.2. By determining the distribution of vehicle types and uses, distraction frequencies among different vehicle types could be compared.

Table 1.2 Crossing by driver characteristics

Gender	Personal (count)	Commercial /farm/work	Passenger	Pick up	SUV/ minivan	Single unit truck	Semi	Motorcycle	Farm	School bus
Male	819	190 (18.8%)	352 (6)	267 (101)	300 (16)	56 (48)	14 (14)	16 (0)	3 (3)	2 (2)
Female	479	13 (2.7%)	268 (2)	14 (6)	208 (5)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)

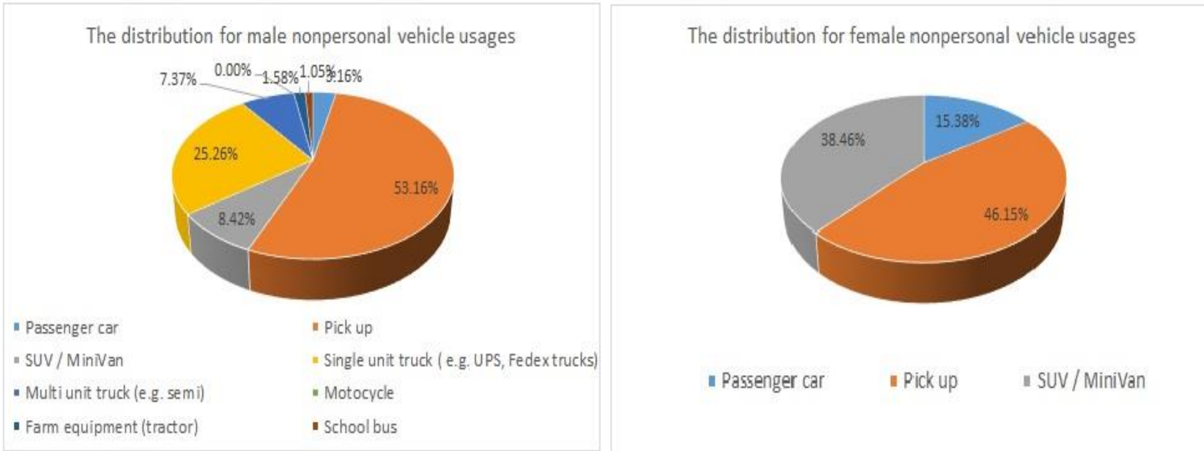
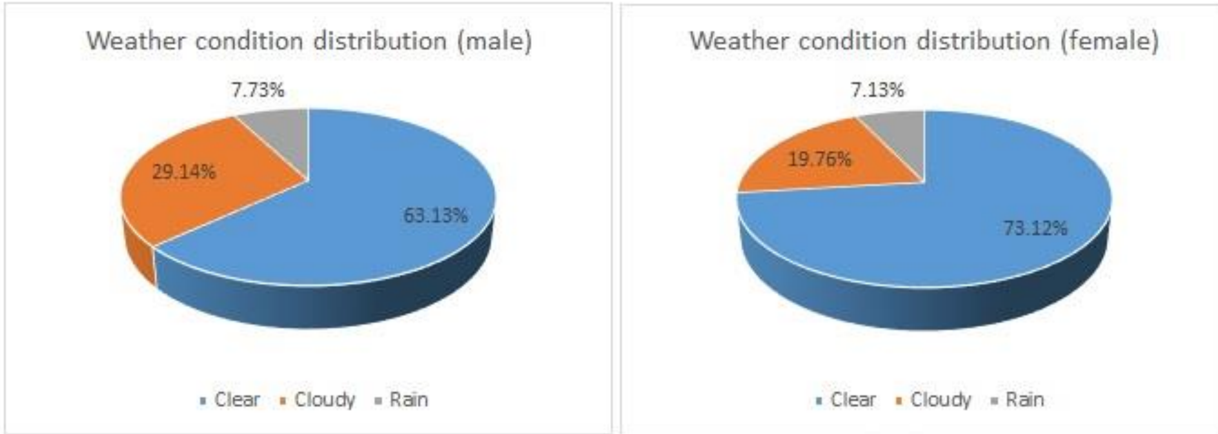


Figure 4.2 Distribution of vehicle types by driver gender

4.4 Crossing by Environmental Characteristics

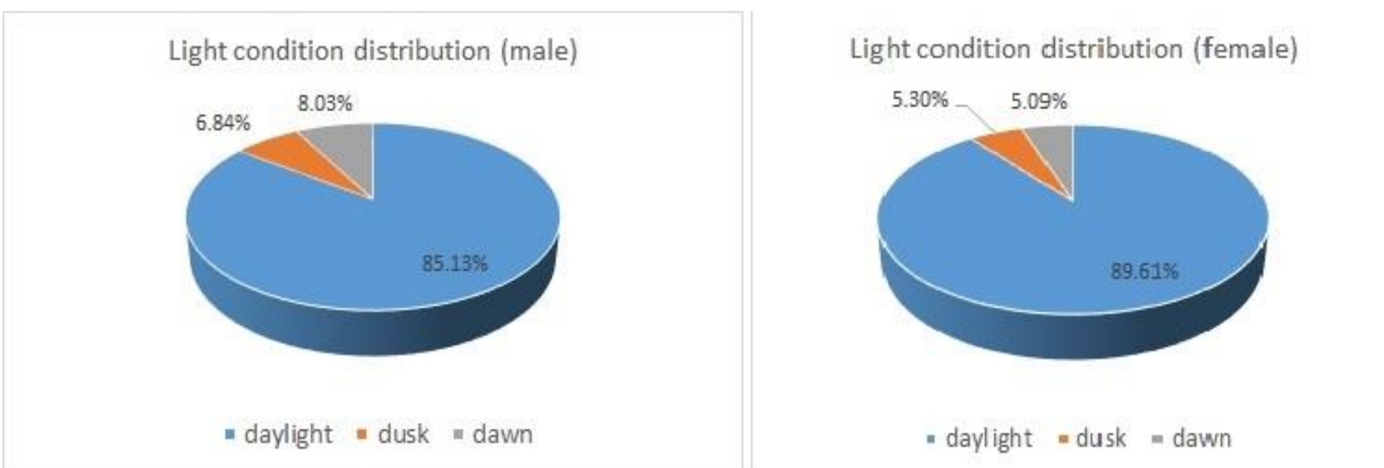
The following basic statistics focused on the distribution of variables associated with environmental characteristics such as pavement conditions, lighting conditions, and weather conditions, grouped by driver gender. Since the data were collected in May and July, neither winter weather nor icy pavement conditions were recorded. The distribution of weather conditions is presented in figure 4.3. The distribution of weather conditions for male and female drivers was similar; however, male drivers more frequently experienced cloudy conditions. Approximately 7.5% of drivers in both gender groups experienced rain. The similar percentages obtained for environmental characteristics enabled a better perspective for the analysis of the effect of weather on distracted driving activities.



(a) (b)

Figure 4.3 Distribution of weather conditions by driver gender

The remaining environmental variable was lighting conditions. Its distribution is presented in figure 4.4.



(a) (b)

Figure 4.4 Distribution of light conditions by driver gender

Table 4.3 includes the descriptive statistics determined for all variables recorded in the study. In chapter 4, section 4.2, cross-comparisons among distracted driving activities and all recorded variables are analyzed and described. Additionally, correlations between witnessed sources of distracted driving activities and four types of crossing violations are presented.

Table 4.3 Descriptive statistics for the collected data

Variable	Description	Mean	Std. Deviation	Minimum	Maximum
DEVICE	Warning device (1 if equipped and 0 if otherwise)	1	0	n/a*	1
TRACK	Number of railroad tracks	2	0	n/a*	2
LANE	Number of traffic lanes	1	0	n/a*	1
INTERSECT	Intersecting road within 250' of the crossing (1 if Yes and 0 if otherwise)	1	0	n/a*	1
ACT	Activities are found near the study site (1 if Yes and 0 if otherwise)	0.9568	0.0440	0	1
FUNCTION	Crossing warning activation for train (1 if Yes and 0 if otherwise)	0.0399	0.0051	0	1
USAGE	Vehicle usage purpose (1 if Personal and 0 if otherwise)	0.8645	0.0088	0	1
GENDER	Driver gender (1 if male and 0 if female)	0.6731	0.0121	0	1
LOOK	0 if look straight, 1 if look one side (right or left) and 2 if look both sides	0.1894	0.0121	0	2
PASSENGER	Passenger accompanied in the front seat (1 if Yes and 0 if otherwise)	0.2061	0.011	0	1
CLEAR	Dummy for clear	0.7229	0.0115	0	1
CLOUDY	Dummy for cloudy	0.2605	0.0113	0	1
RAIN	Dummy for rain	0.0159	0.0032	0	1
DRY	Dummy for dry pavement	0.9841	0.0032	0	1

WET	Dummy for wet pavement	0.0159	0.0032	0	1
DAYTIME	Light condition, 1 if daytime, 2 if dawn, 3 if dusk, and 4 if other	1.6239	0.0472	1	3
PASSENGER	Dummy for passenger cars	0.4162	0.0127	0	1
PICK-UP	Dummy for pick up	0.1867	0.0101	0	1
SUV/MINIVAN	Dummy for SUV/Minivan	0.3389	0.0122	0	1
SINGLE UNIT TRUCK	Dummy for single unit truck	0.0385	0.0050	0	1
SEMI-TRUCK	Dummy for semi-truck	0.0093	0.0025	0	1
MOTORCYCLE	Dummy for motorcycle	0.0106	0.0026	0	1
FARMING EQUIP	Dummy for farming equipment	0.0020	0.0012	0	1
SCHOOL BUS	Dummy for school bus	0.0013	0.0009	0	1

*N/A: Not applicable. All values in each of four variables are identical.

4.5 Distraction Analysis

4.5.1 Overall Distracted Driving Activities Statistics

Sources of distracted driving activities recorded in the field were identified and logged based on the classifications defined by the NHTSA. However, since the data collection method utilized the fixed-location technique, some sources of distracted driving activities were not obvious and difficult to identify externally; these included "adjusting radio or CD," "moving object in vehicle," and "adjusting climate controls," and were not taken into consideration. As a result, sources of distracted driving were consolidated into seven activity categories. The complete list included:

1. Talk to passenger
2. Eat/drink
3. Cellphone use
4. Smoking
5. Reaching for object

6. Look outside

7. Others (e.g., grooming)

The combined analysis of distracted activities is presented in the current study. This included distraction data recorded from two different sites combined into pooled data for further analysis. Overall, non-distracted events were observed in 73% of all observations, while distracted events were observed in 27% of all observations. Converting the proportions to values, 401 events were found to involve one or more distracted driving activities. Of these, two events involved two distracted driving activities simultaneously. Further analysis of the composition of distracted driving activities, as seen at the right of figure 4.5, illustrated the proportions for seven sources of distracted driving. The most frequent activity was talking to passengers (37%), followed by cellphone use (17%). Cellphone use consisted of all cellphone-related activities, such as texting and talking. The other three sources of distracted driving activities, (1) smoking, (2) looking outside, and (3) others, were found to individually comprise at least 10% of distracted driving activities. The activity with the lowest frequency was eating/drinking. Essentially, the distributions of distracted driving activities in this study revealed similar trends as found in previous studies conducted by the NHTSA. For example, Tison et al. [19] found similar proportions for "talking to passenger (34.8%)," "cellphone use (15.6%)," and "eat/drink (5.6%)." Information was unavailable for further comparison with Tyson et al. for the remaining four sources of distracted driving.

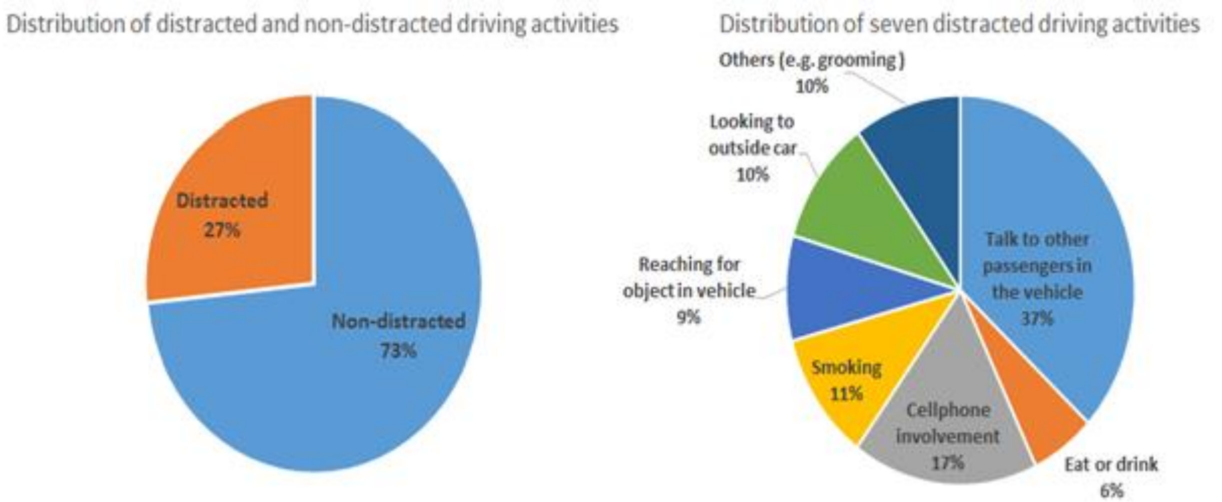


Figure 4.5 Overall distribution of distracted driving activities

4.5.2 Distraction Results by Gender

This section presents distraction data broken down by driver gender. Overall, 261 distracted events were observed among male drivers (26% of male driving observations), and 140 events were observed among female drivers (29% of observed activities). To further break down the data in terms of different sources of distraction, as illustrated in figure 4.6, the distributions of seven distracted driving activities were calculated based on gender. Table 4.4 presents the percentage differential for each distraction-related activity, using values observed for male drivers as a reference point. The negative values presented in table 4.4 suggest that those activities were observed more frequently among male drivers.

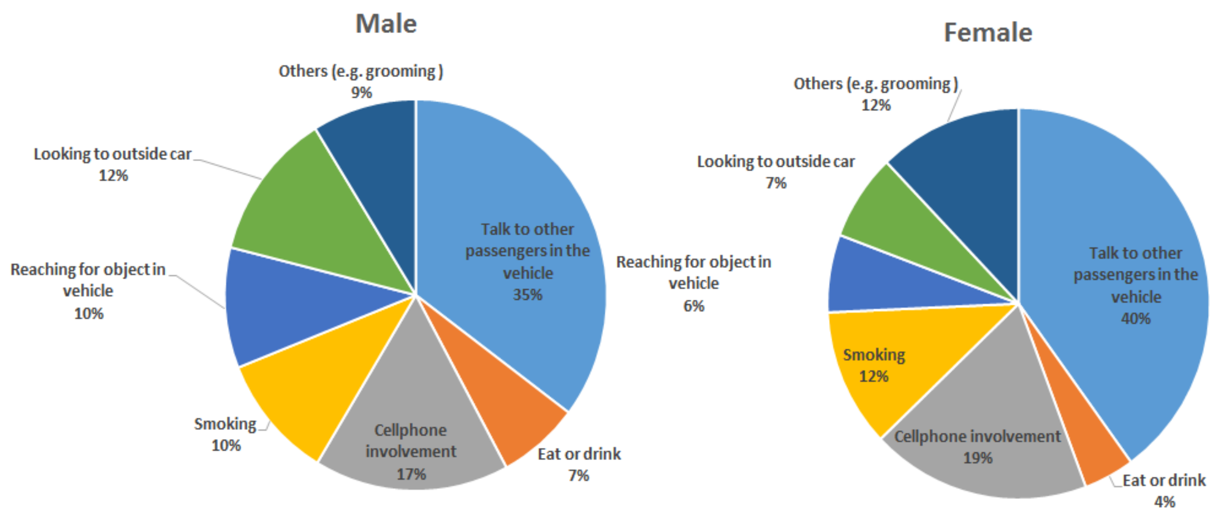


Figure 4.6 Distribution of distracted driving activities by gender

Table 4.4 Descriptive statistics for collected data

Distracted Activity	Diff. (%)
Talk to other passengers in the vehicle	-5%
Eat or drink	3%
Cellphone use	-2%
Smoking	-1%
Reaching for object in vehicle	4%
Looking outside the car	5%
Others (e.g., grooming)	-3%

As seen in figure 4.6 and table 4.4, male drivers generally displayed a greater tendency to engage in visual and manual distractions. Male drivers were found to have higher ratios than females in regards to eating/drinking (7% versus 4%), looking outside the car (12% versus 7%), and reaching for objects in the vehicle (10% versus 6%). Female drivers were more likely to talk to another passenger in the vehicle (40% versus 35%), use a cellphone (19% versus 17%), smoke

(12% versus 10%), or engage in other activities (12% versus 9%). The major differences (differences greater than 4%) between gender groups were observed in relation to behaviors such as talking to passengers in the vehicle (5%) and looking outside the car (5%). These differences are reflected in the recorded values, but were not statistically significantly different. The following sections discuss the relationships between distracted driving and three primary characteristics involving aspects of vehicles, drivers, and the environment.

4.5.3 Distraction and Vehicle Characteristics

Distraction frequencies were broken down to evaluate the relationship between distracted driving activities and vehicle characteristics, such as vehicle use types and vehicle models, grouped by driver gender. Tables 4.5a and 4.5b display the relationships among distracted driving activities, vehicle uses, and vehicle models. The values in Tables 4.5a-b are presented as frequency. In columns 4-11, the values on the left side of the slash represent distraction frequencies observed among non-commercial drivers, whereas the values for commercial/work/farm drivers are displayed on the right side of the slash. First, distraction frequencies under different vehicle uses were compared. Overall, male commercial drivers were found to have a higher distraction ratio than were non-commercial male drivers (31% versus 25%). This result suggested that one in every three male commercial drivers conducted one or more types of secondary tasks while driving. The same trend can be observed when comparing distraction ratios against vehicle uses among female drivers (female commercial = 31%, versus female non-commercial = 28%). These results support the conclusion made by the NHTSA regarding the steady increase of work related distraction found among commercial vehicle drivers [3].

Among pickup trucks, SUVs, and single trucks, higher distraction ratios were found for male commercial drivers (32% versus 26%, 44% versus 25%, 27% versus 0%, respectively). As for school buses, no distracted driving activities were observed.

Table 4.5 Distributions of distraction and vehicle characterized by gender (male)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Male	personal	Commercial/farm /work	Passenger	Pick up	SUV/ minivan	Single unit truck	Semi	Motorcycle	Farm	School bus
Talk to other passengers in the vehicle	72	20	25/0	15/11	31/2	0/6	0/1	1/0	0/0	0/0
Eat or drink	16	2	9/0	5/1	2/0	0/1	0/0	0/0	0/0	0/0
Cellphone involvement	34	9	19/0	4/5	11/2	0/2	0/0	0/0	0/0	0/0
Smoking	21	6	9/0	5/5	7/0	0/1	0/0	0/0	0/0	0/0
Reaching for object in vehicle	18	8	7/0	2/5	9/2	0/0	0/0	0/0	0/1	0/0
Looking to outside car	24	8	7/0	10/3	6/1	0/2	0/0	1/0	0/1	0/0
Others (e.g. grooming)	18	5	12/0	2/2	4/0	0/1	0/1	0/0	0/0	0/0
total (distracted)	203	58	88/0	43/32	70/7	0/13	0/2	2/0	0/2	0/0
Overall (with or without distraction)	819	190	346/6	166/101	284/16	8/48	0/14	16/0	0/3	0/2
Distraction rate	25%	31%	25%/0%	26%/32%	25%/44%	0%/27%	0%/14%	13%/0%	0/67%	0/0

Table 4.6 Distributions of distraction and vehicle characterized by gender (female)

Female	personal	Commercial /farm /work	Passenger	Pick up	SUV/	Single unit	Semi	Motorcycle	Farm	School bus
Talk to passengers in vehicle	55	1	32/1	0/0	23/0	1/0	0/0	0/0	0/0	0/0
Eat or drink	6	0	4/0	0/0	2/0	0/0	0/0	0/0	0/0	0/0
Cellphone involvement	25	1	14/0	1/0	11/1	0/0	0/0	0/0	0/0	0/0
Smoking	16	0	12/0	0/0	4/0	0/0	0/0	0/0	0/0	0/0
Reaching for object in vehicle	8	1	6/0	1/1	2/0	0/0	0/0	0/0	0/0	0/0
Looking to outside car	10	0	4/0	0/0	6/0	0/0	0/0	0/0	0/0	0/0
Others (e.g. grooming)	16	1	8/0	1/1	8/0	0/0	0/0	0/0	0/0	0/0
total (distracted)	136	4	80/0	3/2	56/1	1/0	0/0	0/0	0/0	0/0
Overall (with or without distraction)	479	13	266/2	8/6	203/5	2/0	0/0	0/0	0/0	0/0
Distraction rate	28%	31%	30%/50%	38%/33%	12%/20%	50%/0%	0/0	0/0	0/0	0/0

In contrast to the distraction trends observed among male non-commercial and commercial drivers, higher distraction ratios were found among female non-commercial drivers for most vehicle models. These disparate trends may be attributed to the relatively low commercial female driver population. Consequently, the probability of observing distracted driving activities among female commercial drivers was low. As for vehicle models, such as semi-trucks, motorcycles, farm equipment, and school buses, neither female non-commercial nor commercial drivers were observed operating these vehicle models. No further comparisons could be made among female drivers. The following section discusses the distribution of distraction data across different driver characteristics.

4.5.4 Distraction and Driver Characteristics

Distraction frequencies were broken down in order to evaluate relationships between distracted driving activities and driver characteristics, such as looking behavior and accompanying front seat passengers, grouped by gender. Table 4.6 presents the distributions of seven distraction-related activities among three driver-related characteristics. As opposed to the previous section, the values on the left side of the slash represent distraction frequencies among male drivers, whereas the values for female drivers occur on the right side of the slash. Overall, when drivers were accompanied by passengers in the front seat, female drivers displayed a higher ratio of distraction (64%, versus 53% among males). However, the distraction ratios for talking to passengers in the vehicle among the two gender groups were similar (males = 80%, females = 79%). Without the presence of an accompanying front seat passenger, the ratios of talking to passengers in the vehicle significantly reduced in both gender groups (male = 1%, female = 10%). This reduction in talking to passengers in the vehicle was then captured by an increase in six alternate distractions. Activities found to significantly increase included cellphone use, smoking, and reaching for objects in the vehicle. However, overall distraction ratios for male and female drivers reduced to 19% and 20%, respectively.

Looking behaviors were additionally analyzed. Because only four distraction events were observed for looking to one side and looking on both sides, the analysis focused on drivers who were looking straight ahead while crossing HRGCs. Overall, female drivers again displayed a higher distraction ratio (64%, versus 53% among males). Possible distractions preventing drivers from looking to both sides for the presence of trains included cellphone use, smoking, and others. In comparing distraction ratios between the two gender groups, female drivers seemed to display higher distraction ratios than did male drivers across all three driver characteristics.

Table 4.7 Distributions of distraction and driver characteristics by gender

Activities	Passenger accompanied (M/F)	Passenger NOT accompanied (M/F)	Look straight (M/F)
Talk to other passengers in the vehicle	90/48	2/8	2/8
Eat or drink	3/2	15/4	14/4
Cellphone use	5/1	38/25	35/25
Smoking	4/5	23/11	16/10
Reaching for object in vehicle	2/0	24/9	18/8
Looking to outside of car	2/2	30/8	3/2
Others (e.g., grooming)	7/3	16/14	13/12
total (distracted)	113/61	148/79	101/69
Overall (with or without distraction)	215/95	796/397	653/360
Distraction ratio	53%/64%	19%/20%	15%/19%

*(M/F) represents (male/female)

4.5.5 Distraction and Environmental Characteristics

Distraction frequencies were broken down to evaluate relationships between distracted driving activities and environmental characteristics such as weather conditions, lighting conditions, and pavement conditions. Considering three observed weather conditions (i.e., clear, cloudy, and rain), female drivers appeared to display greater distraction ratios than did male drivers under clear and cloudy weather conditions. Under dry pavement condition, female drivers were also found to display a higher distraction ratio. Female drivers appeared to display high distraction ratios when weather and pavement conditions were clear/fair, as shown in Table 4.7. However, under rainy and wet pavement condition, female drivers exhibited additional caution and concentration, resulting in fewer distractions by other activities. In terms of lighting conditions, female drivers had a higher distraction ratio than did male drivers during daylight conditions. However, female drivers appeared to be more cautious when driving during dawn and dusk periods, resulting in a smaller distraction ratio than that observed among male drivers. Although overall distraction ratios differed between the two gender groups under different conditions, the distributions of seven activities among the two gender groups were similar.

Table 4.8 Distributions of distraction and environmental characteristics by gender

Activities	Clear (M/F)	Cloudy (M/F)	Rain (M/F)	Daylight (M/F)	Dusk (M/F)	Dawn (M/F)	Dry Pavement (M/F)	Wet Pavement (M/F)
Talk to other passengers in the vehicle	82/52	3/3	7/1	79/51	13/5	0/0	85/55	7/1
Eat or drink	13/4	4/2	1/0	16/5	1/1	1/0	17/6	1/0
Cellphone use	23/22	17/4	3/0	35/25	1/0	7/1	40/26	3/0
Smoking	13/10	13/6	1/0	21/15	2/0	4/1	26/16	1/
Reaching for object in vehicle	19/8	6/0	1/1	20/9	2/0	4/0	25/8	1/1
Looking to outside car	25/10	7/0	0/0	25/9	5/1	2/0	32/10	0/0
Others (e.g., grooming)	16/11	6/5	1/1	19/13	1/1	3/3	22/16	1/1
Total (distracted)	191/117	49/20	14/3	215127	25/8	21/5	247/137	14/3
Overall (with or without distraction)	637/358	287/97	78/35	859/440	69/26	81/25	931/456	78/35
Distraction ratios	30%/33%	19%/21%	18%/9%	25%/29%	36%/31%	26%/20%	27%/30%	18%/9%

*(M/F) represents (Male/Female)

4.5.6 Distributions of Distracted Driving and Crossing Violations

Analyses of the relationships between violations and distractions are presented in this section. Overall, 16 HRGC violations were observed. All 16 violations were classified as "vehicle proceeding through crossing under ascending gates." Four of 16 violations, reflecting 25% of all violations, were found to involve distracted driving activities. Three sources of distraction were found to be associated with four HRGC violations. These sources included cellphone use, smoking, and reaching for objects in the vehicle. Two violations were related to smoking. Strenuous examination of the relationship between distracted driving and violation frequency could, logically, provide evidence of a relationship between distracted activities and violation frequency; however, the current HRGC sample size was not sufficient to make conclusive statements. Future research should focus on evaluating the effects of distracted driving activities on crossing violations at HRGCs.

4.6 Conclusion

Based on a series of comparisons of distracted driving activities conducted among two gender groups, female drivers displayed a higher distracted driving ratio (29%) than did male drivers (26%). Of seven sources of distracted driving, four sources of distracted driving were frequent among female drivers, including talking to passengers in the vehicle, cellphone use, smoking, and "others." Other sources of distraction, including eating/drinking, reaching for objects, and looking outside of the vehicle, were found to be more frequent among male drivers. In analyzing the effects of vehicle characteristics on distracted driving, male commercial drivers were found to exhibit higher distraction ratios than were non-commercial male drivers (31% versus 25%). One in every three male commercial drivers engaged in one or more types of secondary tasks while driving. Female drivers were found to display a similar distraction trend in terms of commercial and non-commercial driving. In terms of driver characteristics, when a driver was accompanied by a passenger, female drivers exhibited a higher distraction ratio than did male drivers (64% versus 53%). Comparisons revealed that possible distracting activities preventing drivers from checking both sides for the presence of trains included cellphone use, smoking, and others. Female drivers appeared to display higher distraction ratios when weather and pavement conditions were clear and dry. However, under rainy and wet pavement conditions, female drivers demonstrated more caution and concentration toward driving, evidenced by fewer observed distractions in comparison to males. Based on limited violation information, approximately 25% of HRGC violations were associated with one or more sources of distraction. Distracted driving may potentially result in higher violation rates and could potentially lead to unexpected consequences.

Chapter 5 Conclusions and Recommendations

The objective of this research was to investigate the occurrence of distracted driving at HRGCs, and to identify driver, roadway, environmental, and crossing characteristics associated with distracted driving at HRGCs. Seven sources of distracted driving activities and additional associated factors were investigated. Data were collected at two HRGCs. Calculated distraction ratios suggested that, overall, female drivers were more likely to be distracted than were male drivers (29% of female drivers vs. 26% of male drivers). Commercial drivers, regardless of gender, displayed higher distraction ratios than did non-commercial drivers. This phenomenon was similar to the conclusions of the NHTSA's National Occupant Protection Use Survey. In terms of driver, vehicle, and environmental characteristics, each characteristic resulted in different degrees of driver distraction. Generally, the analysis indicated that both the presence of passengers and prevailing weather conditions were major contributors toward increasing rates of distraction. However, the magnitude of the contribution of each characteristic to distracted driving could not be determined confidently in the current study. In terms of the relationship between distracted driving and crossing violations, the analysis indicated that 25% of HRGC violations were associated with distracted driving. Based on these findings, the following conclusions were reached:

- Out of seven sources of distracted driving, four sources of distraction were popular among female drivers, including talking to passengers, cellphone use, smoking, and "others." Additional sources of distraction, including eating/drinking, reaching for objects, and looking outside of the vehicle, were found to be more frequent among male drivers.

- Overall, male commercial drivers were found to have a higher distraction ratio than were non-commercial male drivers (31% versus 25%). Results suggested that one in every three male commercial drivers conducted one or more types of secondary tasks while driving. The same trend can be observed in comparing distraction ratios against vehicle use types among female drivers (female commercial drivers = 31%, female non-commercial drivers = 28%).
- When a passenger occupied the front seat, female drivers displayed a higher distraction ratio than did male drivers (64% versus 53%). However, distraction ratios for talking to passengers in the vehicle among the gender groups were similar (male 80%, female 79%). Without the presence of a passenger in the front seat, the ratio of talking to passengers in the vehicle significantly decreased among both gender groups (male = 1%, female = 10%).
- Female drivers appeared to display higher distraction ratios when weather and pavement conditions were clear/fair. However, the distraction ratios for male drivers were fairly consistent regardless of weather conditions.
- Analysis indicated that distracted driving could potentially result in higher violation rates. However, the HRGC sample utilized in this study was insufficiently large to make conclusive statements in this regard.

This study explored the effects of various factors on distracted driving activities at a basic level. Certain aspects of distracted driving at HRGCs require further investigation. These include the collection and analysis of data pertaining to hazardous environmental conditions (e.g., icy roads), analysis of HRGCs with greater geographic variability, and the implementation and assessment of countermeasures to reduce distracted driving activities. Moreover, this research did not employ a statistical approach to examine the significance of characteristics associated with distracted driving.

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.

APPENDIX A

DISTRACTED DRIVING DATA EXTRACTION FORM

Event: **0 TRAIN**

1 MOTORIST

2 BICYCLIST

3 PEDESTRIANS

Crossing Time **Record the timestamp when the crossing event reaches the BEGIN LINE of the area of interest**

HH:MM:SS

1. Roadway Environment

Q1 Location of the crossing:

1 Fremont
2 35th St.
3 44th St.
4 Old Cheney& Jamaica
5 S 27th & Saltillo Rd.
6 S14th & Yankee Hill

Q2 Active Warning Device equipped?

1 YES
0 NO

Q3 Number of tracks:

1 1 track
2 2 tracks
3 more than 2 tracks

Q4 Number of traffic lanes:

1 Single
2 Two lanes
3 More than 2 lanes

Q5 Is there an intersecting road is present within 250' of the crossing (either north or south of crossing)?

1 YES
0 NO

Q6 Are any of the following activities found near the study site and may potentially affect driver attention?

1 Accident
2 Special sign (billboard or traffic sign)
3 Work zone
4 Unattended vehicle
0 No presence

Q7 **Was the crossing warning activated for a train crossing event? (i.e. flashing light)**

1 YES

0 NO

2. Vehicle Characteristics

Q8 **What type of transportation mode was found at the crossing (w/ or w/o violation) event?**

1 Personal vehicle

0 Commercial/company/farmer vehicles

Q9 **Please specify the vehicle type:**

0 Passenger car

1 Pick-up truck

2 SUV / Minivan

3 Single unit truck (e.g. UPS, FedEx trucks)

4 Multi-unit truck (e.g. semi)

5 Motorcycle

6 Farm equipment (tractor)

7 School bus

3. Driver Characteristics and Behavior

Q10 **Driver gender:**

0 female

1 male

Q11 **Driver's looking behavior after entering the recording zone before reaching train tracks:**

0 look straight

1 look one side

2 look both sides

Q12 **Is there an accompanying passenger in the front?**

0 No

1 Yes

Q13. **Below is a list of possible secondary activities a driver may be engaged in while approaching/crossing roadway-rail grade crossings. Please record the most likely secondary task that the driver was involved in based on your observation from the footage:**

0 No secondary task observed

1 Talk to other passengers in the vehicle

2 Eat or drink

3 Cellphone use

4 Smoking

5 Reaching for object in vehicle

6 Looking to the side/outside car

7 Others (e.g. personal grooming)

8 Using headsets and/or headphones **(for pedestrians and bicyclists only)**

4. Environmental Factors

Q14 Weather condition

01='Clear' 02='Cloudy'
03='Fog, smog, smoke' 04='Rain'
05='Sleet, hail, freezing rain/drizzle' 06='Snow'
07='Severe crosswinds' (the strong moving/shaking caused by wind)
08='Other'

Q15 Light Condition

1='Daylight' 3='Dusk'
2='Dawn' 4='Dark-lighted roadway'
5='Dark-roadway not lighted' 6='Other'

5. Violation Features for Train Crossing Events

Q16 Was the user involved in any grade crossing violations?

1 YES
0 NO

Q17 Was a crossing warning device activated?

1 YES
0 NO

Q18 Type of violation by the user:

1 Passing between the activation of train warning and the gate descending (denoted as V0)
2 Passing under descending gates (V1)
3 Passing around fully lowered gates (V2)
4 Passing around fully lower gates between successive trains or a stopped train (V3)
5 Passing under ascending gates (V4)

Q19 Types of given violation opportunities to the user:

1 Violation opportunity for V0
2 Violation opportunity for V1
3 Violation opportunity for V2
4 Violation opportunity for V3
5 Violation opportunity for V4

Q20 Queuing position of the user:

1 First in queue
2 Second in queue
3 Third or more in queue

Q21 Did the leading vehicle (in either queuing or moving conditions) in the same direction commit the violation?

1 YES

0 NO

Q22 Type of violation by the leading vehicle:

1 Passing between the activation of train warning and the gate descending (denoted as V0)
2 Passing under descending gates (V1)
3 Passing around fully lowered gates (V2)
4 Passing around fully lower gates between successive trains or a stopped train (V3)
5 Passing under ascending gates (V4)

Q23 Did vehicle in opposite direction commit violation?

1 YES
0 NO

Q24 Type of violation by the opposite vehicle:

1 Passing between the activation of train warning and the gate descending (denoted as V0)
2 Passing under descending gates (V1)
3 Passing around fully lowered gates (V2)
4 Passing around fully lower gates between successive trains or a stopped train (V3)
5 Passing under ascending gates (V4)