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# The Influence of Selected Factors Impacting the Incidence and Severity of Accidents Involving Pedestrian/Bicyclists and Motorized Vehicles in Urban Areas of Louisiana

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# THE INFLUENCE OF SELECTED FACTORS IMPACTING THE INCIDENCE AND SEVERITY OF ACCIDENTS INVOLVING PEDESTRIAN/BICYCLISTS AND MOTORIZED VEHICLES IN URBAN AREAS OF LOUISIANA

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# TABLE OF CONTENTS

# ABSTRACT

The primary purpose of this study was to determine the influence of selected demographic, environmental and infrastructure factors on the incidence and severity of traffic accidents involving a motorized vehicle and a non-motorized (pedestrian or bicyclist) individual. Identification of influential factors can aid in developing more effective countermeasures, targeted education and training programs to reduce the fatality and injury risks to vulnerable road users. A total of 9,538 crash data records involving vulnerable road users and motor vehicle drivers were utilized in this study.

Overall, vulnerable road users were found to have higher incidences of impairment than motorized vehicle drivers in accidents involving the two groups. In addition, it was discovered there was a higher incidence of VRU/motorist accidents in mixed use environments and more of these types of accidents occurring at locations other than at an intersection. The time of day with the highest incidence of VRU/motorist accidents is between the hours of 6 p.m. and 12 a.m. The younger drivers and older VRU's that were most likely to be involved in high severity accidents. Environments with no streetlights in darkness were most likely to experience high incidence of higher severity crashes. Furthermore, it was discovered that the VRU's displayed higher incidence of distraction in VRU/motorist accidents than the motorized driver.

Based on these findings the researcher concluded that environment and VRU behaviors are major contributors to motorized/non-motorized accidents. The researcher recommends education campaigns to persuade vulnerable road users to develop a better understanding of safety practices when interacting with motorized vehicles. The researcher also recommends further study into the appropriate measures to mitigate environment factors such as lighting and mixed-use developments.

# CHAPTER 1. INTRODUCTION

## Rationale

Automobile accidents kill or severely injure approximately 258,806 people in the United States each year (NHTSA 2016). An average of approximately 30,000 lives are lost in the United States every year due to traffic accidents. The negative outcomes of these incidents are not confined to the parties involved but carry over into society as well. In addition to the visible physical injuries incurred in an accident, lingering emotional trauma, property damage and crushing financial problems result as well. In the United States the total economic impact of automobile crashes in 2010 was $242 billion (Blincoe, Miller, Zaloshnja, & Lawrence, 2010).

Accidents between two motorized vehicles are most often restricted to property damage, while an accident involving a motorized vehicle and a non-protected individual (pedestrian or bicyclist) has an almost certain probability of yielding a severe to fatal physical injury to the unprotected individual. The United States has a higher incidence of non-motorized road user involved accidents than other comparable developed countries (Eluru, Bhat, & Hensher, 2008). In the United States non-motorized road users are up to 3 times more likely to be killed than in Germany and up to 6 times more likely to be killed than in the Netherlands. The high incidence of a fatal outcome makes accidents between vehicles and non-motorists especially problematic.

The United States National Highway Transportation Safety Administration (NHTSA) states on average a pedestrian is killed almost every 1.5 hours in a traffic accident (NHTSA 2016 pedestrian traffic safety fact). Pedestrian/bicyclist crashes represented 16 percent of all fatalities and 2 percent of all non-fatal crashes in 2010. These crashes accounted for $16 billion in economic harm (Blincoe, et al., 2010). Louisiana is 6$^{th}$ in the nation in terms of per capita crash costs at $1,255 (Economic and social impact of motor vehicle crashes).

The types of automobile accidents and frequency vary throughout the United States. There are many factors that contribute to this variability such as vehicle type, travel speeds, roadway infrastructure, topography, state traffic laws and weather. The following categories of accidents are most common. (1) The incidence of fatalities in single car accidents occur more than other types of accidents. In 2017 a total of 19,969 people were killed in single car accidents (www.iihs.org). An accident is determined to be a single vehicle when only one vehicle is involved. Typical single vehicle accidents involve run-off-the-road, lane departure, rollover, collisions with road debris or animals. (2) The next highest incidence of fatal crashes involves two vehicles. In 2017, approximately 41% of two vehicle crashes involved a passenger car and light truck (www.iihs.org). (3) Accidents involving more than two vehicles are less common. These accidents typically occur from extreme weather events such as snow, rain or fog. (4) The category of accident at the center of this research involves pedestrians and bicyclists referred to as vulnerable road users. This category of accident accounted for 6,754 fatalities throughout the United States in 2017 (www.iihs.org). These accidents involve a motorized vehicle and a non-motorized vulnerable road user.

Preliminary findings from the Governors Highway Safety Association (GHSA) show an increase of four percent in the number of pedestrians killed in motor vehicle crashes in 2018 (GHSA – 2018 pedestrian traffic fatalities). The same report projects 2018 to have the highest number of pedestrian fatalities since 1990. This national trend is not seen universally across all states. Individual states have seen differing trends with some rising, some falling and others remaining fairly consistent. Unfortunately, Louisiana is one of the states experiencing an increase in vulnerable road user fatalities with a twelve percent increase from 2017 to 2018.

Such a dramatic rise has prompted a renewed focus on better understanding the factors and circumstances behind these trends.

Automobile and non-motorist collisions in urban areas are of concern as cities in the United States continue to encourage citizens to walk or bike. Local governments and communities promote walking and cycling because of their economic and public health benefits. A critical barrier to greater adoption of bicycling or walking in urban areas is traffic safety concerns (Fowler, Berrigan, & Pollack, 2017). Studies have shown crash risk to be a major consideration for people when deciding whether or not to engage in these activities.

Throughout the United States over 80 percent of vulnerable road user involved accidents occur in urban areas. Nationally pedestrian crashes occurring in urban areas occur in dark conditions about 75 percent, on local streets about 35 percent and outside of an intersection 72 percent of the time (GHSA, 2018). Impairment is a moderating factor for increasing incidence of injury level, but nationally involve a driver impaired 17 percent of the time and pedestrian impairment 32 percent.

The primary data source for analyzing crash data are crash reporting data repositories containing crash reports generated by law enforcement officers. These officers typically thoroughly document the circumstances of the accident in these reports. However, these officers can only report on the information they are able to obtain and verify once the accident has occurred. Outside of witness statements these reports do not contain information on the circumstances leading to the accident. The officer must rely on the recollection of those involved and potential witnesses. These statements often do not provide any further detail to the circumstances leading up to the time of the accident, so it is not possible to get more specific information than what is available by the physical evidence.

It is believed that distraction is an increasing factor to all types of automobile accidents throughout the United States. Distraction is extremely difficult to verify after the accident has occurred because it is a behavioral characteristic. One of the growing sources of distraction is electronic devices such as smart phones. Between 2010 and 2017, the number of active smartphones in the Unites States grew more than 350 percent and data usage grew more than 4,000 percent during the same period (GHSA, 2018). Electronic device usage and other categories of distraction are increasingly being captured in crash reporting tools to help provide data driven evidence.

Following the national trend, Louisiana cities are promoting non-vehicular modes of travel as well. These promotions increase individuals' exposure to involvement in accidents with tragic results. As of 2016, Louisiana ranks fifth in the nation for pedestrian fatalities (NHTSA 2016 pedestrian traffic safety fact). The decision to take non-motorized transportation is not necessarily an option in many cases as Louisiana ranks 4th in the nation for a driver's license-less population (DOTD Master Plan 2009). This factor makes foot and bicycle travel the only means for many citizens to commute to work, school, grocery and any other activity away from the home. As Louisiana cities continue to develop infrastructure and promote non-motorized modes of travel, they continue to contend with traffic safety issues.

Research on non-motorist accidents has focused mainly on the incidence and outcomes of accidents based on infrastructure and environmental factors but very little on the behavioral factors. In order to better prevent these types of accidents, or at least minimize the severity, the factors leading to these incidents must be examined. Factors investigated include demographic, environmental and infrastructure variables.

## Purpose of the Study and Research Questions

The primary purpose of this study was to determine the influence of selected demographic, environmental and infrastructure factors on the incidence and severity of traffic accidents involving a motorized vehicle and a non-motorized (pedestrian or bicyclist) individual. Identification of influential factors can aid in developing more effective countermeasures, targeted education and training programs to reduce the fatality and injury risks to vulnerable road users.

## Objectives

The following objectives were designed to guide this research:

1. To describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist on the incidence and severity of the accident in designated urban areas of Louisiana within the five year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate)

    a. Gender of driver, vulnerable road user (VRU);

    b. Age of driver, vulnerable road user (VRU);

    c. Severity of injury for driver, vulnerable road user (VRU);

    d. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

    e. Incidence of distraction for motorized driver and/or non-motorized individual.

2. To describe accidents in urban areas of Louisiana that involve a motorized vehicle and a pedestrian or bicyclist on the following environmental, infrastructure and demographic characteristics:

a. Weather;

b. Environment (lighting, land use);

c. Manner of collision;

d. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

e. Time of day;

f. Vehicle type.

3. To determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Manner of collision;

g. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

h. Time of day;

i. Vehicle type;

j. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

k. Incidence of distraction for motorized driver and/or non-motorized individual.

4. To determine if a model exists explaining a significant portion of the variance in

incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from the following environmental, infrastructure and demographic characteristics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

# CHAPTER 2. LITERATURE REVIEW

## Introduction

Research into the causes of accidents involving motor vehicles and pedestrians or bicyclists have become more pressing in recent years. The increased interest is supported by a recent report from the Governors Highway Safety Association (GHSA) which shows a four percent increase in the number of pedestrians killed in motor vehicle crashes in 2018 (GHSA – 2018 pedestrian traffic fatalities). The GHSA report also states 2018 to have the highest number of pedestrian fatalities since 1990. A literature review was conducted to identify the variables contributing to high pedestrian and bicyclist crash rates. Included studies supported six groups of factors based on a model developed by Lin, Bialkowska-Jelinksa, Kourtellis & Zhang (2019). The factors noted are: Roadway characteristics, socio-demographics, land use, individual and behavioral characteristics, crash characteristics (Chen, Shen, 2019; Eluru, Bhat, & Hensher, 2008) and other factors.

## Vulnerable Road Users

The 2018 global assessment of road safety by the World Health Organization (WHO) found that more than half of the global road traffic deaths (1.35 million) were among the vulnerable road users (VRU) (WHO/OMS, 2018). The term "vulnerable road user" (VRU) is applied to individuals most at risk for injury in traffic as they are not protected by an outside shield (OCDE/OECD, 1998). Members of the VRU group include pedestrians, pedal cyclists and motor cyclists as they all have no external protection from motor vehicles in a collision. Almost without exception these individuals suffer the most severe injuries when involved in collisions with motorized vehicles. Pedestrians and pedal cyclists are studied together as they do not involve motorized modes of travel.

## Spatial Identification

Walking and biking are the most basic modes of travel available to most everyone. These modes are also the most dangerous when sharing space with motorized vehicles. Interactions between motorized and non-motorized road users most often end with the non-motorized users being seriously or fatally injured. When attempting to address the most critical issues involving non-motorized road users it is most often important to identify critical areas for which to deploy limited resources. Identifying target locations where non-motorized crashes occur has allowed for targeted interventions in areas with the most exposure. An effective method to identify target areas is through the use of GIS tools to visualize crashes within Traffic Analysis Zones (TAZ) (Chen, 2015). Identification of non-motorized crashes provides analysis of characteristics related to location such as demographics, land use and proximity to non-motorist residence to crash location.

In low economic neighborhoods non-motorized road users are fatally injured at rates disproportionately higher than other areas (Maciag, 2014). According to a Governing Research Report, “Within metro areas, low-income tracts recorded pedestrian fatality rates approximately twice that of more affluent neighborhoods” (Maciag, 2014). Factors contributing to this outcome include demographic, road environment and land use (Lin, Guo, Bialkowska-Jelinska, Kourtellis and Zhang, 2018). Some of the individual factors include proportion of older adults, usage of public transit, proportion of higher speed roads, density of discount and convenience stores and fast-food restaurants. These factors are positively related to crash incidence and severity.

## Roadway Characteristics

A roadway factor contributing to automobile crashes is the posted speed limit of the road section. Studies have found that speed limit is a critical factor in severe bicycle injuries involving motorized vehicles (Chen & Shen, 2019). High-volume/high-speed roadways are positively associated with high crash and severity rates (Lin, et al., 2018).

## Environment

### Land Use

Variations of commercial, residential and mixed-use areas have an impact on incidents of pedestrian and bicycle crashes. Pedestrians are more likely to be fatally injured in residential areas than commercial areas (Haule, Sando, Kitali, & Richardson, 2019). Factors influential to the proximity of pedestrian crashes to their residence are age, gender, motorized traffic volume, season and pedestrian residence demographic characteristic. Pedestrian's involved in motorized accidents near their residence are most likely to be caused by driver's farther away from their residence. The logic follows that the drivers are less familiar with traffic patterns and behaviors of non-motorized road users in these areas.

### Lighting

Installation of infrastructure items that provides for a safer and pedestrian-friendly environment are more prevalent in affluent neighborhoods (Bridging the Gap, 2012). Infrastructure items promoting greater walkability include sidewalks, marked crosswalks, lighting (Kim, Kim, Ulfarsson, & Porrello, 2007) and traffic calming measures. Large lane widths and number of lanes are positively associated with higher severity in crashes involving non-motorist road users. When pedestrian refuge islands are implemented in urban areas there is a reduction in pedestrian involved collisions (Kang, 2019).

## Demographics

People of all ages engage in walking and bicycling for various reasons. However, risk factors vary based on differing demographic factors such as age. According the Centers for

Disease Control (CDC), adults 50 to 59 years old are involved at the highest rates in bicycle fatality rates involved with motorized vehicles. Fatality rates for pedestrians are highest in the age range of 65 and older. Bicyclist's aged 5-19 years old have the highest incidence of nonfatal injuries in the U.S. Nearly 20% of pedestrian fatalities involved non-motorists under age 15. There is a higher incidence of fatalities and injury for male cyclists than female. Females are 6 times less likely to be killed and 4 times less likely to be injured in accidents involving motor vehicles. A modifying factor for age and gender is environment (urban vs. rural). A study found that there was a significant increase in probability that pedestrians aged 26 to 64 would be severely or fatally injured, as opposed to the same age group in rural areas (Islam & Jones, 2014). This same study found that female pedestrians are likely to experience an increased risk of major injury in urban as opposed to rural locations.

## Individual Characteristics and Behavior

It is not only the built environment that contributes to non-motorist crashes. There are certain characteristics and behaviors of drivers and non-motorist road users that are contributing factors as well. Research notes that problems of non-motorist road user safety is exacerbated in particular by children, elderly, inebriated and distracted users behaving unpredictably making the driver's operation more difficult. Research reveals injury risk is greatest for younger and older cyclists in a given are of exposure. In these cases, it is not necessarily the chronological age that is the issue, but the knowledge attained and ability to apply that knowledge regarding proper road use. Knowledge, or lack of knowledge, of traffic rules is proposed as having a possible effect on accident type, but there are no known assessments to this factor.

One study noted that drivers noticed the cyclist 11% of the time prior to impact, where the cyclist noticed the driver 68% prior to impact (Räsänen & Summala, 1998). The accidents occurred in most part due to the cyclist believing the driver would act in accordance with the applicable laws. Familiarity with the particular accident site and applicable laws were also factors as cyclists familiar with the area were involved in different accident types than cyclists not familiar with the area.

The built environment can be used to help adjust both non-motorized road users and drivers to more positive safe behavior. The city of Austin conducted a study on the effect of low-cost Shared Lane Markings to reduce incidence of non-motorist and vehicle related crashes (Brady, et.al, 2010). Results from the study found that bicyclists greatly reduced unsafe riding behavior like riding on sidewalks or riding past stopped vehicles at sites where lane markings were installed. Likewise, drivers changed lanes in order to pass bicyclists and became less likely to crowd the lane of the bicyclist when passing.

When assessing vehicle to vehicle crashes alcohol impairment is an important contributing factor. In 2016, alcohol related crashes accounted for 28% of all traffic-related deaths in the United States (CDC, 2019). Impairment was found to not be a factor in a state-wide study conducted by the Virginia Department of Transportation (Virginia Department of Transportation, 2017). In this study it was found that in pedestrian related fatal crashes the involved pedestrian was intoxicated 33% and the driver 6%. Even though this was not a major factor it still shows that the pedestrians had an incidence of drinking five times more than drivers. The factor of intoxication changed when digging deeper than overall state level. Fatal crashes involving pedestrians occurring on two-way, undivided roadways with four or more lanes had the highest incidence of pedestrian drinking than other road types.

The likelihood that a bicyclist will be severely injured or killed increases by 375 percent if the accident occurs at a non-intersection and the bicyclist is impaired. When the accident occurs at an intersection and the bicyclist is impaired there is an 82 percent increase in likelihood the non-motorist is severely injured or killed (Moore, Schneider, Savolainen, & Farzaneh, 2011).

Culture

Governments across the world are working diligently to improve the safety of their roadways in order to reduce the incidence of fatal and severe traffic accidents involving their citizens. Many efforts focus on infrastructural aspects because they are more easily assessed and implemented. However, it is also the behavior of individuals that has an impact on the safety of these roadways. A key influencer of behavior on the individual is the cultural environment in which they live. Specifically, what is the safety culture?

Driving a motor vehicle while intoxicated is one of the biggest risk factors and contributors to high severity crashes (Schlembach, Furian, & Brandstätter, 2016). This risky behavior is influenced by the culture of drinking and driving in which the individual lives. According to the National Highway Traffic Safety Administration (NHTSA) in 2017, alcohol-impaired crashes claimed the lives of 10,874 people.

Results from cross-cultural research and controlled experiments show that behavior from alcohol impairment are determined by social and cultural factors (The Social Issues Research Centre, 1998). The same research found that cultural factors, beliefs, attitudes, norms and expectations about drinking are contributing factors to problems related to alcohol consumption. Attitudes vary by country and region about appropriate consumption of alcohol. Examples of differences in perceived “safe” amounts can be seen in the United States where three to four drinks is believed to be safe. On the other hand, in Sweden this amount is considered excessive (Marsh & Stefanou, 2016). In the United States it takes on average three to four drinks within an hour for individuals to reach the legal limit of .08 BAC (Blood Alcohol Concentration) for someone to be considered intoxicated.

Public safety and health lifestyle changes are difficult to change without the support of overall societal and cultural change. Individuals are influenced by their social support groups to the extent they may engage in behavior that is not beneficial for the individual health and wellbeing. A healthcare study of patience at high risk for cardiovascular disease found that over 60% were not following prescribed preventative lifestyle changes. It was discovered that significant contributing factors to the failure of following prescribed changes were family and social gatherings (Serour, Alqhenaei, Al-Saqabi, Mustafa, & Ben-Nakhi, 2006). The individuals reported giving in to the norms of their social circles even though they knew it was detrimental to their health.

Traffic safety culture can be changed through active advocacy and education. Over recent decades the social acceptance and attitudes toward drinking and driving have begun to shift. Identification of the risks involved in driving intoxicated have been promoted successfully by groups such as Mothers Against Drunk Drivers (MADD) (Maskalyk, 2003). These types of organizations have worked to change public opinion and generate public policy shifts to encourage safer driving practices. Impaired driving is both a safety and health concern. A tool utilized by health professionals is to incorporate culture-specific attitudes and values into messages and materials to more effectively promote healthier changes (Brach & Fraserirector, 2000). Within the overall culture it is discovered that gender (Özkan & Lajunen, 2006) and differences in rural versus urban locations (Rakauskas, Ward, & Gerberich, 2009) contribute to attitudes toward safety. Few individuals care about poor health indicators unless the indicators are connected to their life goals (Napier et al., 2014). Understanding this on a group and societal level will aid health, safety and policy professionals in making positive changes.

Incidence of Distraction

Distraction among motor vehicle drivers has long been an issue in traffic safety and one of the leading causes of traffic accidents (Nemme & White, 2010). There are many distracting tasks that drivers can and do engage in while driving such as eating, applying makeup, daydreaming and a myriad of other activities. However, the largest growing distraction is cell phone usage while driving, walking or biking. Safety campaigns and enforcement targeting vehicle drivers to prevent distraction from texting and driving have been a focus of traffic safety in recent years. In the past decade research has discovered that vulnerable road users are also susceptible to distraction from cell phone usage as well.

Mobile phone usage while walking increases safety risks through the additional demands of managing both activities (Lim, Amado, Sheehan, & Van Emmerik, 2015). While either talking or texting pedestrians experience a reduction in situational awareness and engage in unsafe behavior (Nasar & Troyer, 2013). Simulation based studies have shown that participants actively interacting with multimedia devices were hit by vehicles more often in virtual pedestrian environments that those not distracted (Schwebel et al., 2012; Schwebel, McClure, & Porter, 2017)

## Crash Characteristics

Details of crash occurrences between vehicles are important in determinants to their severity. This factor is true in non-motorist crashes as well. It stands to reason that if a non-motorist hits a vehicle the likelihood of damage and/or injury is low. It is when the vehicle strikes the non-motorist that trouble arises. Incidence of bicyclist deaths occur most often in non-intersection locations in urban areas (CDC, 2015).

## Other Characteristics

In addition to the previously discussed factors involved in and leading to automobile accidents, there are other characteristics that are important but difficult to assess. Determining who is at fault in an accident is difficult to determine as most data gathered is post-event. A study in Minneapolis found that bicyclists and motorists equally contributed to causing crashes (Minneapolis, 2013). Other factors were failure to yield right-of-way, bicyclists riding across roadway and motorist following roadway.

# CHAPTER 3. METHODOLOGY

## Purpose of the Study

The primary purpose of this study was to determine the influence of selected demographic, environmental and infrastructure factors on the incidence and severity of traffic accidents involving a motorized vehicle and a non-motorized (pedestrian or bicyclist) individual. Identification of influential factors can aid in developing more effective countermeasures, targeted education and training programs to reduce the fatality and injury risks to non-motorists.

## Objectives

The following objectives were designed to guide this research:

1. To describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist on the incidence and severity of the accident in designated urban areas of Louisiana within the 5-year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate):

    a. Gender of driver, vulnerable road user (VRU);

    b. Age of driver, vulnerable road user (VRU);

    c. Severity of injury for driver, vulnerable road user (VRU);

    d. Incidence of impairment for motorized driver and/or non-motorized individual;

    e. Incidence of distraction for motorized driver and/or non-motorized individual.

2. To describe accidents in urban areas of Louisiana that involve a motorized vehicle and a pedestrian or bicyclist on the following environmental, infrastructure and demographic characteristics:

a. Weather;

b. Environment (lighting, land use);

c. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

d. Time of day;

e. Vehicle type;

3. To determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized road user.

4. To determine if a model exists explaining a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from selected environmental, infrastructure and demographic characteristics.

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

**Population and Sample**

The target population for this study was defined as motor vehicle accidents in urban areas in Louisiana involving pedestrians and/or bicyclists. The accessible population was defined as all accidents in selected urban areas in Louisiana during the period of 2013 through 2017 involving pedestrians and/or bicyclists. The sample analyzed included one hundred percent of the defined accessible population.

**Instrumentation**

After receiving approval from the dissertation committee and the IRB, the researcher designed a computerized recording form to collect and house data from the Louisiana State Crash Data Repository. The specific variables included were determined from a literature review and discussions with subject matter experts.  Data was obtained from the repository and transferred into the research instrument.  The variables included in the instrument are:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized road user;

j. Incidence of distraction for motorized driver and/or non-motorized road user.

**Data Collection**

Data was collected by downloading the selected variables from the Louisiana State Crash Data Repository.  Prior to downloading the data all personal identifiers was deleted from the data.  Therefore, the data received by the researcher was completely anonymous.  Ensuring anonymity, the researcher applied for Exemption from Institutional Oversight with the Institutional Review Board (IRB).  After receiving approval from the dissertation committee and the IRB, the researcher designed a computerized recording form to collect, organize and store data.  The researcher also contacted the Louisiana Department of Transportation and Development (LADOTD) to assist with collecting the selected accident data.  The researcher coordinated with the LADOTD to retrieve study related data.  The data were extracted by personnel under the direction of LADOTD and provided to the researcher. On receipt of the data it was transferred to the researcher-designed computerized recording form. Following the guidelines of the exemption awarded by the IRB, any potential individual identification information was eliminated from the dataset prior to any analyses.

## Data Analysis Strategy

Individual research objectives drove the data analysis.

The first objective of this study was to describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist on the incidence and severity of the accident in designated urban areas of Louisiana within the 5-year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate):

a. Gender of driver, vulnerable road user (VRU);

b. Age of driver, vulnerable road user (VRU);

c. Severity of injury for driver, vulnerable road user (VRU);

d. Incidence of impairment for motorized driver and/or non-motorized individual;

e. Incidence of distraction for motorized driver and/or non-motorized individual.

The variables that were measured as categorical data (nominal or ordinal) were described by presenting the frequencies and percentages in categories. These variables included gender of the parties, incidence of impairment for parties, and incidence of distraction for the parties. The variables that were measured as continuous data were described by presenting means and standard deviations. These variables included age of parties and severity of injury for the parties.

The second objective of this study was to describe accidents in urban areas of Louisiana that involve a motorized vehicle and a pedestrian or bicyclist on the following environmental, infrastructure and demographic characteristics:

a. Weather;
b. Environment (lighting, land use);
c. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);
d. Time of day;
e. Vehicle type.

The variables that were measured as categorical data (nominal or ordinal) were described by presenting the frequencies and percentages in categories. These variables included weather, environment, manner of collision, roadway characteristics, time of day, and vehicle type. No variables were measured as continuous data in this objective.

The third objective of this study was to determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;
b. Age;
c. Weather;
d. Severity of the injury;
e. Environment (lighting, land use);
f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);
g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized road user.

The analyses that were used to accomplish this objective included correlation coefficients for variables that were measured on a continuous scale (interval). For variables that were measured as categorical data, the Chi-square test of independence was used to determine if each of the variables were independent of the variable severity of accident.

The fourth objective of this study was to determine if a model exists explaining a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from selected environmental, infrastructure and demographic characteristics. This objective was accomplished by using multiple regression analysis with severity of the accident entered as the dependent variable and each of the other measures entered into the analysis as independent variables. For the variables that were categorical in nature, each of the categories of the variable were restructured so that it became a separate binary variable. This format is necessary to facilitate the interpretation of the influence of each of the independent variables.

# CHAPTER 4. RESULTS

The primary purpose of this study was to determine the influence of selected demographic, environmental and infrastructure factors on the incidence and severity of traffic accidents involving a motorized vehicle and non-motorized (pedestrian or bicyclist) individual. Identification of influential factors can aid in developing more effective countermeasures, targeted education and training programs to reduce the fatality and injury risks to non-motorists.

The following objectives were designed to guide this research:

1. To describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist on the incidence and severity of the accident in designated urban areas of Louisiana within the 5-year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate):

    a. Gender of driver, vulnerable road user (VRU);

    b. Age of driver, vulnerable road user (VRU);

    c. Severity of injury for driver, vulnerable road user (VRU);

    d. Incidence of impairment for motorized driver and/or vulnerable road user (VRU);

    e. Incidence of distraction for motorized driver and/or vulnerable road user (VRU).

2. To describe accidents in urban areas of Louisiana that involve a motorized vehicle and a pedestrian or bicyclist on the following environmental, infrastructure and demographic characteristics:

    a. Weather;

b. Environment (lighting, land use);

c. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

d. Time of day;

e. Vehicle type.

3. To determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

4. To determine if a model exists explaining a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from the following environmental, infrastructure and demographic characteristics.

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

**Objective One Results**

The first objective of the study was to describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist (heretofore referred to as vulnerable road users) on the incidence and severity of the accident in designated urban areas of Louisiana within the five year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate):

a. Gender of driver, vulnerable road user (VRU);

b. Age of driver, vulnerable road user (VRU);

c. Severity of injury for driver, vulnerable road user (VRU);

d. Incidence of impairment for motorized driver and/or VRU;

e. Incidence of distraction for motorized driver and/or VRU.

Gender

When the gender of the participants in the accident were examined the majority of the vulnerable road users were male (70.9%) whereas, a substantially smaller proportion (but still a majority) of the motorized vehicle drivers were male (57.4%) (see Table 4.1 and Table 4.2).

Table 4.1. Gender of Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Gender (Vulnerable Road User) | Frequency | Percent |
|---|---|---|
| Male | 6,468 | 70.9 |
| Female | 2,660 | 29.1 |
| Total | 9,128[a] | 100.0 |

[a] Gender data was unavailable for 410 of the vulnerable road users

Table 4.2. Gender of Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Gender (Motor Driver) | Frequency | Percent |
|---|---|---|
| Male | 4,457 | 57.4 |
| Female | 3,302 | 42.6 |
| Total | 7,759[a] | 100.0 |

[a] Gender data was unavailable for 1,779 of the motorized vehicle drivers.

Age

Regarding the age of participants in motorized/non-motorized accidents in Louisiana, the mean age of vulnerable road users was 35.08 (SD = 18.678), whereas the mean age of motorized vehicle drivers was 42.49 (SD = 17.044). To further summarize this data, the age was classified into age groups. The age group with the highest percentage of vulnerable road users involved in accidents was 25-34 (n = 1,657, 18.7%). Within groups of motorized vehicle drivers the highest group was also 25-34 (n = 1,707, 23.0%) (see Table 4.3 and Table 4.4).

Table 4.3. Age of Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Age Group (BikePed) | Frequency | Percent |
|---|---|---|
| 01-14 | 1224 | 13.8 |

(table cont'd.)

| Age Group (BikePed) | Frequency | Percent |
|---|---|---|
| 15-17 | 491 | 5.6 |
| 18-20 | 567 | 6.4 |
| 21-24 | 802 | 9.1 |
| 25-34 | 1657 | 18.7 |
| 35-44 | 1100 | 12.4 |
| 45-54 | 1326 | 15.0 |
| 55-64 | 1170 | 13.2 |
| 65-74 | 380 | 4.3 |
| 75-84 | 97 | 1.1 |
| 85-94 | 30 | .3 |
| 95 and up | 2 | .0 |
| Total | 8,846[a] | 100.0 |

*Note.* Mean age of vulnerable road users is 35.08 with a standard deviation of 18.678
[a]Age data was unavailable for 692 of the vulnerable road users.

Table 4.4. Age of Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana

| Age Group (Motor) | Frequency | Percent |
|---|---|---|
| 01-14 | 7 | .1 |
| 15-17 | 139 | 1.9 |
| 18-20 | 396 | 5.3 |
| 21-24 | 713 | 9.6 |
| 25-34 | 1,707 | 23.0 |
| 35-44 | 1,270 | 17.1 |
| 45-54 | 1,209 | 16.3 |
| 55-64 | 1,066 | 14.4 |
| 65-74 | 632 | 8.5 |
| 75-84 | 228 | 3.1 |
| 85-94 | 51 | .7 |
| 95 and up | 2 | .0 |
| Total | 7,420 [a] | 100.0 |

*Note*. Mean age of motor vehicle drivers is 42.49 with a standard deviation of 17.044.
[a]Age data was unavailable for 2,118 of the motorized vehicle drivers.

Accident Severity

When determining the severity of the accident for the involved individuals, there were 414 (4.3%) vulnerable road user deaths and 0 motorist deaths. Motor vehicle drivers had 9,238

(96.9%) incidence of no apparent injury, where vulnerable users had 1,536 (16.1%) incidence of no apparent injury (see Table 4.5 and Table 4.6).

Table 4.5. Severity of Injury for Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring in Urban Areas Of Louisiana.

| Injury (Bike/Ped) | Frequency | Percent |
|---|---|---|
| Fatality | 414 | 4.3 |
| Suspected Serious Injury | 685 | 7.2 |
| Suspected Minor Injury | 3,283 | 34.4 |
| Possible Injury | 3,620 | 38.0 |
| No Apparent Injury | 1,536 | 16.1 |
| Total | 9,538 | 100.0 |

Table 4.6. Severity of Injury for Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Injury (Motor) | Frequency | Percent |
|---|---|---|
| Fatality | 0 | 0.0 |
| Suspected Serious Injury | 4 | .0 |
| Suspected Minor Injury | 48 | .5 |
| Possible Injury | 248 | 2.6 |
| No Apparent Injury | 9,238 | 96.9 |
| Total | 9,538 | 100.0 |

Overall, the severity of the accident was measured as the most severe of the injuries among the participants.

Incidence of Alcohol Involvement

Another variable on which individuals involved in accidents between a motorized vehicle and non-motorized road user was the presence of alcohol and/or drugs. When the vulnerable road users were described on this measure, the majority (n=6,563, 89.6%) had neither alcohol nor drugs present at the time of the accident. Motorized drivers were discovered to also have a majority (n=6,781, 94.5%) of neither alcohol nor drugs present at the time of the accident. (see Table 4.7 and Table 4.8).

Table 4.7. Impairment of Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring In Urban Areas of Louisiana.

| Substance Suspected (Vulnerable Road User) | Frequency | Percent |
|---|---|---|
| Neither Alcohol Nor Drugs Present | 6,563 | 89.6 |
| Yes (Alcohol Present) | 565 | 7.7 |
| Yes (Alcohol and Drugs Present) | 160 | 2.2 |
| Yes (Drugs Present) | 34 | 0.5 |
| Total | 7,322[a] | 100.0 |

[a] Substance suspected data was not available for 2,216 of the vulnerable road users.

Table 4.8. Impairment of Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Substance Suspected (Motorized Driver) | Frequency | Percent |
|---|---|---|
| Neither Alcohol Nor Drugs Present | 6,781 | 94.5 |
| Yes (Alcohol Present) | 286 | 4.0 |
| Yes (Alcohol and Drugs Present) | 100 | 1.4 |
| Yes (Drugs Present) | 9 | 0.1 |
| Total | 7,176[a] | 100.0 |

[a] Substance suspected data was not available for 2,362 of the motorized vehicle drivers.

For each driver and/or vulnerable road user involved in the accident the investigating officer evaluates their state of health or physical well-being and records the corresponding code in their report. For both groups (driver's and VRU's) this assessment was normal for the majority; VRU (n=4,044, 53.8%) and motorized vehicle driver (n=5,588, 77.9%). However, a substantial group of both parties were assessed to be "Inattentive" (32.5% for VRU's and 16.4% for drivers). This data is reported in Table 4.9 for VRUs and Table 4.10 for motorized vehicle drivers.

Table 4.9. Condition of Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Condition Code (Vulnerable Road User) | Frequency | Percent |
|---|---|---|
| Normal | 4,044 | 53.8 |
| Inattentive | 2,445 | 32.5 |
| Drinking Alcohol – Impaired | 447 | 5.9 |
| Distracted | 209 | 2.8 |

(table cont'd.)

| Condition Code (Vulnerable Road User) | Frequency | Percent |
|---|---|---|
| Other | 178 | 2.4 |
| Drinking Alcohol – Not Impaired | 85 | 1.1 |
| Physical Impairment | 40 | 0.5 |
| Drug Use - Impaired | 37 | 0.5 |
| Fatigued | 12 | 0.2 |
| Illness | 11 | 0.1 |
| Apparently Asleep/Blackout | 6 | 0.1 |
| Drug Use – Not Impaired | 2 | 0.0 |
| Total | 7,516[a] | 100.0 |

[a] Condition data was not available for 2,022 of the vulnerable road users.

Table 4.10. Reported Condition of Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas Of Louisiana.

| Condition Code (Motorized Driver) | Frequency | Percent |
|---|---|---|
| Normal | 5,588 | 77.9 |
| Inattentive | 1,176 | 16.4 |
| Distracted | 152 | 2.1 |
| Drinking Alcohol – Impaired | 126 | 1.8 |
| Other | 55 | 0.8 |
| Drinking Alcohol – Not Impaired | 24 | 0.3 |
| Drug Use - Impaired | 16 | 0.2 |
| Fatigued | 13 | 0.2 |
| Physical Impairment | 11 | 0.2 |
| Illness | 8 | 0.1 |
| Apparently Asleep/Blackout | 7 | 0.1 |
| Drug Use – Not Impaired | 0 | 0.0 |
| Total | 7,176[a] | 100.0 |

[a] Condition data was not available for 2,362 of the motorized vehicle drivers.

Incidence of Distraction

Another variable on which the non-motorized crashes were described was the incidence of distraction. Of the 2,624 valid observations for vulnerable road users there were 2,498 (95.2%) that were "Not Distracted". Of the 6,278 valid observations for motorized vehicle drivers there were 5,929 (94.4%) that were "Not Distracted" (see Table 4.11 and Table 4.12).

Table 4.11. Incidence of Distraction for Vulnerable Road Users in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Driver Distraction (Vulnerable Road User) | Frequency | Percent |
|---|---|---|
| Not Distracted | 2,498 | 95.2 |
| Other Outside the Vehicle | 77 | 2.9 |
| Other Electronic Device | 28 | 1.1 |
| Cell Phone | 16 | 0.6 |
| Other Inside the Vehicle | 5 | 0.2 |
| Total | 2,624[a] | 100.0 |

[a] Distraction code data was not available for 6,914 of the vulnerable road users.

Table 4.12. Incidence of Distraction for Motorized Vehicle Drivers in Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Driver Distraction (Motorized Driver) | Frequency | Percent |
|---|---|---|
| Not Distracted | 5,929 | 94.4 |
| Other Outside the Vehicle | 216 | 3.4 |
| Other Inside the Vehicle | 88 | 1.4 |
| Cell Phone | 38 | 0.6 |
| Other Electronic Device | 7 | 0.1 |
| Total | 6,278[a] | 100.0 |

[a] Distraction code data was not available for 3,260 of the motorized vehicle drivers.

## Objective Two Results

The second objective was to describe accidents in urban areas of Louisiana that involve a motorized vehicle and a vulnerable road user on the following environmental, infrastructure and demographic characteristics:

a. Weather;

b. Environment (lighting, land use);

c. Roadway characteristics (number of lanes, roadway type, intersection, not intersection, posted speed limit, surface type);

d. Time of day;

e. Vehicle type.

There were 9,538 accidents involving a pedestrian/bicyclist and motorized vehicle. The results for the selected variables follow:

Weather

The first variable used to describe accidents was weather at the time the accident occurred. Out of the 9,538 accidents occurring in urban areas, three records did not include indicators of weather condition. The largest number of accidents occurred in clear weather conditions (n= 7,574, 79.3%). The second most common weather condition was "cloudy" (n=1,328, 13.9%) (see Table 4.13).

Table 4.13. Weather Conditions for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Weather | Frequency | Percent |
|---|---|---|
| Clear | 7574 | 79.3 |
| Cloudy | 1328 | 13.9 |
| Rain | 532 | 5.6 |
| Fog/Smoke | 45 | .5 |
| Not Reported | 8 | .1 |
| Blowing Sand | 3 | .0 |
| Sleet/Hail | 3 | .0 |
| Total | 9,535[a] | 100.0 |

[a] Weather data was not available for 64 of the crash records.

Environment

Another variable used to describe accidents was lighting at the time the accident occurred. Of the valid 9,469 entries, 5,735 (60.5%) occurred in "Daylight", which was the most common condition. The second most common lighting condition was "Dark – Continuous Street Light" with 2,154 (22.7%) entries (see Table 4.14).

Table 4.14. Lighting Conditions for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Lighting | Frequency | Percent |
|---|---|---|
| Daylight | 5735 | 60.5 |

(table cont'd.)

| Lighting | Frequency | Percent |
|---|---|---|
| Dark – Continuous Street Light | 2154 | 22.7 |
| Dark – No Street Light | 830 | 8.7 |
| Dark – Street Light At Intersection Only | 485 | 5.1 |
| Dusk | 181 | 1.9 |
| Dawn | 85 | 0.9 |
| Other | 18 | 0.2 |
| Total | 9,469[a] | 100.0 |

[a]Lighting data was not available for 69 of the crash records.

Land Use

The land use at the location of the accident was another variable used to describe the motorized/non-motorized accidents. There were 3,470 (36.4%) reported accidents in "Business, Mixed Residential" areas. The second most reported use was "Business Continuous" with 2,720 (28.5%) reported (see Table 4.15).

Table 4.15. Land Use for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Land Use | Frequency | Percent |
|---|---|---|
| Business, Mixed Residential | 3,470 | 36.4 |
| Business Continuous | 2,720 | 28.5 |
| Residential District | 2,447 | 25.7 |
| Residential Scattered | 392 | 4.1 |
| Open Country | 147 | 1.5 |
| School or Playground | 135 | 1.4 |
| Manufacturing or Industrial | 119 | 1.2 |
| Other | 92 | 1.0 |
| Total | 9,538 | 100.0 |

Roadway Characteristics

The first roadway characteristic analyzed was the number of lanes for the road on which the accident occurred. Of the 5,965 valid roadway lanes reported at the time of the accident, 1,872 (52.4%) occurred on four lane roads. The second most reported roadway number of lanes was two with 944 (26.4%) accidents in this category (see Table 4.16).

Table 4.16. Number of Lanes in Roadway for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Number of Lanes | Frequency | Percent |
|---|---|---|
| 1 | 3 | 0.1 |
| 2 | 944 | 26.4 |
| 3 | 4 | 0.1 |
| 4 | 1,872 | 52.4 |
| 5 | 15 | 0.4 |
| 6 | 718 | 20.1 |
| 7 | 0 | 0.0 |
| 8 | 17 | 0.5 |
| Total | 3,573[a] | 100.0 |

[a]Number of lane data was not available for 5,965 of the crash records.

Highway Type

Another roadway characteristic variable used to describe motorized/non-motorized accidents was highway type. Accidents on "City/local roads and streets" had the highest incidence at 5,245 (55.0%). The second highest was "State Road" at 1,730 (18.1%) (see Table 4.17).

Table 4.17. Highway Type for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Highway Type | Frequency | Percent |
|---|---|---|
| City/Local Roads and Streets | 5,245 | 55.0 |
| State Road | 1,730 | 18.1 |
| Parish Road | 1,331 | 14.0 |
| US Highway | 956 | 10.0 |
| Interstate | 146 | 1.5 |
| Other or Not Stated | 126 | 1.3 |
| Toll Road | 4 | .0 |
| Total | 9,538 | 100.0 |

Roadway Type

Roadway type was another roadway characteristic variable used to describe motorized/non-motorized accidents. Most accidents were reported to occur on two-way undivided roads or streets at 5,502 (57.7%). The next highest was roadways with two-way physical separations at 2,251 (23.65) (see Table 4.18).

Table 4.18. Roadway Type for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Roadway Type | Frequency | Percent |
|---|---|---|
| Two-Way Undivided Road or Street | 5,502 | 57.7 |
| Two-Way Physical Separation | 2,251 | 23.6 |
| One-way Road or street | 1,419 | 15.0 |
| Two-Way Physical Barrier | 198 | 2.1 |
| Other | 146 | 1.5 |
| Total | 9,529[a] | 100.0 |

[a]Roadway type data was not available for 22 of the crash records.

Intersection

Whether or not the accident occurred at an intersection was another roadway characteristic variable used to describe motorized / non-motorized accidents. Of the 9,538 accidents, 5,012 (52.5%) did not occur at an intersection, while the remaining 4,526 (47.5%) did occur at an intersection (see Table 4.19).

Table 4.19. Occurrences at Intersections for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Intersection | Frequency | Percent |
|---|---|---|
| Yes | 4,526 | 47.5 |
| No | 5,012 | 52.5 |
| Total | 9,538 | 100.0 |

Posted Speed Limit

The posted speed limit of the roadway at the time of the accident was another variable used to describe motorized/on-motorized accidents. The most reported posted speed was 0 miles per hour with 3,877 (40.6%) incidence. The second most reported posted speed was 35 miles per hour with 1,517 (15.9%) incidence (see Table 4.20).

Table 4.20. Posted Speed of the Roadway for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Posted Speed (Crash) | Frequency | Percent |
|---|---|---|
| 0 | 3877 | 40.6 |
| 1 | 1 | .0 |
| 2 | 3 | .0 |
| 3 | 1 | .0 |
| 4 | 1 | .0 |
| 5 | 17 | .2 |
| 10 | 14 | .1 |
| 15 | 79 | .8 |
| 20 | 528 | 5.5 |
| 23 | 1 | .0 |
| 25 | 1465 | 15.4 |
| 27 | 1 | .0 |
| 30 | 511 | 5.4 |
| 35 | 1517 | 15.9 |
| 39 | 1 | .0 |
| 40 | 471 | 4.9 |
| 45 | 658 | 6.9 |
| 46 | 1 | .0 |
| 50 | 128 | 1.3 |
| 55 | 202 | 2.1 |
| 60 | 24 | .3 |
| 65 | 13 | .1 |
| 70 | 24 | .3 |
| Total | 9,538 | 100.0 |

Surface Type

Another variable used to describe roadway characteristics motorized/non-motorized accidents was the roadway surface type. Of the 9,471 valid observations, the majority of accidents occurred on dry surface conditions (n=8,609, 90.9%) (see Table 4.21).

Table 4.21. Roadway Surface Type for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Surface Type | Frequency | Percent |
|---|---|---|
| Dry | 8,609 | 90.9 |

(table cont'd.)

| Surface Type | Frequency | Percent |
|---|---|---|
| Wet | 845 | 8.9 |
| Ice | 8 | 0.1 |
| Contaminant | 4 | 0.0 |
| Other | 3 | 0.0 |
| Snow/Slush | 1 | 0.0 |
| Total | 9,471[a] | 100.0 |

[a]Surface type data was not available for 68 of the crash records.

Time of Day

When analyzing motorized/non-motorized accidents by time of day 3,573 (37.5%) occurred between 12 P.M. and 6 P.M. The second highest period was 6 P.M. to 12 A.M. with 3,115 (32.7%) occurrences (see Table 4.22).

Table 4.22. Time of Day for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Time of Day Group | Frequency | Percent |
|---|---|---|
| 12 a.m. - 6 a.m. | 850 | 8.9 |
| 6 a.m. - 12 p.m. | 2000 | 21.0 |
| 12 p.m. - 6 p.m. | 3573 | 37.5 |
| 6 p.m. - 12 a.m. | 3115 | 32.7 |
| Total | 9,538 | 100.0 |

Vehicle Type

Another variable used to describe motorized/non-motorized accidents was the vehicle type. Of the 9,155 valid observations, 4,307 (47.0%) involved passenger cars. The second highest category was SUV's with 2,013 (22.0%) (see Table 4.23).

Table 4.23. Vehicle Type for Motorized/Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Vehicle Type | Frequency | Percent |
|---|---|---|
| Passenger Car | 4307 | 47.0 |
| SUV | 2013 | 22.0 |
| Light Truck / Pickup | 1908 | 20.8 |
| Van | 402 | 4.4 |
| Other | 212 | 2.3 |

(table cont'd.)

| Vehicle Type | Frequency | Percent |
|---|---|---|
| Motorcycle | 69 | 0.8 |
| Single Unit Truck with 2 Axles | 49 | 0.5 |
| Truck / Tractor | 28 | 0.3 |
| Bus with Seats for 16 or More | 27 | 0.3 |
| Car/Truck/Van with / Trailer | 24 | 0.3 |
| School Bus | 23 | 0.3 |
| Single Unit Truck with 3 Axles or more | 23 | 0.3 |
| Tractor Semi-Trailer | 22 | 0.2 |
| Emergency Vehicle | 12 | 0.1 |
| Off-Road Vehicle | 12 | 0.1 |
| Bus with Seats for 9-15 Occupants | 8 | 0.1 |
| Truck / Trailer | 6 | 0.1 |
| Farm Equipment | 6 | 0.1 |
| Motor Home | 3 | 0.0 |
| Truck Double | 1 | 0.0 |
| Total | 9,155[a] | 100.0 |

[a]Vehicle type data was not available for 383 of the crash records.

## Objective Three Results

To determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

An a priori significance level of $\alpha < .05$ was used to determine if the independent variables were statistically significant. Of the 14 chosen variables compared, 13 variables were found to be statistically significant as they were not independent of the dependent variable, severity level.

Gender

The first variable examined for a relationship with the variable crash severity was that of gender of the participants in the accident. The gender of the driver of the motorized vehicle was examined first to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 46.192$, df = 4, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that Female drivers tended to be involved in crashes with a lower degree of severity (No Injury - 16.7% as compared to 14.1% among males; and Complaint – 40.5% as compared to 37.0% for males). In contrast, Male drivers tended to be involved in accidents with a higher degree of severity (Fatal – 5.5% as compared to 3.5% for Females; and Severe – 8.3% as compared to 6.0% for Females) (see Table 4.24).

The gender of the vulnerable road user was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 45.410$, df = 4, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that there were marginal differences between males and females on crash severity.

Table 4.24. Cross-Classification of Crash Severity and Motorized Vehicle Driver Gender for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Female<br>N<br>% | Male<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 116 | 244 | 360 |
| | % [a] | 3.5 | 5.5 | 4.6 |
| Severe | n | 198 | 370 | 568 |
| | % [a] | 6.0 | 8.3 | 7.3 |
| Moderate | n | 1,098 | 1,566 | 2,664 |
| | % [a] | 33.3 | 35.1 | 34.3 |
| Complaint | n | 1,337 | 1,648 | 2,985 |
| | % [a] | 40.5 | 37.0 | 38.5 |
| No Injury | n | 553 | 629 | 1,182 |
| | % [a] | 16.7 | 14.1 | 15.2 |
| Total | n | 3,302 | 4,457 | 7,759 |
| | % [a] | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (4), (N = 7,759) = 46.192, $p < .001$
[a]% within gender

One of the notable differences is the higher involvement of male VRU's than female VRU's in no injury crashes (13.7% for males as compared to 9.4% for Females) (see Table 4.25).

Table 4.25. Cross-Classification of Crash Severity and Vulnerable Road User Gender for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Female<br>N<br>% | Male<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 114 | 297 | 411 |
| | % [a] | 4.3 | 4.6 | 4.5 |
| Severe | n | 187 | 498 | 685 |
| | % [a] | 7.0 | 7.7 | 7.5 |
| Moderate | n | 1,059 | 2,223 | 3,282 |
| | % [a] | 39.8 | 34.4 | 36.0 |
| Complaint | n | 1,050 | 2,562 | 3,612 |
| | % [a] | 39.5 | 39.6 | 39.6 |

(table cont'd.)

| Severity | | Female N % | Male N % | Total N % |
|---|---|---|---|---|
| No Injury | n | 250 | 888 | 1,138 |
| | % [a] | 9.4 | 13.7 | 12.5 |
| Total | n | 2,660 | 6,468 | 9,128 |
| | % [a] | 100.0 | 100.0 | 100.0 |

*Note*. $X^2$ (4), (N = 9,128) = 45.410, p < .001
[a]% within gender

Age

Age of vulnerable road users were found to be significantly different by categories of crash severity levels ($F_{4,8,841} = 23.232$, $p < .001$) and ages of motor vehicle drivers were found to be significantly different by categories of crash severity levels ($F_{4,7,415} = 7.205$, $p < .001$). Primarily, it was found that "Fatal" and "Severe" crashes involved younger drivers more than all other levels of crash severities (see Table 4.26).

Table 4.26. Comparison of Motorized Vehicle Driver Age by Crash Severity Levels for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Source | Df | MS | F | p |
|---|---|---|---|---|
| Between Groups | 4 | 2,086.130 | 7.205 | <.001 |
| Within Groups | 7,415 | 289.529 | | |
| Total | 7,419 | | | |

| Group | n | M | Tukey[a] |
|---|---|---|---|
| Fatal | 358 | 39.14 | A, B |
| Severe | 561 | 40.96 | B |
| Moderate | 2,554 | 42.05 | C, B |
| Complaint | 2,818 | 43.25 | C, B |
| No Injury | 1,129 | 43.37 | C |

[a]Groups that do not have a common letter are significantly different.

In addition, "Fatal" and "Severe" crashes involved older vulnerable road users more than all other levels of crash severities (see Table 4.27).

Table 4.27. Comparison of Vulnerable Road User Age by Crash Severity Levels for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Source | Df | MS | F | p |
|---|---|---|---|---|
| Between Groups | 4 | 8,024.497 | 23.232 | <.001 |

(table cont'd.)

| Source | Df | MS | F | p |
|---|---|---|---|---|
| Within Groups | 8,841 | 345.407 | | |
| Total | 8,845 | | | |

| Group | n | M | Tukey[a] |
|---|---|---|---|
| Fatal | 395 | 43.27 | A |
| Severe | 666 | 36.62 | B |
| Moderate | 3,253 | 34.37 | C, D |
| Complaint | 3,577 | 34.93 | B, C |
| No Injury | 955 | 33.53 | C, D |

[a]Groups that do not have a common letter are significantly different.

Weather

Another variable examined for a relationship with the crash severity was the weather conditions at the time of the accident. The variable weather was found not to be significant ($X^2 = 13.045$, df = 12, p = .366). Therefore, the variable weather and crash severity levels were independent. Consequently, there is no relationship between crash accident severity and weather.

Incidence of Severity

Another variable examined for a relationship with the variable crash severity was that of injury severity of the participants in the accident. The overall crash severity level is determined by the highest level of injury of the individuals involved in the accident. The injury level of the vulnerable road user was examined first to determine if it was related to overall crash severity. Examination of the significant chi-square ($x^2 = 37{,}566.801$, df = 16, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that there were strong correlations between vulnerable road user injury level and overall crash severity. One of the notable correlations is the higher involvement of “Fatality” injured vulnerable road users in fatal crashes (100%) (see Table 4.28).

Table 4.28. Cross-Classification of Crash Severity and Vulnerable Road User Injury for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Fatality<br>N<br>% | Suspected Serious Injury<br>N<br>% | Suspected Minor Injury<br>N<br>% | Possible Injury<br>N<br>% | No Apparent Injury<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|---|---|---|
| Fatal | n | 414 | 0 | 0 | 0 | 0 | 414 |
| | % [a] | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 |
| Severe | n | 0 | 685 | 2 | 2 | 2 | 691 |
| | % [a] | 0.0 | 100.0 | 0.1 | 0.1 | 0.1 | 7.2 |
| Moderate | n | 0 | 0 | 3,281 | 7 | 9 | 3,297 |
| | % [a] | 0.0 | 0.0 | 99.9 | 0.2 | 0.6 | 34.6 |
| Complaint | n | 0 | 0 | 0 | 3,611 | 41 | 3,652 |
| | % [a] | 0.0 | 0.0 | 0.0 | 99.8 | 2.7 | 38.3 |
| No Injury | n | 0 | 0 | 0 | 0 | 1,484 | 1,484 |
| | % [a] | 0.0 | 0.0 | 0.0 | 0.0 | 96.6 | 15.6 |
| Total | n | 414 | 685 | 3,283 | 3,620 | 1,536 | 9,538 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (16), (N = 9,538) = 37,566.801, $p < .001$
[a]% within severity

The level of injury of the driver of the motorized vehicle was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 189.887$, df = 12, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that when the motorized vehicle driver injury level was "No Apparent Injury" the overall crash severity level tended to be lower (No Injury – 100% and Complaint – 97.5%) (see Table 4.29).

Table 4.29. Cross-Classification of Crash Severity and Motorized Vehicle Driver Injury for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Suspected Minor Injury | Possible Injury | No Apparent Injury | Total |
|---|---|---|---|---|---|
| | | N<br>% | N<br>% | N<br>% | N<br>% |
| Fatal | n | 5 | 32 | 376 | 413 |
| | % [a] | 10.4 | 12.9 | 4.1 | 4.3 |
| Severe | n | 7 | 35 | 646 | 688 |
| | % [a] | 14.6 | 14.1 | 7.0 | 7.2 |
| Moderate | n | 36 | 88 | 3,173 | 3,297 |
| | % [a] | 75.0 | 35.5 | 34.3 | 34.6 |
| Complaint | n | 0 | 93 | 3,559 | 3,652 |
| | % [a] | 0.0 | 37.5 | 38.5 | 38.3 |
| No Injury | n | 0 | 0 | 1,484 | 1,484 |
| | % [a] | 0.0 | 0.0 | 16.1 | 15.6 |
| Total | n | 48 | 248 | 9,238 | 9,534 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 |

*Note*. $X^2$ (8), (N = 9,534) = 157.195, $p < .001$
[a]% within severity

Lighting

The level of lighting in the environment was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 661.863$, df = 20, $p < .001$) revealed that the variables were not independent indicating that they were consequently related.

The nature of the relationship between these variables was such that “Dark – No Street Lights” lighting conditions tended to be associated with crashes with fatal overall severity (15.8%). In contrast, “Daylight” had the lowest involvement in crashes with fatal severity (1.6%) (see Table 4.30).

Table 4.30. Cross-Classification of Crash Severity and Lighting for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Dark – Cont. Street Light N % | Dusk N % | Dark – No Street Lights N % | Daylight N % | Dawn N % | Dark – Street Light Int. Only N % | Total N % |
|---|---|---|---|---|---|---|---|---|
| Fatal | n | 131 | 4 | 131 | 94 | 9 | 38 | 407 |
| | % [a] | 6.1 | 2.2 | 15.8 | 1.6 | 10.6 | 7.9 | 4.3 |
| Severe | n | 208 | 12 | 115 | 278 | 6 | 62 | 681 |
| | % [a] | 9.7 | 6.6 | 13.9 | 4.9 | 7.1 | 12.8 | 7.2 |
| Moderate | n | 784 | 71 | 277 | 1,919 | 34 | 188 | 3,273 |
| | % [a] | 36.5 | 39.2 | 33.4 | 33.5 | 40.0 | 38.8 | 34.6 |
| Complaint | n | 705 | 72 | 242 | 2,433 | 28 | 149 | 3,629 |
| | % [a] | 32.8 | 39.8 | 29.2 | 42.5 | 32.9 | 30.8 | 38.4 |
| No Injury | n | 320 | 22 | 64 | 1,000 | 8 | 47 | 1,461 |
| | % [a] | 14.9 | 12.2 | 7.7 | 17.5 | 9.4 | 9.7 | 15.5 |
| Total | n | 2,148 | 181 | 829 | 5,724 | 85 | 484 | 9,451 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note*. $X^2$ (20), (N = 9,451) = 661.863, p < .001
[a]% within lighting

Land Use

The land use mix in the environment was next examined to determine if it was related to the overall crash severity. Examination of the significant chi-square ($x^2$ = 260.216, df = 24, p < .001) revealed that the variables were not independent indicating that they were consequently related.

The nature of the relationship between these variables was such that “Open Country” land use tended to be associated with crashes with overall fatal severity (24.5%). In contrast, “School / Playground” had the lowest involvement in crashes with fatal severity (0.7%) (see Table 4.31).

Table 4.31. Cross-Classification of Crash Severity and Land Use for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Bus / Res Mixed N % | Residential N % | Open Country N % | Res Scattered N % | School / Playground N % | Mfg./Ind N % | Bus. Continuous N % | Total N % |
|---|---|---|---|---|---|---|---|---|---|
| Fatal | n | 149 | 66 | 36 | 45 | 1 | 4 | 103 | 404 |
| | % [a] | 4.3 | 2.7 | 24.5 | 11.5 | 0.7 | 3.4 | 3.8 | 4.3 |
| Severe | n | 253 | 178 | 13 | 28 | 1 | 17 | 190 | 680 |
| | % [a] | 7.3 | 7.3 | 8.8 | 7.1 | 0.7 | 14.3 | 7.0 | 7.2 |
| Moderate | n | 1,235 | 866 | 44 | 138 | 45 | 45 | 892 | 3,265 |
| | % [a] | 35.6 | 35.4 | 29.9 | 35.2 | 33.3 | 37.8 | 32.8 | 34.6 |
| Complaint | n | 1,313 | 942 | 44 | 140 | 58 | 33 | 1,085 | 3,615 |
| | % [a] | 37.8 | 38.5 | 29.9 | 35.7 | 43.0 | 27.7 | 39.9 | 38.3 |
| No Injury | n | 520 | 395 | 10 | 41 | 30 | 20 | 450 | 1,466 |
| | % [a] | 15.0 | 16.1 | 6.8 | 10.5 | 22.2 | 16.8 | 16.5 | 15.5 |
| Total | n | 3,470 | 2,447 | 147 | 392 | 135 | 119 | 2,720 | 9,430 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (24), (N = 9,430) = 260.216, $p < .001$
[a]% within land use

Roadway Characteristics

The number of lanes per roadway was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2$ = 23.492, df = 8, p < .05) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that "2 lane" roadways tended to be associated with crashes with overall fatal severity (9.6%). This roadway characteristic also had the highest incidence of complaint severity crashes (41.6%) (see Table 4.32).

Table 4.32. Cross-Classification of Crash Severity and number of lanes for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | 2 Lanes<br>N<br>% | 4 Lanes<br>N<br>% | 6 Lanes<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|---|
| Fatal | n | 91 | 146 | 51 | 288 |
| | % [a] | 9.6 | 7.7 | 6.9 | 8.1 |
| Severe | n | 72 | 162 | 73 | 308 |
| | % [a] | 7.7 | 8.6 | 9.9 | 8.6 |
| Moderate | n | 295 | 654 | 258 | 1,207 |
| | % [a] | 31.1 | 34.7 | 35.1 | 33.8 |
| Complaint | n | 394 | 669 | 256 | 1,319 |
| | % [a] | 41.6 | 35.5 | 34.8 | 36.9 |
| No Injury | n | 95 | 256 | 97 | 448 |
| | % [a] | 10.0 | 13.6 | 13.2 | 12.5 |
| Total | n | 948 | 1,887 | 735 | 3,570 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (8), (N = 3,570) = 23.492, p < .05
[a] % within number of lanes

The type of roadway was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2$ = 108.957, df = 16, p < .05) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that "Two-Way Barrier" roadways tended to be associated with crashes with overall fatal severity (8.1%) (see Table 4.33).

Table 4.33. Cross-Classification of Crash Severity and Roadway Type for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Two-way Undivided Road N % | One-way Road N % | Two-Way Barrier N % | Other N % | Two-way Physical Separation N % | Total N % |
|---|---|---|---|---|---|---|---|
| Fatal | n | 230 | 29 | 16 | 2 | 136 | 413 |
| | % [a] | 4.2 | 2.0 | 8.1 | 1.4 | 6.0 | 4.3 |
| Severe | n | 426 | 60 | 22 | 11 | 170 | 689 |
| | % [a] | 7.7 | 4.2 | 11.1 | 7.5 | 7.6 | 7.2 |
| Moderate | n | 1,885 | 484 | 66 | 42 | 813 | 3,290 |
| | % [a] | 34,3 | 34.1 | 33.3 | 28.8 | 36.1 | 34.6 |
| Complaint | n | 2,132 | 553 | 73 | 72 | 819 | 3,649 |
| | % [a] | 38.7 | 39.0 | 36.9 | 49.3 | 36.4 | 38.3 |
| No Injury | n | 829 | 293 | 21 | 19 | 313 | 1,475 |
| | % [a] | 15.1 | 20.6 | 10.6 | 13.0 | 13.9 | 15.5 |
| Total | n | 5,502 | 1,419 | 198 | 146 | 2,251 | 9,516 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note*. $X^2$ (16), (N = 9,516) =108.957, $p < .05$
[a]% within roadway type

Whether or Not the Accident Was at an Intersection was Next Examined to Determine if it was Related to the Overall Crash Severity.

Examination of the significant chi-square ($x^2 = 97.621$, df = 4, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that accidents not occurring at an intersection had higher incidence of overall fatal severity (5.7%). Accidents with Moderate severity occurred with same frequency whether within or not within an intersection (38.3%) (see Table 4.34).

The reported speed limit for the area in which the accident occurred was examined to determine if there was a relationship with overall severity. The posted speed limits were found to be significantly different for the overall crash severity ($F_{4, 5,650} = 73.644$, df = 4, $p < .001$). It was found that the posted speed limit was higher among overall "Fatal" and "Severe" crashes (see Table 4.35).

Table 4.34. Cross-Classification of Crash Severity and Intersection for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Yes<br>N<br>% | No<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 126 | 288 | 414 |
| | % [a] | 2.8 | 5.7 | 4.3 |
| Severe | n | 285 | 406 | 691 |
| | % [a] | 6.3 | 8.1 | 7.2 |
| Moderate | n | 1,557 | 1,740 | 3,297 |
| | % [a] | 34.4 | 34.7 | 34.6 |
| Complaint | n | 1,734 | 1,918 | 3,652 |
| | % [a] | 38.3 | 38.3 | 38.3 |
| No Injury | n | 824 | 660 | 1,484 |
| | % [a] | 18.2 | 13.2 | 15.6 |
| Total | n | 4,526 | 5,012 | 9,538 |
| | % [a] | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (4), (N = 9,538) = 97.621, $p < .001$
[a]% within intersection

The roadway surface type was next examined to determine if it was related to the overall severity. Examination of the significant chi-square ($x^2 = 39.541$, df = 8, $p < .001$) revealed that the variables were not independent indicating that they were consequently related.

Table 4.35. Cross-Classification of Crash Severity and Reported Posted Speed Limit for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Source | Df | MS | F | P |
|---|---|---|---|---|
| Between Groups | 4 | 6,894.743 | 73.644 | <.001 |
| Within Groups | 5,650 | 93.623 | | |
| Total | 5,654 | | | |
| Group | n | M | Tukey[a] | |
| Fatal | 218 | 43.14 | A | |
| Severe | 351 | 35.74 | B | |
| Moderate | 1,875 | 32.98 | C | |
| Complaint | 2,229 | 32.38 | C | |
| No Injury | 982 | 31.68 | C | |

[a]Groups that do not have a common letter are significantly different.

The nature of the relationship between these variables was such that accidents occurring on "Blacktop" had higher incidence of fatal severity (5.3%) (see Table 4.36).

Table 4.36. Cross-Classification of Crash Severity and Roadway Surface Type for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Blacktop N % | Concrete N % | Other N % | Total N % |
|---|---|---|---|---|---|
| Fatal | n | 292 | 120 | 0 | 412 |
| | % [a] | 5.3 | 3.0 | 0.0 | 4.3 |
| Severe | n | 397 | 288 | 3 | 688 |
| | % [a] | 7.2 | 7.3 | 6.3 | 7.2 |
| Moderate | n | 1834 | 1,425 | 20 | 3,279 |
| | % [a] | 33.4 | 35.9 | 41.7 | 34.5 |
| Complaint | n | 2,142 | 1,485 | 18 | 3,645 |
| | % [a] | 39.1 | 37.5 | 37.5 | 38.4 |
| No Injury | n | 818 | 647 | 7 | 1,472 |
| | % [a] | 14.9 | 16.3 | 14.6 | 15.5 |
| Total | n | 5,483 | 3,965 | 48 | 6,496 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (8), (N = 9,496) = 39.541, p < .001
[a]% within surface type

Time of Day

The time of day was next examined to determine if it was related to the overall severity. Examination of the significant chi-square ($x^2$ = 427.827, df = 12, p < .001) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that accidents occurring during the time frame of "12 a.m. – 6 a.m." had higher incidence of overall fatal severity (12.5%) (see Table 4.37).

Table 4.37. Cross-Classification of Crash Severity and Time of Day for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | 6 am–12 pm N % | 12 pm–6 pm N % | 6 pm–12 am N % | 12 am–6 pm N % | Total N % |
|---|---|---|---|---|---|---|
| Fatal | n | 42 | 71 | 195 | 106 | 414 |
| | % [a] | 2.1 | 2.0 | 6.3 | 12.5 | 4.3 |
| Severe | n | 88 | 190 | 312 | 101 | 691 |
| | % [a] | 4.4 | 5.3 | 10.0 | 11.9 | 7.2 |
| Moderate | n | 655 | 1,199 | 1,128 | 315 | 3,297 |
| | % [a] | 32.8 | 33.6 | 36.2 | 37.1 | 34.6 |
| Complaint | n | 872 | 1,486 | 1,059 | 235 | 3,652 |
| | % [a] | 43.6 | 41.6 | 34.0 | 27.6 | 38.3 |
| No Injury | n | 343 | 627 | 421 | 93 | 1,484 |
| | % [a] | 17.2 | 17.5 | 13.5 | 10.9 | 15.6 |
| Total | n | 2,000 | 3,573 | 3,115 | 850 | 9,538 |
| | % [a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Vehicle Type

The vehicle type was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 45.410$, df = 4, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that accidents involving "Truck/Tractor" and "Light Pickup Truck" had higher incidence of fatal severity (17.9% and 6.8%) (see Table 4.38).

Table 4.38. Cross-Classification of Crash Severity and Motorized Vehicle Type for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Motor-cycle N % | Passenger Car N % | Truck/ Tractor N % | Bus N % | Light Pickup Truck N % | Van N % | SUV N % | Total N % |
|---|---|---|---|---|---|---|---|---|---|
| Fatal | n | 2 | 148 | 13 | 3 | 130 | 11 | 83 | 390 |
| | %[a] | 2.9 | 3.4 | 10.7 | 6.0 | 6.8 | 2.7 | 4.1 | 4.4 |
| Severe | n | 5 | 292 | 7 | 5 | 157 | 27 | 145 | 638 |
| | %[a] | 7.2 | 6.8 | 75.7 | 10.0 | 8.2 | 6.7 | 7.2 | 7.2 |

(table cont'd.)

| Severity | | Motor-cycle N % | Passenger Car N % | Truck/ Tractor N % | Bus N % | Light Pickup Truck N % | Van N % | SUV N % | Total N % |
|---|---|---|---|---|---|---|---|---|---|
| Complaint | n | 22 | 1,646 | 39 | 11 | 754 | 142 | 796 | 3,410 |
| | %[a] | 31.9 | 38.2 | 32.0 | 22.0 | 39.5 | 35.3 | 39.5 | 38.4 |
| No Injury | n | 10 | 695 | 26 | 12 | 244 | 71 | 314 | 1,372 |
| | %[a] | 14.5 | 16.1 | 21.3 | 24.0 | 12.8 | 17.7 | 15.6 | 15.5 |
| Total | n | 69 | 4,307 | 28 | 50 | 1,908 | 402 | 2,013 | 8,871 |
| | %[a] | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (24), (N = 8,871) = 85.048, p < .001
[a]% within vehicle type

Incidence of Impairment for Motorized Driver and/or Non-Motorized Individual

The incidence of impairment was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2 = 132.174$, df = 4, $p < .001$) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that accidents involving drivers that were "Impaired" had higher incidence of overall fatal severity (21.1%) (see Table 4.39).

Table 4.39. Cross-Classification of Crash Severity and Motorized Vehicle Driver impairment for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Impaired N % | Not Impaired N % | Total N % |
|---|---|---|---|---|
| Fatal | n | 30 | 254 | 284 |
| | % [a] | 21.1 | 4.5 | 5.0 |
| Severe | n | 31 | 419 | 450 |
| | % [a] | 21.8 | 7.5 | 7.9 |
| Moderate | n | 40 | 1,947 | 1,987 |
| | % [a] | 28.2 | 34.8 | 34.7 |
| Complaint | n | 34 | 2,070 | 2,104 |
| | % [a] | 23.9 | 37.0 | 36.7 |
| No Injury | n | 7 | 898 | 905 |
| | % [a] | 4.9 | 16.1 | 15.8 |

(table cont'd.)

*Note*. $X^2$ (4), (N = 5,730) = 132.174, p < .001
[a]% within driver impairment

The nature of the relationship between crash severity and impairment was such that accidents involving vulnerable road users that were "Impaired" had higher incidence of fatal severity (9.3%) (see Table 4.40).

Table 4.40. Cross-Classification of Crash Severity and Vulnerable Road User impairment for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Impaired<br>N<br>% | Not Impaired<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 45 | 33 | 78 |
| | % [a] | 9.3 | 0.8 | 1.7 |
| Severe | n | 72 | 175 | 247 |
| | % [a] | 14.9 | 4.3 | 5.5 |
| Moderate | n | 202 | 1,432 | 1,634 |
| | % [a] | 41.7 | 35.4 | 36.1 |
| Complaint | n | 130 | 1,751 | 1,881 |
| | % [a] | 26.9 | 43.3 | 41.5 |
| No Injury | n | 35 | 653 | 688 |
| | % [a] | 7.2 | 16.1 | 15.2 |
| Total | n | 484 | 4,044 | 4,528 |
| | % [a] | 100.0 | 100.0 | 100.0 |

*Note*. $X^2$ (4), (N = 4,528) = 324.217, p < .001
[a]% within vulnerable road user impairment

Incidence of Distraction for Motorized Driver and/or Non-Motorized Individual

The incidence of distraction was next examined to determine if it was related to the crash severity. Examination of the significant chi-square ($x^2$ = 412.952, df = 4, p < .001) revealed that the variables were not independent indicating that they were consequently related. The nature of the relationship between these variables was such that accidents involving drivers that were "Not Distracted" had higher incidence of fatal severity (4.5%) (see Table 4.41).

Table 4.41. Cross-Classification of Crash Severity and Motorized Vehicle Driver distraction for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Distracted<br>N<br>% | Not Distracted<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 31 | 254 | 285 |
| | % [a] | 2.3 | 4.5 | 4.1 |
| Severe | n | 68 | 419 | 487 |
| | % [a] | 5.1 | 7.5 | 7.0 |
| Moderate | n | 448 | 1,947 | 2,395 |
| | % [a] | 33.7 | 34.8 | 34.6 |
| Complaint | n | 596 | 2.070 | 2,666 |
| | % [a] | 44.9 | 37.0 | 38.5 |
| No Injury | n | 185 | 898 | 1,083 |
| | % [a] | 13.9 | 16.1 | 15.7 |
| Total | n | 1,328 | 5,588 | 6,916 |
| | % [a] | 100.0 | 100.0 | 100.0 |

*Note.* $X^2$ (4), (N = 6,916) = 412.952, $p < .001$
[a]% within driver distraction

The nature of the relationship between crash severity and distraction was such that accidents involving vulnerable road users that were “Distracted” had higher incidence of fatal severity (1.7%) (see Table 4.42).

Table 4.42. Cross-Classification of Crash Severity and Vulnerable Road User distraction for Motorized and Non-Motorized Accidents Occurring in Urban Areas of Louisiana.

| Severity | | Distracted<br>N<br>% | Not Distracted<br>N<br>% | Total<br>N<br>% |
|---|---|---|---|---|
| Fatal | n | 44 | 33 | 77 |
| | % [a] | 1.7 | 0.8 | 1.1 |
| Severe | n | 174 | 175 | 349 |
| | % [a] | 6.6 | 4.3 | 5.2 |
| Moderate | n | 949 | 1,432 | 2,381 |
| | % [a] | 35.8 | 35.4 | 35.5 |
| Complaint | n | 1,148 | 1,751 | 2,899 |
| | % [a] | 43.3 | 43.3 | 43.3 |
| No Injury | n | 339 | 653 | 992 |
| | % [a] | 12.8 | 16.1 | 14.8 |

*Note.* $X^2$ (4), (N = 6,698) = 37.527, $p < .001$
[a]% within vulnerable road user distraction

## Objective Four Results

To determine if a model exists explaining a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from the following environmental, infrastructure and demographic characteristics.

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of impairment for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

The regression analysis began with an examination of the bivariate correlations. Two-way correlations between the independent variables and crash "Severity" are present in Table 4.43.

Three of the nine correlations were found to be statistically significant. The highest correlations with crash "Severity" were found to be with the factor "Daylight" ($r = -.197$, $p < .001$), "Driver Injury" ($r = -.119$, $p < .001$) and "Crash Posted Speed" ($r = .134$, $p < .001$) which is the posted speed recorded by the investigating officer.

Table 4.43. Relationship Between Selected Accident Characteristics and "Crash Severity" of Motorized and Non-Motorized Accidents Occurring In Urban Areas of Louisiana.

| Variable | r | P |
|---|---|---|
| Daylight | -.197 | < .001 |
| Dark No Street Light | .171 | < .001 |
| Crash Posted Speed | .134 | < .001 |
| Bike/Pedestrian Impaired | .134 | < .001 |
| Hour Range 12 am | .130 | < .001 |
| Motorist Injury | -.119 | < .001 |
| Hour Range 12 pm | -.110 | < .001 |
| Hour Range 6 pm | .106 | < .001 |
| Motorist Impaired | .102 | < .001 |

The variance inflation factor (VIF) was examined to verify the absence of excessive collinearity or formation of singularities. Hair et al. (2006) states "A common cutoff threshold is a tolerance value of .10 which corresponds to a VIF value of 10" (p.230). No excess multi-collinearity was found within this analysis as tolerance values ranged from .662 to .989.

Presented are the results of the multiple regression analysis utilizing "Severity" as the dependent variable are in Table 4.44.

The first variable in the regression model was "Daylight". Alone this variable explained 3.9% of the variance in "Severity" of crashes involving motorized and non-motorized individuals.

Two additional variables explained an additional 2.3% of the variance in "Severity" levels. The first of these additional variables was "Motorist Injury" explaining 1.2%, then "Crash Posted Speed" explaining the remaining 1.1%. These three variables explained a total of 6.2% of the variance in crash "Severity" for accidents involving motorized and non-motorized individuals. The nature of the influence of these variables was such that accidents occurring in "Daylight" and "Motorist Injury" tended to be associated with lower crash severity levels. To the contrary, the variable "Crash Posted Speed" tended to be associated with higher crash severity levels.

Table 4.44. Multiple Regression Analysis of "Severity" Of Accidents Involving Motorized and Non-Motorized Accidents Occurring in Urban Areas Of Louisiana.

ANOVA

| Source of Variation | df | MS | F | p |
|---|---|---|---|---|
| Regression | 3 | 190.576 | 210.412 | < .001 |
| Residual | 9534 | .906 | | |
| Total | 9537 | | | |

Model Summary

| Model | R Square | R Square Change | F Change | Sig. F Change | Standardized Coefficients Beta |
|---|---|---|---|---|---|
| Daylight | .039 | .039 | 386.276 | < .001 | -.177 |
| Motorist Injury | .051 | .012 | 125.096 | < .001 | -.109 |
| Crash Posted Speed | .062 | .011 | 108.990 | < .001 | .105 |

Variables no in the Equation

| Variable | t | p |
|---|---|---|
| Dark No Street Light | 8.620 | < .001 |
| Hour Range 12 pm | -.866 | .387 |
| Hour Range 6 pm | -.983 | .326 |
| Hour Range 12 am | 6.239 | .326 |
| Motorist Impaired | 8.106 | < .001 |
| Bike/Pedestrian Impaired | 8.626 | < .001 |

# CHAPTER 5. SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

## Purpose and Objectives

The primary purpose of this study was to determine the influence of selected demographic, environmental and infrastructure factors on the incidence and severity of traffic accidents involving a motorized vehicle and a non-motorized (pedestrian or bicyclist) individual. Identification of influential factors can aid in developing more effective countermeasures, targeted education and training programs to reduce the fatality and injury risks to vulnerable road users.

The following objectives were designed to guide this research:

1. To describe traffic accidents involving a motorized vehicle and a pedestrian and/or bicyclist on the incidence and severity of the accident in designated urban areas of Louisiana within the 5-year period of 2013 through 2017 on the following selected characteristics of the individual parties (defined as the driver of the motor vehicle and the bicyclist or pedestrian as appropriate)

   a. Gender of driver, vulnerable road user (VRU);

   b. Age of driver, vulnerable road user (VRU);

   c. Severity of injury for driver, vulnerable road user (VRU);

   d. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

   e. Incidence of distraction for motorized driver and/or non-motorized individual.

2. To describe accidents in urban areas of Louisiana that involve a motorized vehicle and a pedestrian or bicyclist on the following environmental, infrastructure and demographic characteristics:

a. Weather;

b. Environment (lighting, land use);

c. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

d. Time of day;

e. Vehicle type.

3. To determine if a relationship exists between the severity of an accident and the following demographics:

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

4. To determine if a model exists explaining a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a pedestrian or bicyclist from the following environmental, infrastructure and demographic characteristics.

a. Gender;

b. Age;

c. Weather;

d. Incidence of severity;

e. Environment (lighting, land use);

f. Roadway characteristics (number of lanes, roadway type, intersection, posted speed limit, surface type);

g. Time of day;

h. Vehicle type;

i. Incidence of alcohol involvement for motorized driver and/or non-motorized individual;

j. Incidence of distraction for motorized driver and/or non-motorized individual.

## Summary of Methodology

### Population and Sample

The target population for this study was defined as motor vehicle accidents in urban areas in Louisiana involving pedestrians and/or bicyclists. The accessible population is defined as all accidents in selected urban areas in Louisiana during the period of 2013 through 2017 involving pedestrians and/or bicyclists. The sample analyzed was 100% of the defined accessible population.

### Instrumentation

After receiving approval from the dissertation committee and the IRB, the researcher designed a computerized recording form to collect data from the Louisiana State Crash Data Repository. The specific variables included were determined from a literature review and discussions with subject matter experts.  Data were obtained from the repository and transferred into the research instrument.

Data Collection

Data was collected by downloading the selected variables from the Louisiana State Crash Data Repository.  Prior to downloading the data all personal identifiers were deleted from the data.  The data was extracted by personnel under the direction of LADOTD and provided to the researcher.  On receipt of the data it was transferred to the researcher-designed computerized recording form.  A total of 9,538 records were utilized for the research.

## Summary of Findings

Objective One

Objective one was to describe traffic accidents involving a motorized vehicle and a vulnerable road user (VRU) on the incidence and severity of the accident in designated urban areas of Louisiana within the 5-year period of 2013 through 2017 on selected individual participant characteristics.  For both groups males made  up the majority where VRU's had (n=6,468, 70.9%) and motorized vehicle drivers had (n=4,457, 57.4%), also both groups had a majority of individuals in the same age group of 25-34 with VRU's having (n=1,657, 18.7%) and motorized vehicle drivers having (n=1,707, 23.0%), VRU's experienced fatalities (n=414, 4.3%) where motorized vehicle drivers did not experience any fatalities (n=0, 0.0%).

Objective Two

Objective two was to describe accidents in urban areas of Louisiana involving motorized vehicles and a vulnerable road user (VRU) on selected crash characteristics.  For crashes involving a motor vehicle driver and VRU the environmental land use of "Business, Mixed Residential" displayed the most incidences (n=3,470, 36.4%), the roadway characteristic Number of Lanes value of “4” experienced the most incidences (n=1,872, 52.4), the majority of accidents occurred “Not at Intersection” (n=5,012, 52.5%), the Crash Posted Speed of “35” involved the most number of accidents (n=1,517, 15.9%), the time of day grouping “12 p.m. to 6 p.m.” was the time frame most active with accidents(n=3,573, 37.5%), the vehicle type of “Passenger Car” was involved in the most accidents (n=4,307, 47.0%).

Objective Three

Objective three was to determine if a relationship exists between the severity of an accident and selected demographic and crash elements. It was discovered that male drivers tended to be involved in accidents with a higher degree of severity (Fatal – 5.5% as compared to 3.5% for Females; and Severe – 8.3% as compared to 6.0% for Females). The nature of the relationship between crash severity and VRU’s was such that there were marginal differences between males and females and crash severity. When evaluating the driver age it was found that “Fatal” and “Severe” crashes involved older drivers than all other levels of crash severities. When evaluating whether the accident occurred at an intersection or not it was found that accidents not occurring at an intersection had higher incidence of fatal severity (5.7%).

Objective Four

Objective four was to determine if a model exists to explain a significant portion of the variance in incidence and severity of accidents involving a motorized vehicle and a vulnerable road user. It was discovered that the variables “Daylight”, “Motorist Injury” and “Crash Posted Speed” exhibited the highest level of parsimony explaining approximately six percent of the incidence and severity of accidents involving a motorized vehicle and a vulnerable road user.

## Conclusions, Implications and Recommendations

The following conclusions, implications and recommendations are based on the findings of the study.

Conclusion One

The first conclusion of this study is that there was a higher incidence of impairment among vulnerable road users (VRU) than among motor vehicle drivers (MVD) in accidents involving these two groups. This conclusion is based on the finding that when examining the presence of drugs and/or alcohol approximately 6% of motor vehicle drivers were shown to have one or both of these substances present in their systems, where about 10% of vulnerable road users had the same condition. In addition, motor vehicle drivers were found to be impaired at a rate of 2%, where vulnerable road users were found to be impaired at approximately seven percent.

The implication of this conclusion is the impairment of vulnerable road users is a more pressing concern for traffic safety in urban areas. Though not a large percentage of overall crash involvement, the percentage of VRU that were impaired was over three times that of motor vehicle drivers. These findings are congruent with a study performed in Virginia where it was discovered that in fatal crashes motor vehicle drivers were drinking 6% of the time and VRU's were drinking 33% (VDOT, 2017). Urban areas are increasingly granting companies permission to setup bike share locations thus promoting more citizens to cycle to their various destinations within the city. Also, more developments are being constructed to include residential and commercial mixes to promote residents to walk from their homes to various destinations. As urban areas push citizens to increase use of non-motorized modes of travel this issue has the potential of becoming a much larger public safety concern.

Based on the conclusion the researcher recommends that education, awareness campaigns and enforcement efforts be increased to reduce the incidence of VRU impairment in traffic areas. An example that would potentially address all these aspects is to include a component in the driver's license acquisition process highlighting the negative impacts of impairment in all modes of travel. This could come in the form of additional materials at the time of acquisition/renewal or an on-line computer based mini course completed prior to license acquisition/renewal.

Further research into this area should be conducted to determine other factors that may be contributing to VRU's traveling impaired in traffic areas. Factors such as, are these accidents occurring near venues selling alcoholic beverages? Are there other events or circumstances occurring that compel individuals to engage in non-motorized travel impaired?

Conclusion Two

The second conclusion of this study is that there was a higher incidence of accidents involving motor vehicles and vulnerable road users in environments with mixed business and residential than any other environment. This conclusion is based on the finding that when examining the environment in terms of land use, it was discovered that crashes occurred 36.4% of the time in environments with a mix of business and residential.

The implications of this conclusion are there is the potential to exacerbate the incidence of accidents involving VRU's as developments are designed as mixed environments. An excerpt from the Delaware Complete Communities Toolbox describes mixed-use developments as:

> As defined by the MRSC of Washington, mixed-use development is characterized as pedestrian-friendly development that blends two or more residential, commercial, cultural, institutional, and/or industrial uses. Mixed use is one of the ten principles of Smart Growth, a planning strategy that seeks to foster community design and development that serves the economy, community, public health, and the environment.

A study in Florida found approximately 64% of crashes involving older pedestrians were within two miles of the VRU's residence (Haule et al, 2019). In addition, many downtown area revitalization plans call for mixed use development as well.

Based on the conclusions the researcher recommends government regulation and construction practices require proven VRU safety measures be integral to any mixed use development. The increased use of mixed use developments makes it important to include proven safety measures for VRU's in the design and implementation to aid in reducing exposure to motor vehicle accidents.

The researcher also recommends further research into this area be conducted to determine the overall factors leading to increased incidents of motor vehicle and VRU accidents in mixed use developments. Further questions include: "are there deficiencies in the infrastructure that is leading to VRU exposure to higher accident rates;" "could the behavior of the VRU be a primary contributing factor to involvement in higher accident rates?"

Conclusion Three

The third conclusion of this study is that there was a higher incidence of accidents involving motor vehicles and vulnerable road users occurring at locations other than an intersection. This conclusion is based on the finding when examining the roadway characteristic of intersection, it was discovered that 52.5% of crashes occurred at locations other than at an intersection.

The implications of this conclusion are VRU's are not utilizing designated intersection infrastructure to safely interact with motor vehicle traffic thus not taking full advantage of potential safety measures at the intersection. On a national level the majority of pedestrian fatalities occurred at a location other than an intersection 72% of the time according to the Governors Highway Safety Association (GHSA) 2018 report.

Based on this conclusion the researcher recommends increased education and implementation of safety measures to encourage VRU's to use designated intersections in areas with vehicle traffic. Promoting the usage of designated pedestrian and bicycle pathways through public media such as billboards, social media and radio/tv ads could be effective tools. Similar campaigns have been used to successfully address other safety concerns such as drinking and driving, seatbelt usage and motorcycle awareness.

Further research into this area should be conducted to determine the underlying reasons for VRU avoidance of intersections. Further data indicating whether the reasons for avoidance are behavioral or an unintended consequence of infrastructure design should be collected. For example, the use of pedestrian countdown signals can be utilized to help drivers and pedestrians gauge the available to safely cross an intersection. However, the same timer may prompt pedestrians and motorists to move more quickly through the intersection while not behaving as cautiously as they would otherwise. This hurried state would have the potential to cause more harm than good to the treated area. This information would be necessary to understand what measures to take in order to enact meaningful corrections to the issue.

Conclusion Four

The fourth conclusion of this study was that there is incidence of higher severity of accidents occurring between the hours of 6 p.m. and 12 a.m. than any other time of the day. This conclusion is based on the finding when examining the time of day, it was discovered that fatal and severe crashes occurred most frequently between 6 p.m. and 12 a.m.

The implications of this conclusion are the evenings are the most dangerous times for vulnerable road users to interact with motor vehicles. There could be several reasons to explain why this time would be so dangerous. One may be the onset of fatigue from the workday for motor drivers. The Center for Disease Control (CDC) labels fatigued driving as "drowsy driving" and state it is a serious road safety concern. Another reason could be impairment as workers (both motor driver and VRU) may stop for drinks prior to going home. A third reason may be lack of visibility as this period consists mostly of nighttime conditions.

Based on the conclusions the researcher recommends further research into this area should be conducted to determine the root causes for accidents during this time period in the areas of high incidence. It is not a function of the absolute time period but of the activities that occur during this period that contributes to the higher severity incidents. Also, there are likely differences based on location. Even within a city there could be differences based on type of work and environment. For example, an area with a higher concentration of bars may lead to a higher degree of impairment versus an area where shift-workers may be getting of a long shift just prior to the midnight hour where drowsy driving may be more a factor.

Conclusion Five

The fifth conclusion of this study was that younger drivers and older VRU's were more likely to be involved in fatal and severe crashes. This conclusion was based on the finding when examining the relationship with age, it was discovered that higher severity crashes involved younger drivers (fatal mean age = 39.14 and no injury mean age = 43.37) and it was the older VRU's (fatal mean age = 43.27 and no injury mean age = 33.53) who were involved in higher severity crashes.

This conclusion may seem logical at first glance, but these results may be atypical. Older drivers are likely more involved as they could have more trouble seeing the VRU and once they do their reaction times may not allow for avoidance of causing serious injury to the other individual. On the other hand, older drivers tend to drive more slowly and more cautiously which would tend to aid in their avoidance of potential serious injury to the VRU. Additionally, it would seem to make sense that younger VRU's would be injured as they may take more changes when interacting with motor vehicle traffic. They may try to cross traffic at more dangerous times believing they have the physical ability to "beat" traffic. Though bicyclists tend to be younger it is the pedestrians that are typically older who would not exhibit these behaviors.

Based on the conclusions the researcher recommends further research into this area should be conducted to determine a clearer relationship with age and accident severity. For this particular data set and analysis there may be other factors that are interacting leading to these results.

Conclusion Six

The sixth conclusion of this study was that highest incidence of severity involved with the element of lighting was in the dark with no streetlights. This conclusion was based on the finding when examining the relationship between accident severity and environmental lighting, it was discovered that "dark with no streetlight" was involved in fatal severity at 15.8%.

The implications of this conclusion are that areas with no lighting where VRU's and motor vehicles interact have high incidence are most dangerous for the VRU. A study of bicyclist injury severities in North Carolina came to a similar conclusion noting that "darkness with no streetlights" was a significant factor contributing to higher severity accidents with motor vehicles. This factor accounted for 14.6% of fatal accidents and 20.7% of severe accidents

(Kim, et al, 2007). These results could have been made less severe with the implementation of lighting as the same study shows a fatality rate of 2.9% with “dark – streetlights”.

Based on the conclusions the researcher recommends non-lighted traffic areas where vulnerable road users and motorized vehicles could interact be fitted with adequate lighting. While the researcher does not have specific cost information, the cost installing lighting in targeted areas would seem to be reasonable if it reduces fatalities. The addition of lighting should contribute to the reduction of severity for VRU’s in accidents with motor vehicles.

The researcher recommends that further research into this area be conducted to determine additional contributing factors to the severity level for VRU’s in these low or no lighting accidents. Some additional information to include is what type of clothing is the VRU wearing at the time of the accident? Are the VRU’s using any other type of safety equipment such as reflectors or lighting to help motor vehicle drivers better see them? Also, are there other infrastructure factors exacerbating the issue of visibility in the areas with low to no lighting?

Conclusion Seven

The seventh conclusion of this study was vulnerable road users in fatal accidents had a higher incidence of distraction. This conclusion was based on the finding when examining the relationship between severity and VRU distraction, it was discovered that the VRU was distracted at 1.7%. This percentage was over twice that of non-distracted fatal crashes at 0.8% for VRU’s.

The implications of this conclusion are VRU distraction has become a more significant factor in accidents in which they are involved. A research study found that pedestrian injuries due to mobile phone distraction increased in injury at a greater rate relative to total pedestrian injuries (Naser & Troyer, 2013). Distraction can take many forms, but the data is revealing cell phone distraction as the area of growth in VRU accidents.

Based on the conclusions the researcher recommends education outreach and coordination with cell phone vendors to help reverse the trend of increase in distracted accidents. There are currently several ad campaigns on television, social media and radio targeting texting and driving, however there are none that target non-motorized road users. Awareness of the dangers of being distracted in traffic areas could help in reducing the safety hazard. In addition, there are applications and safety features currently embedded in phones that are driver aware. A similar function could alert users that are walking or biking that they are in a traffic area to discourage distracting usage of the phone.

Further research into this area should be conducted to determine the situations in which the phones are causing distraction and the characteristics of the distracted individuals. This information would likely involve additional information from the crash reports such as narrative information, questionnaires and observational data. Crash data are gathered post incident which more often is unable to accurately capture the exact circumstances involved. More interactive methods directly involving individuals would provide additional data for analysis.

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# APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL

**ACTION ON EXEMPTION APPROVAL REQUEST**

LSU

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/research

**TO:** Randall Verret
AEEE

**FROM:** Dennis Landin
Chair, Institutional Review Board

**DATE:** March 14, 2019

**RE:** **IRB#** E11598

**TITLE:** Determine Influence of Selected Factors Impacting the Incidence and Severity of Accidents Involving Pedestrian/Bicyclists and Motorized Vehicles in Urban Areas of Louisiana

**New Protocol/Modification/Continuation:** New Protocol

**Review Date:** 3/14/2019

**Approved** ___X___ **Disapproved**________

**Approval Date:** 3/14/2019 **Approval Expiration Date:** 3/13/2022

**Exemption Category/Paragraph:** 4b

**Signed Consent Waived?:** N/A

**Re-review frequency:** (three years unless otherwise stated)

**LSU Proposal Number** (if applicable):

By: Dennis Landin, Chairman DLandin

**PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –**
**Continuing approval is CONDITIONAL on:**

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

* *All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

# VITA

Mark Verret was born in Metairie, Louisiana. He graduated with a Bachelor of Business Administration in August 1999 from the University of New Orleans (UNO). Mark then went on to work for Walt Disney Cruise Line as an IT Analyst. Between August 2001 and June 2005, he worked at the Louisiana State University Agricultural Center as a Network Analyst. In June 2005, Mark joined the Highway Safety Research Group, a division of Information Systems and Decision Sciences (ISDS), at LSU as a Systems Administrator and currently serves as the Information Technology Manager. Mark earned his Master of Public Administration in December 2005. From 2008 to the present, he taught multiple ISDS and Continuing Education courses within the area of business intelligence. He expects to receive his degree of Doctor of Philosophy in Agricultural and Extension Education and Evaluation in December 2019 from LSU.