2008

The effectiveness of the introduction and amendment of traffic laws on Louisiana road crashes

Vamshi Krishna Mudumba
Louisiana State University and Agricultural and Mechanical College, vmudum1@lsu.edu

THE EFFECTIVENESS OF THE INTRODUCTION AND AMENDMENT OF TRAFFIC LAWS ON LOUISIANA ROAD CRASHES

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science in Civil Engineering

in

The Department of Civil and Environmental Engineering

By
Vamshi Krishna Mudumba
B.E., Osmania University, 2004
May 2008

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to my professor, Dr. Chester G. Wilmot, for his patience, motivation and support throughout my stay in LSU. This work would not have been possible without his encouragement, financial support and guidance in every part of my project.

I express my thankfulness to my committee members, Dr. Sherif Ishak and Dr. Hak Chul Shin for their time and support. I thank Dr. Fu for helping me in solving simple to very complicated problems at every stage of my project. I thank Dr. Charles Monlezun for helping me with the statistics part of my research. I would also like to thank Dr. Joe Abraham from the LSU writing center for helping me in improving my writing skills in English.

I would like to thank my friends Shourie, Ismail bhai, Ballu, Mac, Brad, Praveen, Bhayya, Anil, Dada, Murat, Gopu, Chris, Rustin, Dr. Gopal, Zahangir, Tamil, Suresh, Vamsi, Sudhir, Raghu, Sachin, Dinesh and Roop who made my stay in LSU a most memorable event of my life. My special thanks to Ravi and Wakeel.

Finally, I would like to thank my dad Mr. Mohana Charyulu for his support and encouragement through out my life.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

Evaluating the safety benefit of a treatment provides information to the future safety projects of our transportation system. Various transportation laws have been amended in the state of Louisiana, aiming to reduce the roadway crash rates. The major traffic laws introduced or amended in the state in the past decade were the Graduated Driver Licensing (GDL) Program in 1998, repealing the mandatory motorcycle helmet law in 1999 and reenacting it in 2004, introducing the open alcohol container laws in 2000, and lowering the per se Blood Alcohol Content (BAC) from 0.10 to 0.08 percent in 2003. A before-and-after analysis was conducted using Analysis of Variance (ANOVA) to identify the effect of the above traffic laws in reducing crash rates in the state in the presence of other factors influencing crash rates. The dependent variables considered in the analysis were the total, fatal, injury, and property damage only (PDO) crash rates, while the independent variables were all the factors that significantly influence the above dependent variables. The analysis of each law was performed independently for both motor vehicle and motorcycle crash rates, as certain laws are applicable either for crashes due to motor vehicles or motorcycles. At the 5 percent significance level, the results concluded that GDL program was effective in decreasing the young driver motor vehicle injury, PDO and all crash rates; BAC law was effective in decreasing the alcohol-related motorcycle injury, motor vehicle injury, PDO and all crash rates. There was insufficient evidence at 5 percent significance level to prove that GDL program was effective in decreasing the young driver motor vehicle fatality rates; Open container law in decreasing the alcohol-related motor vehicle crash rates at all severity levels; BAC law in decreasing the alcohol-related motorcycle fatal, PDO and all crash rates, and motor

vehicle fatality rates; Helmet laws in influencing motorcycle crash rates at all severity levels.

1. INTRODUCTION

1.1. Background

Traffic laws are a system of rules that are enforced to govern traffic and regulate the safe operation of vehicles. Appropriate traffic safety laws are essential for well balanced transportation facilities in a society. Enforcing new traffic rules can never be a popular public activity, but it is essential to keep traffic crashes in control. Benefits of changes in the legislation are anticipated before implementing new traffic laws or amending the existing traffic laws in the society. Traffic laws in the United States are made at the federal as well as at the state level, but states are responsible for enforcing traffic laws. Federal legislation directs states to adopt lifesaving laws within a specified period of time or threatens to penalize states for millions of dollars by withholding funds from the Highway Trust Fund.

The U.S. Department of Transportation (DOT) was established in 1966 to address the issues of the safety, efficiency and accessibility of the nation’s transportation system, and regulate the state DOTs in implementing traffic laws effectively. Various modal administrations such as the Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), etc. were established under the U.S. DOT to monitor the various transportation laws in the states. The NHTSA is responsible for reducing injuries, deaths and economic losses resulting from the motor vehicle and motorcycle crashes.

1.2. Problem Statement

Evaluating the benefits of applying legislation to reduce traffic crashes is essential for the future transportation system. Various transportation laws have been enacted or amended in the state of Louisiana in the past decade, but the effectiveness of these laws in reducing roadway crash rates has not been identified. Identifying the effectiveness of a traffic law will provide direction for further changes in the existing system.

2. LITERATURE REVIEW

2.1. Introduction

A detailed literature review was conducted to identify the effectiveness of traffic laws in reducing motor vehicle crash rates. Traffic laws are introduced by the states to provide safe and efficient transportation system to our society. Recent new laws in Louisiana include introducing a Graduated Driver Licensing (GDL) system for young drivers, repealing and reenacting the mandatory motorcycle helmet laws, introducing open alcohol container laws, lowering the per se Blood Alcohol Content (BAC) from 0.10 to 0.08 percent, and mandating the use of seat belts for motor vehicle drivers as well as the passengers.

2.2. Louisiana Traffic Laws

Louisiana enacted the GDL system for young drivers through Act 725 of the 1997 regular session, and was signed into law effective January 1st 1998. Unlike other states, which provided restrictions on young drivers of fifteen (15), sixteen (16) and seventeen (17) years of age, the GDL law in Louisiana provided a graduated licensing method for minor drivers of fifteen (15) and sixteen (16) years of age only. The law enabled minors with a class 'E' learner's permit to drive when accompanied by a licensed adult of at least twenty-one (21) years of age. The learner's permit can be upgraded to the class "E" intermediate license, upon reaching sixteen (16) years of age and maintaining the learner's permit for a minimum of ninety (90) days. This class "E" intermediate license allows minors to drive alone or with other passengers in the vehicle, but prohibits driving between the hours of 11:00 PM and 5:00 AM, unless accompanied by an adult driver of at least twenty-one (21) years of age.

Louisiana has amended its motorcycle helmet laws several times in the past fifty years. Louisiana first adopted the motorcycle helmet law applicable to all riders in the year 1968. The law was amended in 1976 and only riders of less than eighteen (18) were required to wear a helmet. Then in 1982, the law was again reenacted to its original state and required all riders in the state to wear a helmet. Later the law was again repealed through Act 404 of the 1999 regular session, effective August 15th 1999. This Act required helmet use by riders under the age of eighteen (18) and by the riders who were not covered by a health insurance policy with medical benefits of at least $10,000 for bodily injuries. Again the law was finally modified through Act 742 of the 2004 regular session, effective August 15th of 2004, and required all motorcycle riders to wear a helmet.

Various alcohol-related laws were amended in the state aimed at reducing drunk driving crashes. The law prohibiting the possession of an open alcoholic container or consumption of an alcoholic beverage in motor vehicles was implemented through Act 97 of the 2000 1st extraordinary session. The law was effective throughout the state of Louisiana from June 6th of 2000. Later, the law related to the legal blood alcohol content (BAC) level for motor vehicle drivers was amended through Act 781 and was effective from September 30th of 2003. This law reduced the legal BAC level for an adult driving under the influence (DUI) from 0.10 percent to 0.08 percent.

2.3. Before-and-After Analysis

A before-and-after analysis is the most common method used to identify the effect of a treatment in reducing the motor vehicle crashes. This can be done by using the following methods:

- Time Series Analysis

- By using control groups in comparing two populations
- By using an observational before-and-after method developed by Ezra Hauer
- By using Analysis of Variance (ANOVA)

Time-series analysis identifies the trend components in the data and provides a best fit curve for the available data. This method predicts the change in crashes at a particular time, but does not predict the effect of a single treatment in the presence of other significant factors. This drawback can be rectified by using control groups in the analysis. The concept of using control groups eliminates the magnitude of a change in crashes due to the factors other than the treatment. The observational before-and-after study method developed by Hauer uses Empirical Bayes (EB) approach to eliminate the error due to regression to the mean. This method predicts crashes in the 'after' period assuming the treatment was not applied, and the predicted crashes are compared with the actual crashes observed in the after period. In estimating crashes in the after period, this method uses data on certain sections with no effect of the treatment.

ANOVA compares two or more populations and identifies the change in crashes due to a treatment in the presence of other significant factors. Thus, the influence of extraneous factors can be removed to allow better identification of the influence of the treatment under review.

In a study by Haselton, et al. (2001) three different methodologies were compared to determine significant change in traffic collisions due to increase of speed limits on California state highways. The three methods were frequentist analysis, ANOVA and the observational before-and-after procedure developed by Ezra Hauer. The ANOVA model was developed in the study to compare the mean of a population before and after the treatment was applied. The study concluded that both ANOVA and the observational before-and-after methods were effective in conducting before-and-after collision studies.

A before-and-after analysis using the Empirical Bayes method and ANOVA was conducted by Yuan, et al. (2000) to estimate the benefits from highway safety improvements at different site locations. The study, conducted for the Connecticut Department of Transportation, developed ANOVA models to study the statistical relation between the dependent variable and the independent variables. The study considered the crash rate reduction as the dependent variable, which was regarded as the basic criterion for evaluating the safety benefit of the improvement. The ANOVA model was developed in the following format:

$$P_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Where,

P_{ij} is the crash rate reduction of site j with treatment i,
μ is overall effect on the sites (such as weather, traffic volume, geometric etc),
α_i is the effect due to highway safety improvement i,
ε_{ij} is errors that are identically and independently distributed

From the study, it was concluded that the improvements reduced the total number of crashes.

2.4. Identifying the Impact of Traffic Laws Using Before-and-After Analysis

Different studies have been conducted in the past to identify the effectiveness of changes in traffic laws in reducing crash rates. The following sections explain each law and their performance in reducing crash rates.

2.4.1. Graduated Driver Licensing Method for Reducing Young Driver Crashes

Extensive research has been done in the past to identify the effectiveness of the GDL system in reducing young driver crashes. A study conducted by Hartling et al. (2004), reviewed the effectiveness of GDL in reducing the crash rates of young drivers. This study reviewed 13 different studies that were implemented between 1979 and 1998 in the United States, Canada, New Zealand, and Australia. The study concluded that GDL is effective in reducing crash rates among the young drivers to whom it is applied. However, the magnitude of the GDL influence could not be identified in the study.

In a study by Shope et al. (2001), the early impact of Michigan's GDL program on traffic crashes among 16-year-old drivers was identified. The Michigan GDL program was effective from April 1st, 1997, and provided driving restrictions on teens younger than 18 years of age. The study analyzed motor vehicle crash data for 16-year-olds, by comparing their crash data for the year 1996 (before GDL program implementation) with that of 1998 and 1999 (after GDL program implementation). The study did not include the data for 1997, as the probability for unusual levels of licensing just before and just after implementing the law is high. In addition to the before-and-after analysis, comparisons were also made between crashes of 16-year-old drivers and crashes of drivers 25 years or older. This controlled for the possibility of changes in 16-year-old driver crashes due to the factors other than GDL program. The study concluded that the implementation of the GDL program reduced the overall crash risk for 16-year-old drivers by 25 percent from 1996 to 1999.

In a similar study conducted by Foss et al. (2001), for the state of North Carolina, it was concluded that the crash rates among the 16-year-old drivers declined for all levels of severity. The study observed that the fatal crashes declined by 57 percent and the minor injury crashes declined by 23 percent among 16 year-olds due to the introduction of GDL law.

The state of Florida instituted a GDL program for its young drivers effective July 1st of 1996. The state provided restrictions on young drivers of fifteen, sixteen, and seventeen years of age. The study compared Florida's crash data for 1995-1997 with similar data from Alabama, which did not have a GDL program for its young drivers in the same period (Ulmer et al., 2000). The study identified that the state of Florida had a reduction of 9 percent in its fatal and injury crash rates among the young drivers during 1997.

While most studies concluded that a GDL program is effective in reducing crashes among young drivers, a study by Masten and Hagge (2003) on evaluating the California's GDL program could not find an overall impact of it in reducing crashes among young drivers. The study found no overall impact as California's teens and parents were largely participating in the program requirements even before implementation of the law.

2.4.2. Mandatory Motorcycle Helmet Law Effectiveness

Generally, compared with cars, motorcycle riders have a higher risk of being involved in a fatal accident (Diamantopoulou, 1996). A large number of research studies have been published in the past 15 years to address the effectiveness of mandatory helmet laws in reducing motorcycle injury and fatal crashes. Most of the studies have concluded that introducing a mandatory helmet law has reduced motorcycle fatalities.

The effectiveness of motorcycle helmets and mandatory helmet laws in the state of Louisiana was addressed in a study by Schneider (2006). The study compared the percentage of drivers and passengers killed in motorcycle crashes who were not wearing a helmet with the percentage killed while wearing a helmet. The study observed that between 1999 and 2005, on average, 6.6 percent of motorcycle drivers not wearing helmets were killed in motorcycle crashes, while only 3.5 percent of motorcycle drivers wearing helmets were killed. Based on the above observation it was concluded that not wearing a helmet increases the risk of motorcycle drivers being killed in a crash. Assuming that helmet wearing will be decreased by repealing the law, it was concluded that a change in mandatory helmet laws will influence the number of fatalities. This conclusion is questionable because the high risk of fatalities for motorcycle riders not wearing helmets can also be due to the other characteristics associated with the riders. Such other characteristics include aggressive driving, peer influence, age of drivers, sex of drivers, etc. But the study could not consider these predominant factors that can influence fatalities, except for including alcohol use by drivers. Alcohol use among motorcycle riders without wearing helmets increases the probability of fatality from 6.6 percent to 19.7 percent.

Auman et al. (2002) identified the effect of the 1992 Maryland motorcycle helmet use law in preventing deaths and brain injuries among motorcyclists. The study compared the motorcycle fatalities for seasonally comparable 33-month periods that occurred before and after the enactment of the law. The study concluded that the motorcycle fatality rate dropped from 10.3 per 10,000 registered motorcycles to 4.5 after introducing the law.

A study by Sosin et al. (1990) reviewed the deaths resulting from head injuries from motorcycle crashes from 1979 to 1986. The fatality rates were identified for the states based on the population and the motorcycle registrations. The study concluded that the states with partial or no motorcycle helmet laws had a crash rate twice that of states with comprehensive helmet laws. In a similar study, the effect of the reenacted comprehensive helmet law for the state of Nebraska was identified by Muelleman et al. (1992). The study used a before-and-after analysis on two urban counties, representing 40 percent of the Nebraska's population. The analysis for the study used a period of one year before the reenactment of the law effective January 1st 1989, and one year after the reenactment of the law. The study concluded that the helmet law resulted in fewer crashes, fatalities and severe head injuries. Another study by Bledsoe, et al. (2005), identified the trends in motorcycle crashes and fatality risks, and motorcycle registrations. The results of this study also concluded that the repeal of the mandatory helmet laws had a significant adverse effect on road safety.

2.4.3. Alcohol-Related Laws

Alcohol-related crashes are one of the major contributing factors to fatalities in the state of Louisiana. In 2002, alcohol-related crashes accounted for 47 percent of the traffic fatalities in the state (Louisiana Traffic Records Data Report, 2002). Different enforcement laws have been implemented in the state to address the problem of alcohol-related crashes. The following literature provides the information on studies which identified the effectiveness of alcohol-related laws in reducing crashes.

A study by Gorman, et al. (2005) assessed the effects of BAC laws introduced in the state of Texas in 1999 on alcohol-involved crashes and fatalities. The study used time series methods to analyze data obtained from the Fatality Analysis Reporting System (FARS) and Texas Department of Public Safety (DPS) reports of alcohol-related crashes. The study concluded that the 0.08 percent BAC laws had no significant influence in reducing the alcohol-related crashes in the state of Texas.

In a similar study by Zador, et al. (2004), the effect of reducing the illegal per se BAC level from 0.1 percent to 0.08 percent in the state of Maryland were investigated. The study compared the changes in the fatal motor vehicle crashes of Maryland with crashes of five other neighboring states. The basic criteria for the comparison of crashes were the changes in crash frequency and crash frequency ratios among the different crash severity levels and not on the population crash rates. This study also concluded that there was no statistical evidence that reducing the per se BAC level from 0.1 percent to 0.08 percent had an effect in reducing the alcohol-related fatal crashes.

The NHTSA (April 2002) evaluated the effectiveness of open alcohol container laws in the states including Iowa, Maine, Rhode Island, and South Dakota. The study conducted a before-and-after analysis and concluded that three out of four states had a decline in their proportion of alcohol-related crashes as a result of the change in open alcohol container laws.

3. OBJECTIVES

The objective of this research was to identify the effectiveness of the introduction and amendment of traffic laws in reducing the roadway crash rates in Louisiana. The study analyzed the change in the roadway crash rates with a change in the Louisiana transportation laws that were introduced or amended between the years 1998 and 2004. To achieve this, statistical analysis was conducted to compare crashes that occurred before and after the implementation of each law.

4. METHODOLOGY

4.1. Introduction

The primary objective of this study was to analyze the crash statistics of Louisiana, and identify the effectiveness of traffic laws in reducing crash rates. To achieve this, a before-and-after analysis was used to compare the means and the variances of the populations collected before and after applying the legislation. A traditional before-and-after analysis uses control groups to identify changes in safety due to other factors than the treatment. The traffic laws were amended or introduced throughout the state, therefore using control sites was not feasible in the current study. The major traffic laws introduced or amended in the state were GDL laws, mandatory helmet laws, open alcohol container laws and the reduction of per se BAC level from 0.1 percent to 0.08 percent, and they are considered for the scope of this study.

The Analysis of Variance (ANOVA) procedure was used to study the relationship between the dependent variables and the independent variables. The frequency of crashes per month per unit population was assumed to be the basic criteria for evaluating the safety benefit of a treatment. This makes the crash rate per month per unit population to be the dependent variable in the analysis while the change in laws and various other factors that can influence crash rates form the independent variables. ANOVA was conducted for all crash rates combined, and for each severity level. The ANOVA compared the means and the variance between the subdivided groups and within the subdivided groups, and identified the significance of the independent variables in influencing the response variable. The Statistical Analysis Software (SAS) was used to develop the ANOVA results for each crash severity type in the scope of this study.

4.2. Hypothesis

The null hypothesis (H_0) was that the treatment had no effect in reducing the crash rate in the state. If the null hypothesis was not rejected it was concluded that there was insufficient evidence to suggest that the treatment had a significant effect in reducing crash rates.

4.3. Data

The database used for the analysis was obtained from the Louisiana Department of Transportation and Development (LADOTD), and Highway Safety Research Group (HSRG) of Louisiana State University (LSU). The crash data was obtained for a period of twelve years from 1995 to 2006, and consisted of detailed information on crashes that occurred throughout the state of Louisiana. Each year of the data consisted of approximately 150,000 crash records and was provided in Microsoft Access format. The database was developed using the uniform motor vehicle crash reports maintained by the state police. The state police investigated all crashes that occurred in Louisiana and reported them to the Department of Public Safety and Corrections. This department appointed the HSRG at LSU to create a database from the records and correct it by eliminating errors and imputing missing data. Later, it was distributed to LADOTD for further research and development.

The data contained details of each crash such as crash year, crash date, crash time crash type, crash contributing factors, driver characteristics such as age and sex, occupant characteristics, vehicle characteristics, pedestrian characteristics, people injured at different severity levels, etc. The data was provided in different tables such as a Crash_Table, Vehicle_Table, Occupant_Table and Pedestrian_Table, each of which explained different characteristics of a crash. Microsoft Access queries were used to filter the data and create new data items of the variables required for the before-and-after analysis. The analysis was done independently for all crash rates combined, and for each severity level such as number of fatality rates, number of injury crash rates and number of property damage only (PDO) crash rates.

4.3.1. Sample Data

As explained in Section 4.3, each year of the data consisted of information on approximately 150,000 crashes. Working on different tables of a year with such huge data created problems in the Access database. So, the data used in the analysis was a 20 percent sample of the data collected for each year from 1995 to 2006 when required.

The analysis required information on different characteristics of crashes, such as alcohol-related crashes, young driver crashes, motorcycle crashes, and alcohol-related motorcycle crashes, which could be obtained by combining tables with different characteristics of each crash. A column with common identities was required to combine tables, so the data for one or more tables was combined using column "CRASH_NUM", which has the same crash numbers in all the tables. If different tables of a year were sampled independently, the crash numbers in the column "CRASH_NUM" of each table would be different, and it would not be possible to combine tables based on crash numbers. So, the data was sampled for each year by combining all required variables from a year into a new data file.

4.3.2. Combining Data of All Years

The sample of data obtained for twelve years was combined into one dataset to save time on querying for each individual year. A new database with the name "Combined Sample Data" was created by including all the variables necessary for the analysis.

4.4. Dependent and Independent Variables

The ANOVA results were developed through the SAS software package using the dependent and the independent variables as explained below.

4.4.1. Dependent Variables

The dependent variables in this study were the crash rates per month per unit population at each level of severity. The analysis was performed independently for each law for both motor vehicle and motorcycle crashes. Therefore four different models were developed for each law for motor vehicle as well as motorcycle crashes as explained below:

- Total Crash rate per Month
- Fatality rate per Month
- Injury Crash rate per Month
- PDO Crash rate per Month

4.4.2. Independent Variables

The independent variables were factors that significantly influenced the change in crash rates. The impact of traffic laws might appear to influence crash rates, but the actual change in crash rates can be due to factors other than the traffic laws. So, the independent variables were included in the analysis to extract the change in the crash rates due to legislation only, by eliminating the influence of the independent variables.

The independent variables selected for a particular crash severity model were not the same for all the models in the analysis. These variables in the database were coded either as categorical or quantitative variables. Categorical variables are the variables that are not naturally measured, but take values among several possible categories. The quantitative variables are naturally measured numbers for which arithmetic operations make sense. As ANOVA performs analysis using groups, the independent variables were analyzed only as categorical variables. The quantitative variables, when required, were converted into categorical variables based on its distribution with the crash rates for a particular severity level. The variables were identified by writing queries in the Access database.

Traffic law was included as independent variable in the analysis. Dummy variable was used to represent conditions before and after the introduction of a traffic law. Dummy variable in the models identified the significance of the changes in the law on the dependent variable (crashes at different severity levels). This variable along with the other factors that influenced crash rates were included in the model and the significance of the dummy variable in the presence of the other was identified.

4.5. Data Analysis

The data analysis for this study was conducted in two phases. First, the variables that had an influence in changing the crash rates were identified. Second, an ANOVA procedure was used to identify the effectiveness of each law for motor vehicle and motorcycle crash rates at different levels of severity in the presence of the variables identified as significant in influencing crash rates. This procedure identifies the effect of the legislation in the presence of the other independent variables affecting crash rates. The SAS software package was used to perform the analysis.

4.5.1. Identifying Independent Variables

The independent variables for the analysis were chosen based on their significance in influencing crash rates. The variables that can possibly influence the crash rates of motor vehicles and motorcycles were identified from the database based on the initial analysis of the data and logical inference. All such identified variables were converted into categorical variables and were queried to identify the crashes in each category. The crashes in each category of a variable were represented in the form of crash rates based on the population statistics of each category in the state such as, male and female licensed driver population, licensed driver population by age group, number of registered motor vehicles, etc.

A one-way ANOVA was performed on crash rates between different categories of each variable using the SAS software package. This identified whether the change within the variable affects the crash rates or not. Though the crash rates change between different categories of a variable, it might not influence the effect that legislation has on crash rates, unless the population statistics within the categories change unequally between the before and after observations. It was assumed that the crash rates change proportionally to the change in the population statistics. So after identifying the variable as having a positive impact on crash rate, a two-way ANOVA was performed on crash rates with the same categories by including the legislation as an additional independent variable. This procedure identified the change in crash rates within different categories of a variable before and after the introduction of legislation. If the variable was identified as significant in influencing the crash rates in both the tests, it was included in identifying the effectiveness of legislation along with other variables for further analysis.

4.5.2. Identifying the Effect of Legislation

The effect of the introduction or amendment of each traffic law in reducing crash rates was identified by comparing the 'before' population which had no effect of the law, with the 'after' population, which had an effect of the change in the law. As the change in crash rates from 'before' to 'after' period can not be attributed only due to the treatment, the influence of the other variables was also included in the analysis. A multi-variant

ANOVA was used to estimate the significance of each law in the presence of the other independent variables as explained in the previous sections.

4.5.3. Interpreting Results

The general linear models (GLM) procedure was used to get the ANOVA results from the SAS software package. The GLM method provides the F-value and the P-value of each variable, which explains its significance in influencing the dependent variable. If the calculated F-value is greater than $F_{\alpha, t-1, n-t}$, where ‘α’ is the significance level, ‘t’ is number of groups and ‘n’ is the number of values in a group, then the variables are considered to be significant and the null hypothesis can be rejected. For the present study, the level of significance α is chosen to be 5 percent. Similarly, if the obtained P-value is less than α, the null hypothesis can be rejected. An interaction between two or more variables explains the significance of them in affecting the crash rates together. This interaction variable explains the change in crash rates with the presence of two or more variables. The results for multi-variant ANOVA are interpreted similar to the results of the ANOVA.

5. RESULTS AND DISCUSSION

5.1. Candidate Independent Variables from the Database

The initial selection of variables that are likely to influence the crash rates over time, and thereby impact any before-and-after study, were identified from the database based on logical reasoning.

Intuitively, and from the results of past studies, factors such as speed, alcohol or drug involvement, use of passenger restraint systems, driver and occupant age and gender, and number of registered vehicles affect crash rates and crash severity. For example, in a study of speed and crashes involving 10,000 drivers on 600 miles of rural highways, Solomon (1964) concluded that crash-involvement rates decreased with increasing speeds up to 65 miles per hour, then increased at higher speeds. Similarly, it was estimated that approximately 39 percent of the fatal crashes in the United States involve alcohol (Traffic Safety Facts, 2005). The alcohol-related fatalities in Louisiana increased from 431 in 1999 to 451 in 2004 (Champagne, 2005).

However, while several factors may influence crash rates or crash severity, if they do not change between the before and after observations, they have no affect on the results. Thus, the task was to review the influence of the candidate variables above on crash rate and crash severity, and for those that have a significant impact, to determine whether they changed over the period in which the before-and-after study was conducted. If they have a significant impact and do change during the period of analysis, then they should be included in the study. If not, they can safely be excluded.

Some of the candidate variables identified above can be eliminated from further consideration based on the negligible change they will undergo during the period chosen for the before-and-after study, or because their affect is incorporated in the crash rate. For example, speed, alcohol and drug involvement, and the use of passenger restraint systems are likely to change little in the limited period typically chosen for a before-and-after study. Also, the effect of the number of registered vehicles was largely accommodated by expressing crashes in terms of crashes per unit population. However, the impact of gender, age, and occupants was analyzed in this study as described below.

5.1.1. Driver Gender

The variable "Driver Gender" was thought to possibly have an impact on the motor vehicle crash rates, while its impact on the motorcycle crash rates was thought to be negligible. This was confirmed by an initial analysis of the data. The motor vehicle crash rates for both driver genders were calculated based on male and female licensed driver population in the state. The population statistics for the male and female driver population was available only for a particular month in each year. So the values for other months were calculated based on interpolation using the available values.

5.1.2. Driver Age

The variable "Driver Age" was thought to possibly have an impact on both motor vehicle and motorcycle crash rates. This was conformed by an initial analysis of the data. The motor vehicle crash rates for the variable were calculated based the number of licensed drivers at different age groups, while the motorcycle crash rates were calculated based on the registered motorcycles in each year. The missing information on the number of licensed drivers and the number of registered motorcycles for a particular time period was calculated based on interpolation using the available values.

5.1.3. Occupant Age

Peer influence is considered an important factor in contributing to motor vehicle crashes (Charles Sturt University, 1998). Therefore the variable "Occupant Age" was thought to possibly have an impact on the motor vehicle crash rates. The impact of the variable on the motorcycle crash rates was thought to be negligible. This was conformed by an initial analysis of the data. The motor vehicle crash rates for the variable were calculated based on the total population of Louisiana at different age groups from 1995 to 2006. The missing information on the Louisiana population statistics was calculated based on interpolation using the available values.

5.1.4. Occupant Gender

The variable "Occupant Gender" was thought to possibly have an impact on motor vehicle crash rates. Its impact on motorcycle crash rates was thought to be negligible. This was conformed by an initial analysis of the data. The motor vehicle crash rates for both driver genders were calculated based on male and female population in the state. The population statistics missing for a time period were calculated using interpolation with the available data.

5.2. Independent Variables for the Analysis

This section discusses analysis on the variables that were included in identifying the effectiveness of legislation. The analysis on the variables was done independently for each law using data as explained in Table 5-1 and Table 5-2. The analysis was done independently for each law as all the laws are not influenced by the same variables. For example, the variable "Driver Age" can be significant in influencing the crash rates with the GDL law, while it may not be significant in influencing the crash rates with the open container law. Also, subdividing the data as explained in Table 5-1 and Table 5-2 will eliminate the change in the crash rates due to other laws.

A change in certain variable definitions was observed from the year 1999 due to a change in the uniform motor vehicle crash report in 1999. The data for the analysis of each law was also selected based on the similarity in data definitions, which might influence the crash counts before and after the change in definitions is observed. The data used for the analysis of identifying the significance of variables with different laws are given below in Table 5-1 and Table 5-2.

Table 5-1: Data Used for the Analysis of Motor Vehicle Crash Rates

Legislation/Effective Date	Data Used	Reason
GDL Law Jan 1st 1998	Crashes due to 15 and 16 year-olds between Jan 1995-Dec 1998	The data between Jan 95 and Dec 98 was influenced only by the GDL law. Jan 95 was the start of the data and there was a change in the variable definitions after Dec 98
Open Container Law Jun 6th 2000	Alcohol-related crashes between Jan 1999-Sep 2003	The data between Jan 99 and Sep 03 was influenced only by the Container Law. Jan 99 was the start of data with new definitions and BAC law was effective Sep 30th 03
Reduction of BAC Level Sep 30th 2003	Alcohol-related crashes between Jun 2000-Dec 2006	The data between Jun 00 and Dec 06 was influenced only by the reduction of BAC Law. Container Law was effective June 6th 00 and data ends at Dec 06.

5.2.1. Driver Gender

A one-way ANOVA test of motor vehicle crash rates was performed between male and female drivers for each law independently, using data under consideration, as explained in Table 5-1. This identifies the significance of the difference in the crash rates due to male and female drivers. The results of the one-way ANOVA test for "Driver Gender" at different severity levels for each law are given in Table 5-3, Table 5-4 and Table 5-5. When the calculated F-value is greater than $F_{\alpha,\ t-1,\ n-t}$, where 'α' is the significance level, 't' is number of groups and 'n' is the number of values in a group, or if the obtained P-value is less than α, then the variables are considered to be significant,

Table 5-2: Data Used for the Analysis of Motorcycle Crash Rates

Legislation/Effective Date	Data Used	Reason
Repeal of Mandatory Motorcycle Helmet Law Aug 15th 1999	Motorcycle crashes between Jan 1999-Sep 2003	The data between Jan 99 and Sep 03 was influenced only by the Helmet Law. Jan 99 was the start of data with new definitions and BAC law was effective Sep 30th 2003
Reduction of BAC Level Sep 30th 2003	Alcohol-related motorcycle crashes between Aug 1999-Aug2004	The data between Aug 99 and Aug 04 was influenced only by the reduction of BAC Law. Repeal of Helmet Law was effective Aug 99 and it was reenacted in Aug 04.
Reenacting of Mandatory Motorcycle Helmet Law Aug 15th 2004	Motorcycle crashes between Oct 2003-Dec 2006	The data between Oct 03 and Dec 06 was influenced only by reenacting of the helmet law. BAC law was effective Sep 03 and the data ends at Dec 06.

otherwise they are considered to be insignificant. The results from Table 5-3 show that the variable "Driver Gender" was significant in influencing the young driver fatality, PDO and all crash rates for the analysis of GDL law, while there was insufficient evidence to prove that variable was significant in influencing the young driver injury crash rates for the analysis of GDL law. Similarly, the results from Table 5-4 and Table 5-5 show that the variable "Driver Gender" was significant in influencing the alcohol-related crash rates at all severity levels for the analysis of both open container and BAC laws.

After identifying the significance of the variable at different severity levels for different laws, a two-way ANOVA test was performed between each law and Driver Gender by including the crash severities identified as significant from Table 5-3, Table 5-4 and Table 5-5. The interaction effect between the variable and the law tells whether the difference of the change in the crash rates due to male and female drivers before and after

Table 5-3: Significance of Driver Gender on Young Driver Crash Rates for GDL Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	96	4.0	0.0484	0.05
Injury Crashes	96	1.18	0.2810	0.05
PDO Crashes	96	15.47	0.0002	0.05
All Crashes	96	11.20	0.0012	0.05

Table 5-4: Significance of Driver Gender on Alcohol-Related Crash Rates for Open Container Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	114	577.44	<0.0001	0.05
Injury Crashes	114	1272.47	<0.0001	0.05
PDO Crashes	114	816.49	<0.0001	0.05
All Crashes	114	1634.02	<0.0001	0.05

Table 5-5: Significance of Driver Gender on Alcohol-Related Crash Rates for BAC Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	158	626.86	<0.0001	0.05
Injury Crashes	158	514.24	<0.0001	0.05
PDO Crashes	158	422.96	<0.0001	0.05
All Crashes	158	646.45	<0.0001	0.05

the law was significant or not. It was assumed that motor vehicle drivers of both the genders respond to legislation uniformly, and the change in the crash rates of male and female drivers before and after the change in a law was only due to the law. It was also assumed that the crash rates change proportionally to the motor vehicle driver population. The results of the interaction effect between the variable and different laws are shown in Table 5-6, Table 5-7 and Table 5-8.

Table 5-6: Interaction Effect between Driver Gender and GDL Law for Young Driver Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	96	0.01	0.9162	0.05
PDO Crashes	96	1.07	0.3034	0.05
All Crashes	96	0.47	0.4940	0.05

Table 5-7: Interaction Effect between Driver Gender and Open Container Law for Alcohol-Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	114	2.34	0.1286	0.05
Injury Crashes	114	0.93	0.3376	0.05
PDO Crashes	114	0.20	0.6583	0.05
All Crashes	114	0.07	0.7965	0.05

Table 5-8: Interaction Effect between Driver Gender and BAC Law for Alcohol–Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	158	1.47	0.2277	0.05
Injury	158	14.51	0.0002	0.05
PDO Crashes	158	13.68	0.0003	0.05
All Crashes	158	16.48	<0.0001	0.05

The results from Table 5-6 show that there was insufficient evidence to prove that the variable “Driver Gender” was significant in influencing the young driver fatality, PDO and all crash rates with GDL law. Similarly, the results from Table 5-7 show that there was insufficient evidence to prove that the variable “Driver Gender” was significant in influencing the alcohol-related crash rates at all severity levels with open container law. The results from Table 5-8 show that the variable “Driver Gender” was significant in influencing the alcohol-related injury, PDO and all crash rates with BAC law. There was insufficient evidence to prove that the variable was significant in influencing the alcohol-related fatality rates with BAC law.

5.2.2. Driver Age

The variable “Driver Age” was coded as a continuous variable in the data, but was converted into a categorical variable based on its distribution with the crash rates, and based on logical inference. Similar characteristics within a distribution are coded as a group, which reduces the error due to the averages within the group. The categories for the variable are chosen independently for each level of severity due to both motor vehicle and motorcycle crashes. The distributions of motor vehicle and motorcycle crash rates with the Driver Age at different severity levels are given in Appendix A and Appendix B respectively. Based on the above discussion, the age of different drivers for all motor vehicle crash severity levels are categorized into “15-18”, “19-21”, “22-25”, “26-40”, “41-60” “>60” groups for the analysis of open container and BAC law. The driver ages for all motor vehicle crash severity levels are categorized as “15” and “16” for the analysis of GDL law. The drivers of age 15 and 16 were the only ages considered for the analysis of GDL law, as the law influences minors of 15 and 16 year-olds only. Similarly, the age of different drivers for motorcycle fatalities are categorized into “15-21”, “22-

32", "33-54", ">54", for motorcycle injury crashes are categorized into "15-21", "22-32", "33-54", ">54", for PDO crashes are categorized into "15-21", "22-54", "55-85" and for all crashes are categorized into "15-21", "22-45", "46-64", ">64".

A one-way ANOVA test of motor vehicle and motorcycle crash rates was performed between different driver age groups for each law independently, using data under consideration, as explained in Table 5-1 and Table 5-2. This identifies the significance of the difference in the crash rates due to different driver age groups. The results of the one-way ANOVA test for "Driver Age" at different severity levels of motor vehicle crash rates are given in Table 5-9, Table 5-10 and Table 5-11. Similarly, the results of the one-way ANOVA test for "Driver Age" at different severity levels of motorcycle crash rates are given in Table 5-12, Table 5-13 and Table 5-14. The results from Table 5-9 show that the variable "Driver Age" was significant in influencing the young driver motor vehicle crash rates at all severity levels for the analysis of GDL law. Similarly, the results from Table 5-10 and Table 5-11 show that the variable "Driver Age" was significant in influencing the alcohol-related motor vehicle crash rates at all severity levels for the analysis of both open container and BAC laws. The results from Table 5-12 and Table 5-14 show that the variable "Driver Age" was significant in influencing the motorcycle crash rate at all severity levels for the analysis of both repeal and reenact of mandatory helmet laws. The results from Table 5-13 show that the variable "Driver Age" was significant in influencing the motorcycle fatality, injury and all crash rates for the analysis of BAC law.

A two-way ANOVA test was performed between each law and "Driver Age" by including the crash severities identified as significant from Table 5-9 to Table 5-14. The

Table 5-9: Significance of Driver Age on Young Driver Motor Vehicle Crash Rates for GDL Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	96	7.39	0.0078	0.05
Injury Crashes	96	22.12	<0.0001	0.05
PDO Crashes	96	24.04	<0.0001	0.05
All Crashes	96	27.93	<0.0001	0.05

Table 5-10: Significance of Driver Age on Alcohol-Related Motor Vehicle Crash Rates for Open Container Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	342	90.01	<0.0001	0.05
Injury Crashes	342	788.93	<0.0001	0.05
PDO Crashes	342	385.22	<0.0001	0.05
All Crashes	342	859.13	<0.0001	0.05

Table 5-11: Significance of Driver Age on Alcohol-Related Motor Vehicle Crash Rates for BAC Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	474	90.51	<0.0001	0.05
Injury Crashes	474	216.98	<0.0001	0.05
PDO Crashes	474	212.77	<0.0001	0.05
All Crashes	474	363.23	<0.0001	0.05

interaction effect between the variable and the law tells whether the difference of the change in the crash rates due to different driver age groups before and after the law was significant or not. It was assumed that motor vehicle and motorcycle drivers of all age

Table 5-12: Significance of Driver Age on Motorcycle Crash Rates for Repeal of Mandatory Helmet Law (1999)

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	228	23.56	<0.0001	0.05
Injury Crashes	228	157.11	<0.0001	0.05
PDO Crashes	171	95.65	<0.0001	0.05
All Crashes	228	244.60	<0.0001	0.05

Table 5-13: Significance of Driver Age on Alcohol-Related Motorcycle Crash Rates for BAC Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	180	6.16	0.0026	0.05
Injury Crashes	180	22.04	<0.0001	0.05
All Crashes	180	51.52	<0.0001	0.05

Table 5-14: Significance of Driver Age on Motorcycle Crash Rates for Reenactment of the Mandatory Helmet Law (2004)

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	156	19.66	<0.0001	0.05
Injury Crashes	156	93.73	<0.0001	0.05
PDO Crashes	117	79.72	<0.0001	0.05
All Crashes	156	151.03	<0.0001	0.05

groups respond to legislation uniformly and the change in the crash rates of different driver age groups before and after the change in a law was only due to the law. It was also assumed that the motor vehicle and motorcycle crash rates change proportionally to the driver population. The results of the interaction effect between the variable and different laws are shown in Table 5-15 to Table 5-20.

Table 5-15: Interaction Effect between Driver Age and GDL Law for Young Driver Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	96	0.01	0.9116	0.05
Injury	96	5.79	0.0181	0.05
PDO	96	11.77	0.0009	0.05
All Crashes	96	11.91	0.0008	0.05

Table 5-16: Interaction Effect between Driver Age and Open Container Law for Alcohol-Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	342	1.43	0.2134	0.05
Injury	342	1.83	0.1073	0.05
PDO	342	7.88	<0.0001	0.05
All Crashes	342	4.32	0.0008	0.05

Table 5-17: Interaction Effect between Driver Age and BAC Law for Alcohol-Related Motor Vehicle Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	474	3.70	0.0027	0.05
Injury	474	7.66	<0.0001	0.05
PDO Crashes	474	7.73	<0.0001	0.05
All Crashes	474	14.40	<0.0001	0.05

Table 5-18: Interaction Effect between Driver Age and Repeal of Mandatory helmet Law in 1999

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	276	2.11	0.0997	0.05
Injury	276	1.45	0.2298	0.05
PDO	207	0.31	0.7338	0.05
All Crashes	276	2.51	0.0594	0.05

Table 5-19: Interaction Effect between Driver Age and BAC Law for Alcohol-Related Motorcycle Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	240	0.96	0.4121	0.05
Injury	240	1.32	0.2682	0.05
All Crashes	240	0.12	0.8852	0.05

Table 5-20: Interaction Effect between Driver Age and Mandatory Helmet Law of 2004

Crash	Number of Observations	F-Value	P-Value	Significance
Fatalities	156	0.34	0.7936	0.05
Injury	156	0.73	0.5373	0.05
PDO	127	0.26	0.7752	0.05
All Crashes	156	0.06	0.9822	0.05

The results from Table 5-15 show that the variable "Driver Age" was significant in influencing the young driver injury, PDO and all crash rates. There was insufficient evidence to prove that the variable was significant in influencing the young driver fatality rates with GDL law. The results from Table 5-16 and Table 5-17 show that the variable

"Driver Age" was significant in influencing the alcohol-related PDO and all crash rates with open container law, and fatal, injury, PDO and all crash rates with BAC law. There was insufficient evidence to prove that the variable was significant in influencing the alcohol-related fatality and injury crash rates with open container law. The results from Table 5-18 and Table 5-20 show that there was insufficient evidence to prove that the variable was significant in influencing the motorcycle crash rates at all severity levels with repeal and reenact of mandatory helmet laws. The results from Table 5-19 show that there was insufficient evidence to prove that the variable was significant in influencing the alcohol-related motorcycle fatality, injury and all crash rates with BAC law.

5.2.3. Occupant Age

The variable Occupant Age was categorized based on the distribution of the crash rates with the occupant age and based on logical inference. Similar characteristics within a distribution are grouped together, which reduces the error due to the averages within a group. The distributions of the Occupant age with the crash rates at different severity levels are provided in APPENDIX A. The age of different occupants for the analysis of motor vehicle crashes at all severity levels are categorized into "<5", "5-14", "15-18", "19-21", "22-25", "26-50", and ">50" groups.

A one-way ANOVA test of motor vehicle crash rates was performed between different occupant age groups for each law independently, using data under consideration, as explained in Table 5-1. This identifies the significance of the difference in the crash rates due to different occupant age groups. The results of the one-way ANOVA test for "Occupant Age" at different severity levels for each law are given in Table 5-21, Table 5-22 and Table 5-23. The results from Table 5-21 show that the variable "Occupant Age" was significant in influencing the young driver injury, PDO and all crash rates for the analysis of GDL law. The results from Table 5-22 and Table 5-23 show that the variable "Occupant Age" was significant in influencing the alcohol-related crash rates at all severity levels for the analysis of both open container and BAC laws.

Table 5-21: Significance of Occupant Age on Young Driver Crash Rates for GDL Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Injury Crashes	336	193.19	<0.0001	0.05
PDO Crashes	336	388.71	<0.0001	0.05
All Crashes	336	585.18	<0.0001	0.05

Table 5-22: Significance of Occupant Age on Alcohol-Related Crash Rates for Container Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	399	55.40	<0.0001	0.05
Injury Crashes	399	219.38	<0.0001	0.05
PDO Crashes	399	34.82	<0.0001	0.05
All Crashes	399	295.66	<0.0001	0.05

Table 5-23: Significance of Occupant Age on Alcohol-Related Crash Rates for BAC Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	553	69.13	<0.0001	0.05
Injury Crashes	553	131.48	<0.0001	0.05
PDO Crashes	553	38.32	<0.0001	0.05
All Crashes	553	176.80	<0.0001	0.05

After identifying the significance of the variable at different severity levels for different laws, a two-way ANOVA test was performed between each law and Occupant

Age by including the crash severities identified as significant from Table 5-21, Table 5-22 and Table 5-23. The interaction effect between the variable and the law tells weather the difference of the change in the crash rates due to different occupant age groups before and after the law was significant or not. It was assumed that the crash rates change proportionally to the population change in the state. The results of the interaction effect between the variable and different laws are shown in Table 5-24, Table 5-25 and Table 5-26.

Table 5-24: Interaction Effect between Occupant Age and GDL Law for Young Driver Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Injury	336	1.39	0.2168	0.05
PDO Crashes	336	4.28	0.0004	0.05
All Crashes	336	4.48	0.0002	0.05

Table 5-25: Interaction Effect between Occupant Age and Open Container Law for Alcohol-related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	399	1.09	0.3696	0.05
Injury Crashes	399	0.81	0.5604	0.05
PDO Crashes	399	3.30	0.0036	0.05
All Crashes	399	0.63	0.7079	0.05

The results from Table 5-24 show that the variable "Occupant Age" was significant in influencing young driver PDO and all crash rates with GDL law. There was insufficient evidence to prove that the variable was significant in influencing the young-

Table 5-26: Interaction Effect between Occupant Age and BAC Law for Alcohol-Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	553	0.47	0.8277	0.05
Injury Crashes	553	0.22	0.9696	0.05
PDO Crashes	553	5.65	<0.0001	0.05
All Crashes	553	1.32	0.2447	0.05

driver injury crash rates with GDL law. The results from Table 5-25 show that the variable "Occupant Age" was significant in influencing alcohol-related motor vehicle PDO crash rates, while there was insufficient evidence to prove that the variable was significant in influencing alcohol-related fatal, injury and all crash rates with open container law. Similarly, the results from Table 5-26 show that the variable "Occupant Age" was significant in influencing the alcohol-related PDO crash rates with BAC law while there was insufficient evidence to prove that the variable was significant in influencing alcohol-related fatality, injury and all crash rates with BAC law.

5.2.4. Occupant Gender

A one-way ANOVA test of motor vehicle crash rates was performed between male and female occupants for each law independently, using data under consideration, as explained in Table 5-1. This identifies the significance of the difference in the crash rates due to male and female occupants. The results of the one-way ANOVA test for "Occupant Gender" at different severity levels for each law are given in Table 5-27, Table 5-28 and Table 5-29. The results from Table 5-27 show that there was insufficient evidence to prove that the variable "Occupant Gender" was significant in influencing the young driver crash rates at all severity levels for the analysis of GDL law. The results from Table 5-28 show that the variable "Occupant Gender" was significant in influencing the alcohol-related fatal, injury, and all crash rates for the analysis of open container law while there was insufficient evidence to prove that the variable was significant in influencing the alcohol-related PDO crash rates for the analysis of open container law. The results from Table 5-29 show that the variable "Occupant Gender" was significant in influencing the alcohol-related crash rates at all severity levels for the analysis of BAC law.

Table 5-27: Significance of Occupant Gender on Young Driver Crash Rates for GDL Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	96	0.62	0.4329	0.05
Injury Crashes	96	0.04	0.8342	0.05
PDO Crashes	96	2.14	0.1469	0.05
All Crashes	96	1.34	0.2504	0.05

Table 5-28: Significance of Occupant Gender on Alcohol-Related Crash Rates for Container Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	114	34.19	<0.0001	0.05
Injury Crashes	114	110.34	<0.0001	0.05
PDO Crashes	114	1.92	0.1684	0.05
All Crashes	114	78.06	<0.0001	0.05

After identifying the significance of the variable at different severity levels for different laws, a two-way ANOVA test was performed between each law and Occupant

Table 5-29: Significance of Occupant Gender on Alcohol-Related Crash Rates for BAC Law

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	158	52.66	<0.0001	0.05
Injury Crashes	158	27.98	<0.0001	0.05
PDO Crashes	158	7.35	0.0075	0.05
All Crashes	158	46.74	<0.0001	0.05

Gender, by including the crash severities identified as significant from Table 5-27, Table 5-28 and Table 5-29. The interaction effect between the variable and the law tells whether the difference of the change in the crash rates due to male and female occupants before and after the law was significant or not. It was assumed that the crash rates change proportionally to the population change in the state. The results of the interaction effect between the variable and different laws are shown in Table 5-30 and Table 5-31.

Table 5-30: Interaction Effect between Occupant Gender and Container Law for Alcohol-Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	114	0.25	0.6173	0.05
Injury Crashes	114	0.79	0.3751	0.05
All Crashes	114	0.36	0.5471	0.05

The results from Table 5-30 and Table 5-31 show that there was insufficient evidence to prove that the variable “Occupant Gender” was significant in influencing the alcohol-related crash rates at all severity levels with open container and BAC laws.

Table 5-31: Interaction Effect between Occupant Gender and BAC Law for Alcohol-Related Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level
Fatalities	158	0.00	0.9741	0.05
Injury Crashes	158	1.19	0.2778	0.05
PDO Crashes	158	2.42	0.1217	0.05
All Crashes	158	0.01	0.9187	0.05

5.3. Identifying the Effectiveness of GDL Law

The change in the motor vehicle crash rates among drivers of 15 and 16 year-olds due to GDL Law associated with the change due to variables Driver Gender, Driver Age, Occupant Age and Occupant Gender was identified in this section. The variables that can significantly influence the young driver crash rates associated with GDL law at different severity levels are shown in Table 5-32.

Table 5-32: Variables Influencing Young Driver Crash Rates Associated with GDL Law

Variable / Crash Severity	Driver Gender	Driver Age	Occupant Age	Occupant Gender
Fatalities	NO	NO	NO	NO
Injury	NO	YES	NO	NO
PDO Crashes	NO	YES	YES	NO
All Crashes	NO	YES	YES	NO

The variables Driver Gender and Occupant Gender were not significant in influencing the young driver crash rates at all severity levels associated with the GDL law. The variable Driver Age was significant in influencing the young driver injury, PDO and all crash rates associated with GDL law, while the variable was insignificant in influencing the fatality rates. The variable Occupant Age was significant in influencing the young driver PDO and all crash rates associated with GDL law, while it was insignificant in influencing the fatality and injury crash rates. The effectiveness of GDL law in the presence of four other variables was calculated and given below in Table 5-33.

Table 5-33: Effectiveness of GDL Law on Young Driver Motor Vehicle Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	48	0.40	0.5324	0.05	Insufficient Evidence
Injury	96	36.20	<0.0001	0.05	Decreased
PDO Crashes	288	19.25	<0.0001	0.05	Decreased
All Crashes	288	53.52	<0.0001	0.05	Decreased

5.4. Identifying the Effectiveness of Open Container Law

The change in the alcohol-related motor vehicle crash rates due to open container law associated with the change due to variables Driver Gender, Driver Age, Occupant Age and Occupant Gender was identified in this section. The variables that can significantly influence the alcohol-related crash rates associated with the open container law at different severity levels are shown in Table 5-34.

The variables Driver Gender and Occupant Gender were not significant in influencing the alcohol-related crash rates at all severity levels associated with the open container law. The variable Driver Age was found to be significant in influencing the alcohol-related PDO and all crash rates, while it was found to be insignificant for fatality and injury crash rates. The variable Occupant Age was found to be significant in influencing alcohol-related PDO crash rates, while it was found to be insignificant for

Table 5-34: Variables Influencing Alcohol-Related Crash Rates Associated with Open Container Law

Variable / Crash Severity	Driver Gender	Driver Age	Occupant Age	Occupant Gender
Fatalities	NO	NO	NO	NO
Injury	NO	NO	NO	NO
PDO Crashes	NO	YES	YES	NO
All Crashes	NO	YES	NO	NO

fatal, injury and all crash rates. The effectiveness of open container law in the presence of four other variables was calculated and given below in Table 5-35.

Table 5-35: Effectiveness of Open Container Law on Alcohol-Related Motor Vehicle Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	57	1.07	0.3057	0.05	Insufficient Evidence
Injury	57	0.53	0.4710	0.05	Insufficient Evidence
All Crashes	342	1.70	0.1929	0.05	Insufficient Evidence

5.5. Identifying the Effectiveness of the BAC Law

The change in the alcohol-related crash rates due to reduction of per se BAC from 0.1 percent to 0.08 percent associated with the change due to variables Driver Gender, Driver Age, Occupant Age and Occupant Gender was identified in this section.

5.5.1. Motor Vehicle Crash Rates

The variables that can significantly influence the alcohol-related motor vehicle crash rates associated with the reduction of per se BAC from 0.1 percent to 0.08 percent at different severity levels are shown below in Table 5-36.

Table 5-36: Variables Influencing Alcohol-Related Crash Rates Associated with BAC Law

Variable / Crash Severity	Driver Gender	Driver Age	Occupant Age	Occupant Gender
Fatalities	NO	YES	NO	NO
Injury	YES	YES	NO	NO
PDO Crashes	YES	YES	YES	NO
All Crashes	YES	YES	NO	NO

The variable Occupant Gender was not significant in influencing the alcohol-related crash rates at all severity levels associated with BAC law. The variable Driver Gender was significant in influencing the alcohol-related injury, PDO and all crash rates associated with the BAC law, while there was insufficient evidence to prove that the variable was significant in influencing the fatality rates. The variable Driver Age was significant in influencing the alcohol-related crash rates at all severity levels associated with the BAC law. The variable Occupant Age was significant in influencing the PDO crash rates with BAC law, while the variable was not significant in influencing the fatality, injury and all crash rates. The effectiveness of the reduction of per se BAC from 0.1 percent to 0.08 percent in reducing the alcohol-related crash rates in the presence of four other variables was calculated and given below in Table 5-37.

5.5.2. Motorcycle Crash Rates

The following table shows the significance of the variable Driver Age on alcohol-related motorcycle crash rates associated with the reduction of per se BAC from 0.1 percent to 0.08 percent at different severity levels.

Table 5-37: Effectiveness of BAC Law on Alcohol-Related Motor Vehicle Crash Rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	474	0.52	0.4714	0.05	Insufficient Evidence
Injury Crashes	474	9.72	0.0019	0.05	Decreased
PDO Crashes	1422	5.22	0.0225	0.05	Decreased
All Crashes	474	44.71	<0.0001	0.05	Decreased

Table 5-38: Driver Age Variable Influencing Alcohol-Related Motorcycle Crash Rates with BAC Law

Variable / Crash Severity	Driver Age
Fatalities	NO
Injury	NO
PDO Crashes	NO
All Crashes	NO

The variable Driver Age was not significant in influencing the alcohol-related crash rates at all severity levels with the reduction of per se BAC from 0.1 percent to 0.08 percent. The effectiveness of BAC law in influencing the alcohol-related motorcycle crash rates was given in Table 5-39.

5.6. Identifying the Effectiveness of the Mandatory Helmet Laws

The change in the motorcycle crash rates due to repeal of mandatory helmet laws associated with the change due to variable Driver Age was identified in this section.

Table 5-39: Effectiveness of BAC Law on Alcohol-Related Motorcycle Crash rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	60	0.59	0.4468	0.05	Insufficient Evidence
Injury	60	3.96	0.0500	0.05	Decreased
PDO Crashes	60	1.03	0.3143	0.05	Insufficient Evidence
All Crashes	60	1.48	0.2284	0.05	Insufficient Evidence

5.6.1. Repeal of Mandatory Helmet Law (1999)

The different crash severities of the variable "Driver Age" that can significantly influence the motorcycle crash rates associated with the repeal of mandatory helmet law in 1999 are given in Table 5-40.

Table 5-40: Driver Age Variable Influencing Motorcycle Crash rates with Helmet Law (1999)

Variable / Crash Severity	Driver Age
Fatalities	NO
Injury	NO
PDO Crashes	NO
All Crashes	NO

The variable Driver Age was not significant in influencing motorcycle crash rates associated with the repeal of mandatory helmet law in 1999 at all severity levels. The effectiveness of the repeal of mandatory helmet law in 1999 in influencing the motorcycle crash rates was given in Table 5-41.

Table 5-41: Effectiveness of Helmet Law (1999) on Motorcycle Crash rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	57	1.33	0.2536	0.05	Insufficient Evidence
Injury Crashes	57	1.96	0.1672	0.05	Insufficient Evidence
PDO Crashes	57	0.69	0.4083	0.05	Insufficient Evidence
All Crashes	57	1.19	0.2798	0.05	Insufficient Evidence

5.6.2. Reenacting Mandatory Helmet Law in 2004

The different crash severities of variable "Driver Age" that can significantly influence the motorcycle crash rates associated with the reenact of mandatory helmet law in 2004 are given in Table 5-42.

Table 5-42: Driver Age Variable Influencing Motorcycle Crash rates with Helmet Law (2004)

Variable / Crash Severity	Driver Age
Fatalities	NO
Injury	NO
PDO Crashes	NO
All Crashes	NO

The variable "Driver Age" was not significant in influencing motorcycle crash rates with the mandatory helmet law of 2004 at all severity levels. The effectiveness of reenacting the mandatory helmet law in 2004 in influencing the motorcycle crash rates was given in Table 5-43.

Table 5-43: Effectiveness of Helmet Law (2004) on Motorcycle Crash rates

Crash Severity	Number of Observations	F-Value	P-Value	Significance Level	Change in Crash Rates
Fatalities	39	0.46	0.5021	0.05	Insufficient Evidence
Injury Crashes	39	0.01	0.9376	0.05	Insufficient Evidence
PDO Crashes	39	0.05	0.8179	0.05	Insufficient Evidence
All Crashes	39	0.00	0.9764	0.05	Insufficient Evidence

6. SUMMARY AND CONCLUSIONS

6.1. Study Summary

The study presented a methodology to identify the effectiveness of traffic laws in the presence of other variables which can also influence crash rates along with the legislation. The analysis used the crash data for twelve years (1995-2006), obtained from LADOTD and HSRG. The initial selection of variables that are likely to influence the crash rates over time, and thereby impact any before-and-after study, were identified from the database based on logical reasoning. The final variables for the analysis were confirmed by an initial analysis of the data. Each such identified variable was divided into two or more categories, and the crashes within each category were identified using Microsoft Access 2003 and SQL Queries. The crash rates for each such identified variable were calculated based on the population statistics, such as registered motor vehicles, licensed drivers in the state, total population of the state, etc.

A one-way ANOVA test was performed for each variable between its categories for each law independently, and the significance of the difference in the crash rates due to different categories was identified. After identifying the variable as significant in influencing crash rates, a two-way ANOVA test was performed by including the legislation as an additional variable. The interaction effect between the variable and the law tells whether the difference of the change in the crash rates due to different categories before and after the law is significant or not. If the null hypothesis was rejected in both the tests, it was concluded that the variable influenced the crash rates along with the legislation, and the presence of the variable was included in identifying the effectiveness of the legislation. The effectiveness of each law was identified using ANOVA, in the presence of all variables identified as significant in influencing crash rates.

6.2. Conclusions

The study assessed the safety impact of five major laws amended or introduced in the state between 1998 and 2004.

The GDL law was found to be effective in decreasing the motor vehicle injury, PDO and all crash rates among 15 and 16 year-old drivers. There was insufficient evidence at the 5 percent significance level to conclude that the law had an influence on motor vehicle fatality rates among 15 and 16 year-old drivers.

The open container law was found to have no significant impact at 5 percent significance level on alcohol-related motor vehicle crash rates at all severity levels. More accurate results might be obtained by using regression analysis to identify the difference of the predicted crash rates and observed crash rates as explained in Section 6.3.

The reduction of per se BAC from 0.1 percent to 0.08 percent was effective in decreasing the alcohol-related motor vehicle injury, PDO and all crash rates. There was insufficient evidence at 5 percent significance level to prove that the reduction of per se BAC from 0.1 percent to 0.08 percent had an influence on the alcohol-related motor vehicle fatality rates. The law was also effective in decreasing the alcohol-related motorcycle injury crash rates. There was insufficient evidence at the 5 percent significance level to prove that the law was effective in influencing the alcohol-related motorcycle fatality, PDO and all crash rates.

The impact of the repeal of mandatory helmet law in 1999 and reenactment of the mandatory helmet law in 2004 was not found to be significant using the available data. There was insufficient evidence to prove that motorcycle helmet laws had an impact in decreasing the motorcycle crash rates at all severity levels. More accurate results might be obtained by eliminating the seasonal impact on motorcycle crash rates as explained in Section 6.3.

6.3. Future Research

Future research can be conducted using the following procedures, which can also provide accurate results.

- The actual reduction in the crash rates due to the introduction or amendment of a traffic law is the difference of the crash rates in the after period, if the law was not applied, and the actual observed crash rates in the after period. Identifying the difference of the predicted and observed crash rates in the after period of a law will eliminate the influence of extraneous factors, which can not be identified directly from the data. The crash rates in the after period of a law, if the law was not applied can be predicted using regression analysis. The model developed to predict crash rates should include all the possible factors from the data that can significantly influence crash rates along with the traffic law. For example, amount of travel (VMT), time, driver age, driver gender, occupant age and occupant gender can influence the crash rates along with the traffic law. The difference of the predicted crash rates and the observed crash rates will provide the actual reduction in the crash rates due to the introduction or amendment of a traffic law.
- The seasonal effect influencing the motorcycle crash rates can be eliminated by conducting the analysis on the difference of the crash rates before and after the law for the same time period. For example, the difference of the crash rates for the month of July before the law and for the month of July after the law will eliminate the increase of the motorcycle crash rates due to peak summer travel. Similarly, the difference of the crash rates for the month of December before the law and for

the month of December after the law will eliminate the sudden decrease in the crash rates due to the low motorcycle travel of winter.

REFERENCES

Auman, K.M., Kufera, J.A., Ballesteros, MF, Smialek, J.E., and Dischinger, P.C. 2002. “Autopsy Study of Motorcyclist Fatalities: The Effect of the 1992 Maryland Motorcycle Helmet Use Law”, American Journal of Public Health 92(8): 1352-1355.

Bledsoe, G. H. and G. Li (2005). "Trends in Arkansas Motorcycle Trauma After Helmet Law Repeal." Southern Medical Journal **98**(4): 436-440.

Champagne, J.E. and Schneider, H. “Highlights of the 2004 Louisiana Traffic Records Data Report.” Department of Information Systems and Decision Sciences, Louisiana State University, 2005.

Diamantopolou, K., Skalova, MK., and Cameron, M. “ Causality Crash Risks for Motorcycle Riders in Victoria: 1994” March 1996, Monash University Accident Research Center. Report No. 90.

Foss, R.D., Feaganes, J.R, and Rodgman, E.A. 2001. Initial Effects of Graduated Driver Licensing on 16-Year-Old Driver Crashes in North Carolina. Journal of the American Medical Association 286, No. 13: 1588-1592.

Gorman, D.M., Huber, J.C. and Carozza, S.E. “Evaluation of the Texas 0.08 BAC Law”, Alcohol and Alcoholism 2006 41(2):193-199; doi:10.1093/alcalc/agh253.

Hartling L, Wiebe N, Russel K, Petruk J, Spinola C, Klassen TP. Graduated Driver Licensing for Reducing Motor Vehicle Crashes Among Young Drivers. *Cochrane Database of Systematic Reviews* 2004, Issue 2. Art No: CD003300. DOI: 10.1002/14651858.CD003300.Pub2.

Haselton, C.B., Gibby, A.R., Ferrara, T.C. and Khorashadi, A. “Methodologies Used to Analyze Collision Experience Associated with Speed Limit Changes on Selected California Highways”. TRB 2002 Annual Meeting, National Research Council, Washington, D.C, 2002.

Masten, S.V. and Hagge, R.A. 2003. Evaluation of California’s graduated driver licensing program. Report No. 205. Sacramento, CA: California Department of Motor Vehicles.

Motorcycle Helmet Use Laws, April 2004, Traffic Safety Facts, http://www.nhtsa.dot.gov/people/injury/new-fact-sheet03/MotorcycleHelmet.pdf. Date Accessed: 06/28/2007.

Muelleman, R. L., E. J. Mlinek, et al. (1992). "Motorcycle crash injuries and costs: effect of a reenacted comprehensive helmet use law." Annals of Emergency Medicine **21**: 266-272.

Open Container Laws and Alcohol Involved Crashes, April 2002, National Highway Traffic Safety Administration, http://www.nhtsa.dot.gov/people/injury/research/OpenContainer/open_container_criteria.htm. Date Accessed: 06/28/2007.

Road and Traffic Related Injuries: Risk Factors, Charles Sturt University, 1998, http://hsc.csu.edu.au/pdhpe/core1/improving/3-2/3-2-3/riskfactors.html. Date Accessed: 08/25/2007.

Schneider, H. 2006. The Effectiveness of Motorcycle Helmets and Mandatory Helmet Laws. Louisiana Highway Safety Research Group, Louisiana State University, BatonRouge.

Shope, J.T., Molnar, L.J., Elliot, M.R., and Waller, P.F. 2001. Graduated Driver Licensing in Michigan: Early Impact on Motor Vehicle Crashes Among 16-year-old Drivers. Journal of the American Medical Association 286, No. 13: 1593-1598.

Solomon, D. "Accidents on Main Rural Highways Related to Speed, Driver, and Vehicle," Federal Highway Administration, Washington, DC, July 1964.

Sosin, D.M., Sacks, J.J. and Holmgreen, P. (1990). "Head-injury-associated deaths from motorcycle crashes: relationship to helmet-use laws." Journal of the American Medical Association Vol 264 No:18: 2395-2399.

Stuster, J., Burns, M., and Fiorentino, D. "Open Container Laws and Alcohol Involved Crashes: Some Preliminary Data", for National Highway Traffic Safety Administration, Report no: DOT HS 809 426, April, 2002

Traffic Safety Facts 2005, NHTSA, http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2005/OverviewTSF05.pdf Date Accessed: 01/12/2007.

Ulmer, R.G., Preusser, D.F., Williams, A.F., Ferguson, S.A., and Farmer, C.M. 2000. Effect of Florida's Graduated Licensing Program on the Crash Rate of Teenage Drivers. Accident Analysis and Prevention 32, 527-532.

Washington, S., Leonard, J., Manning, D.G., Roberts, C., Williams, B., Bacchus, A.R., Devanhalli, A., Ogle, J. and Melcher, D. "Scientific Approach to Transportation Research", for National Cooperative Highway Research Program 20 45, Vol 1 and 2.

Yuan, F., Ivan, J., Garric, N. and Davis, C. Estimating Benefits from Specific Highway Safety Improvement: Phase II Safety Benefits of Intersection Approach Realignment. For the Joint Highway Research Advisory Council (JHRAC) of Connecticut Department of Transportation, December 2000.

APPENDIX A

MOTOR VEHICLE CRASHES

SQL Queries

For Each year of Motor vehicle crashes at Different Severity Levels due to driver age

```
SELECT distinct crash_tb.CRASH_NUM, crash_tb.CRASH_DATE,
crash_tb.NUM_PED_KIL, crash_tb.NUM_OCC_INJ, vehic_tb.CRASH_NUM,
vehic_tb.DR_AGE, 1 AS Expr1
FROM crash_tb INNER JOIN vehic_tb ON crash_tb.CRASH_NUM =
vehic_tb.CRASH_NUM;
```

For Each year of Motor vehicle crashes at Different Severity Levels due to Driver Gender

```
SELECT distinct crash_tb.CRASH_NUM, crash_tb.CRASH_DATE,
crash_tb.NUM_TOT_INJ, crash_tb.NUM_TOT_KIL, vehic_tb.CRASH_NUM,
vehic_tb.DR_SEX, 1 AS Expr1
FROM crash_tb INNER JOIN vehic_tb ON crash_tb.CRASH_NUM =
vehic_tb.CRASH_NUM;
```

For Each year of Motor vehicle crashes at Different Severity Levels due to Occupant Age

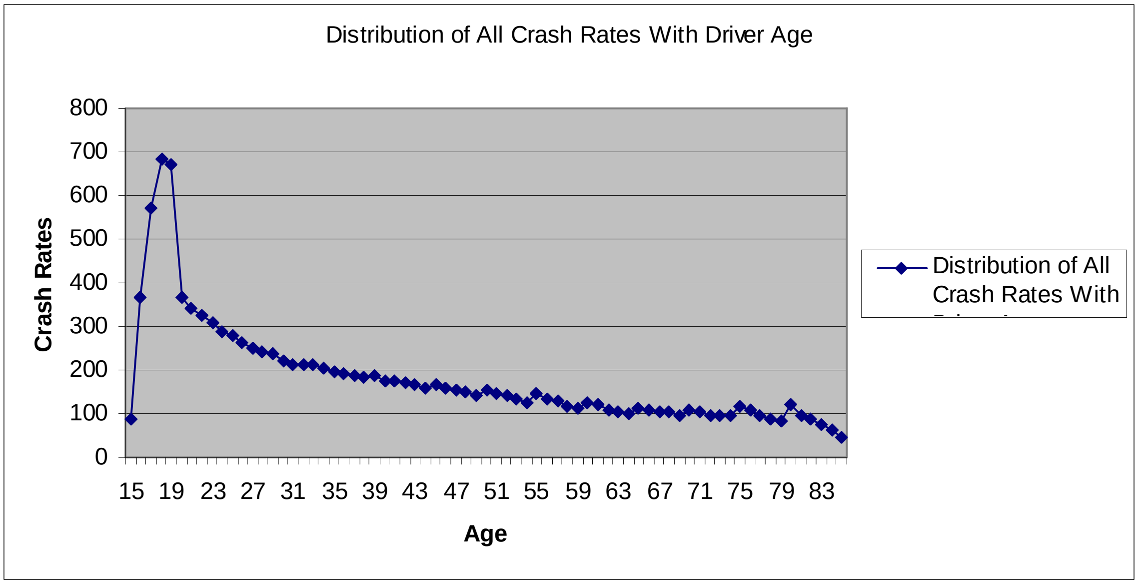
```
SELECT DISTINCT crash_tb.CRASH_NUM, crash_tb.CRASH_DATE,
crash_tb.NUM_TOT_INJ, crash_tb.NUM_TOT_KIL, occup_tb.CRASH_NUM,
occup_tb.OCC_AGE, 1 AS Expr1
FROM crash_tb INNER JOIN occup_tb ON crash_tb.CRASH_NUM =
occup_tb.CRASH_NUM;
```

For Each year of Motor vehicle crashes at Different Severity Levels due to Occupant Gender

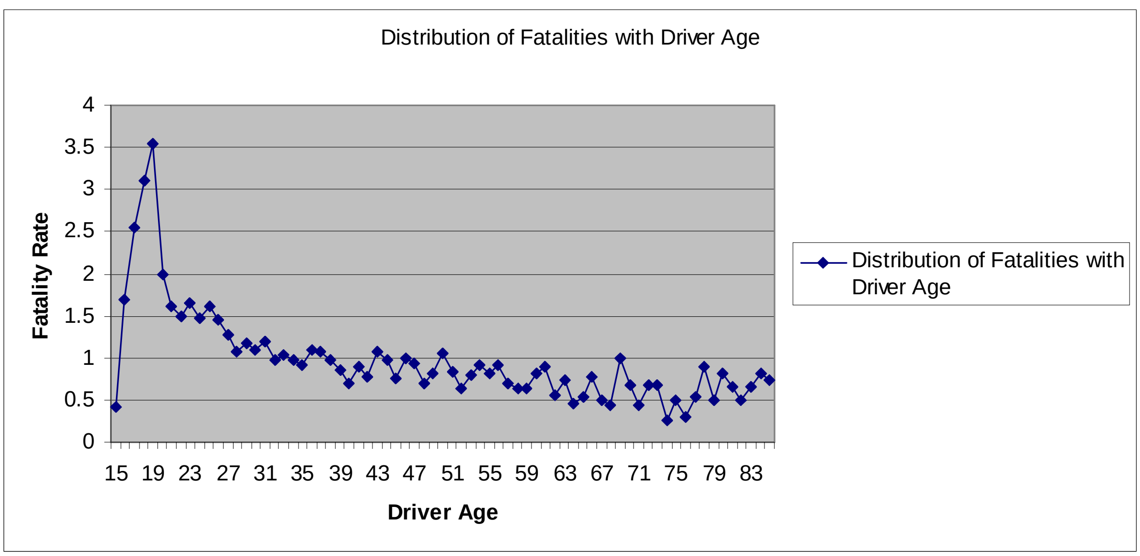
```
SELECT DISTINCT crash_tb.CRASH_NUM, crash_tb.CRASH_DATE,
crash_tb.NUM_TOT_INJ, crash_tb.NUM_TOT_KIL, occup_tb.CRASH_NUM,
occup_tb.OCC_SEX, 1 AS Expr1
FROM crash_tb INNER JOIN occup_tb ON crash_tb.CRASH_NUM =
occup_tb.CRASH_NUM;
```

Distribution of Motor Vehicle Crash Rates with Driver Age at Different Severity Levels

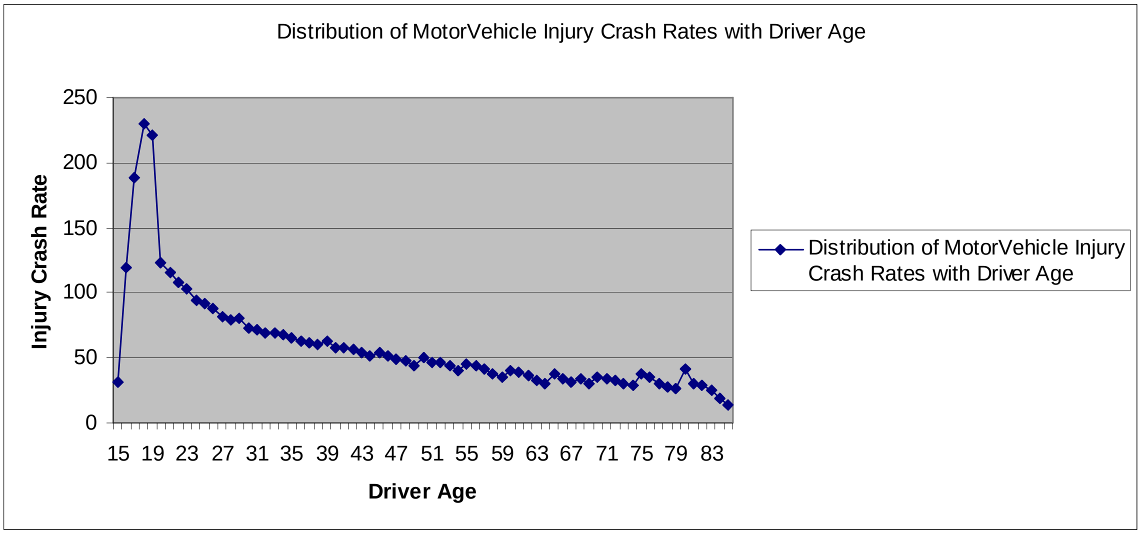
Distribution of Motor Vehicle Crash Rates with Driver Age



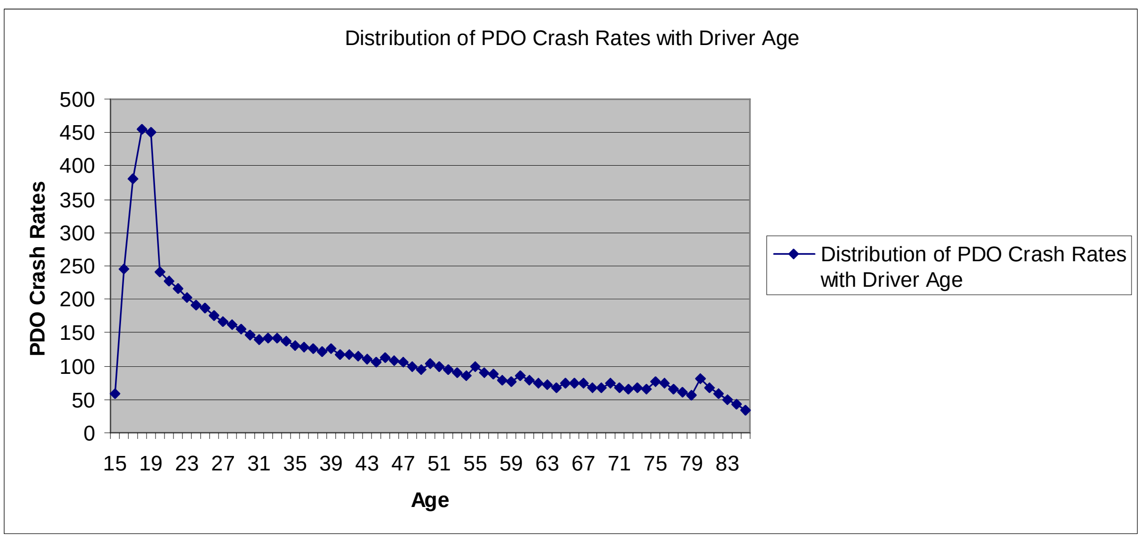
Distribution of Motor Vehicle Fatalities with Driver Age



Distribution of Motor Vehicle Injury Crash Rates with Driver Age

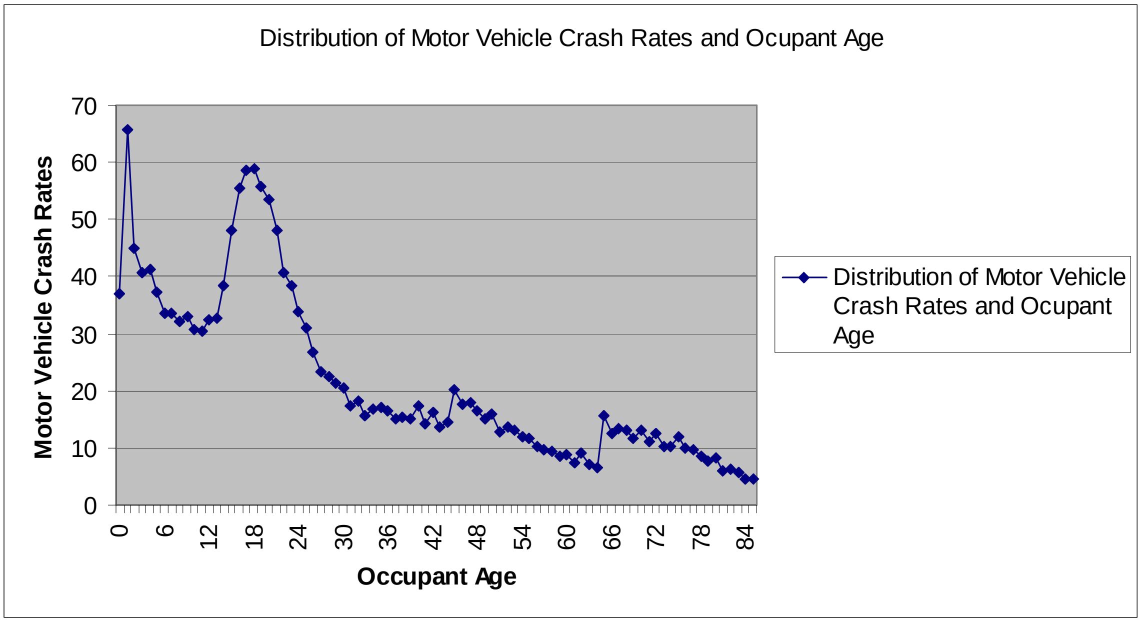


Distribution of Motor Vehicle PDO Crash Rates with Driver Age

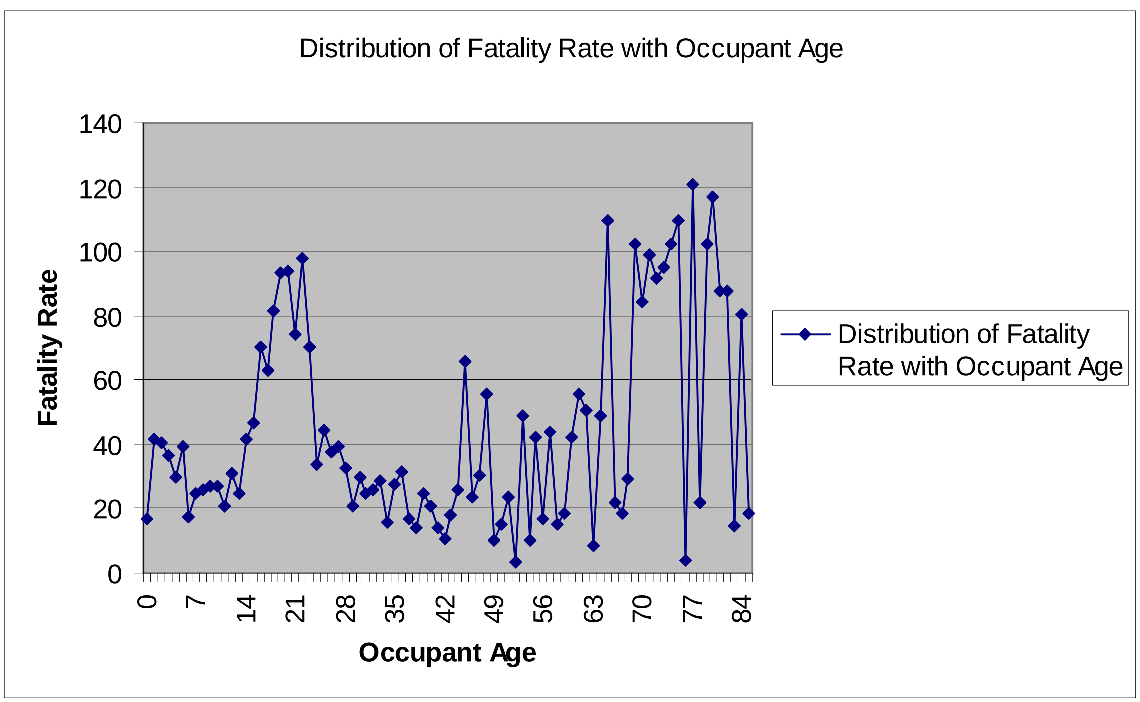


Distribution of Motor Vehicle Crash Rates with Occupant Age at Different Severity Levels

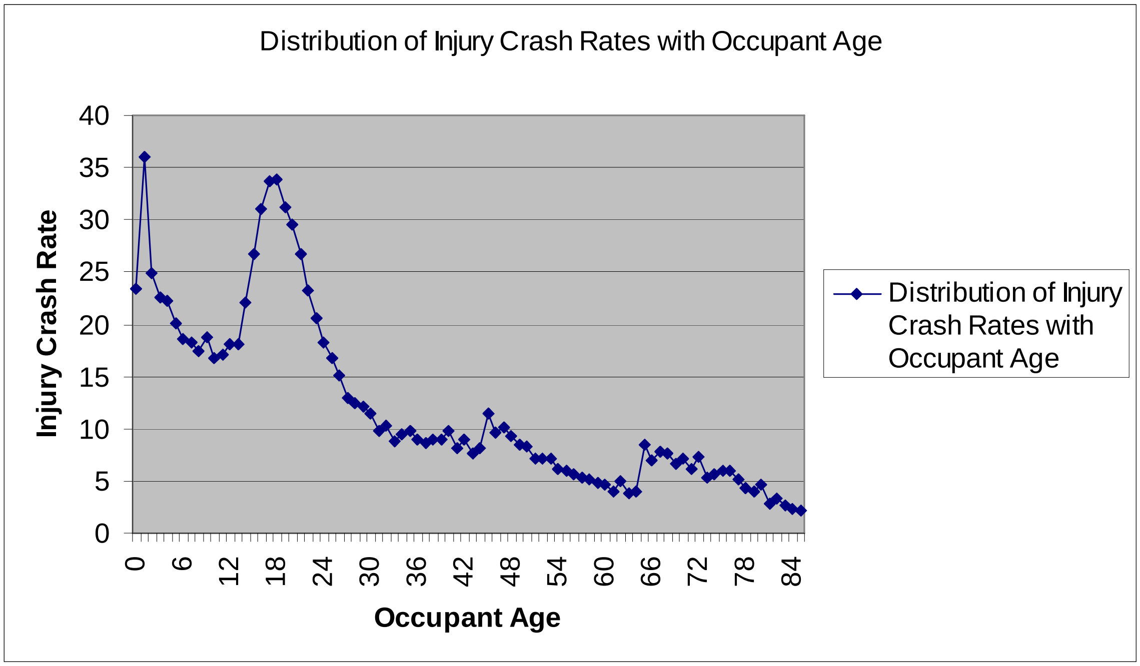
Distribution of Motor Vehicle Crash Rates with Occupant Age



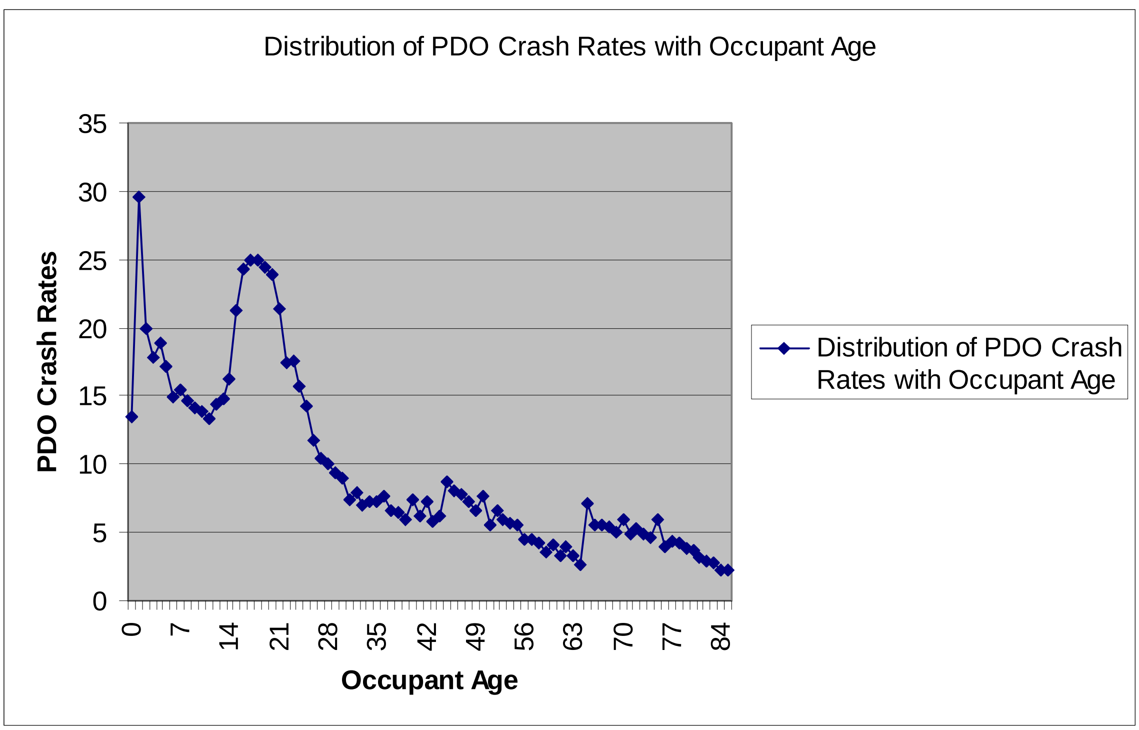
Distribution of Motor Vehicle Fatality Rates with Occupant Age



Distribution of Motor Vehicle Injury Crash Rates with Occupant Age



Distribution of Motor Vehicle PDO Crash Rates with Occupant Age



APPENDIX B

MOTORCYCLE CRASHES

SQL Queries

For Each year of Motorcycle crashes between the years 1995 and 1998

```
SELECT crash_tb.CRASH_NUM, crash_tb.CRASH_DATE, crash_tb.NUM_TOT_INJ,
crash_tb.NUM_TOT_KIL, vehic_tb.CRASH_NUM, vehic_tb.DR_AGE,
vehic_tb.DR_SAFETY_DEVICE, vehic_tb.VEH_TYPE_CD, 1 AS Expr1 FROM
crash_tb INNER JOIN vehic_tb ON crash_tb.CRASH_NUM = vehic_tb.CRASH_NUM
WHERE (((vehic_tb.VEH_TYPE_CD)="I" Or (vehic_tb.VEH_TYPE_CD)="J"));
```

For Each year of Motorcycle crashes between the years 1999 and 2006

```
SELECT CRASH_TB.CRASH_NUM, CRASH_TB.CRASH_DATE,
CRASH_TB.NUM_TOT_INJ, CRASH_TB.NUM_TOT_KIL,
VEHIC_TB.CRASH_NUM, VEHIC_TB.DR_AGE, VEHIC_TB.DR_PROTSYS_CD,
VEHIC_TB.VEH_TYPE_CD, 1 AS Expr1 FROM CRASH_TB INNER JOIN
VEHIC_TB ON CRASH_TB.CRASH_NUM = VEHIC_TB.CRASH_NUM WHERE
(((VEHIC_TB.VEH_TYPE_CD)="E"));
```

For Combining Motorcycle crashes of all years between the 1995 and 2006

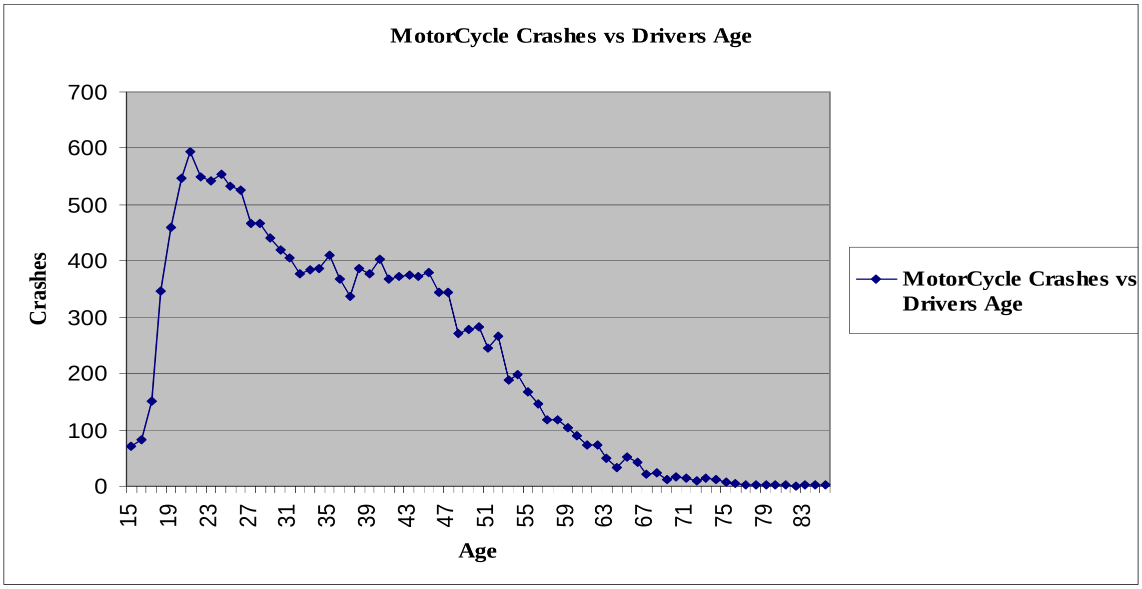
```
Select * from ForMotorCycleCrashes1995
Union All
Select * from ForMotorCycleCrashes1996
Union All
Select * from ForMotorCycleCrashes1997
Union All
Select * from ForMotorCycleCrashes1998
Union All
Select * from ForMotorCycleCrashes1999
Union All
Select * from ForMotorCycleCrashes2000
Union All
Select * from ForMotorCycleCrashes2001
Union All
Select * from ForMotorCycleCrashes2002
Union All
Select * from ForMotorCycleCrashes2003
Union All
Select * from ForMotorCycleCrashes2004
Union All
Select * from ForMotorCycleCrashes2005
UNION ALL Select * from ForMotorCycleCrashes2006;
```

For Motorcycle crashes of all years between different age groups

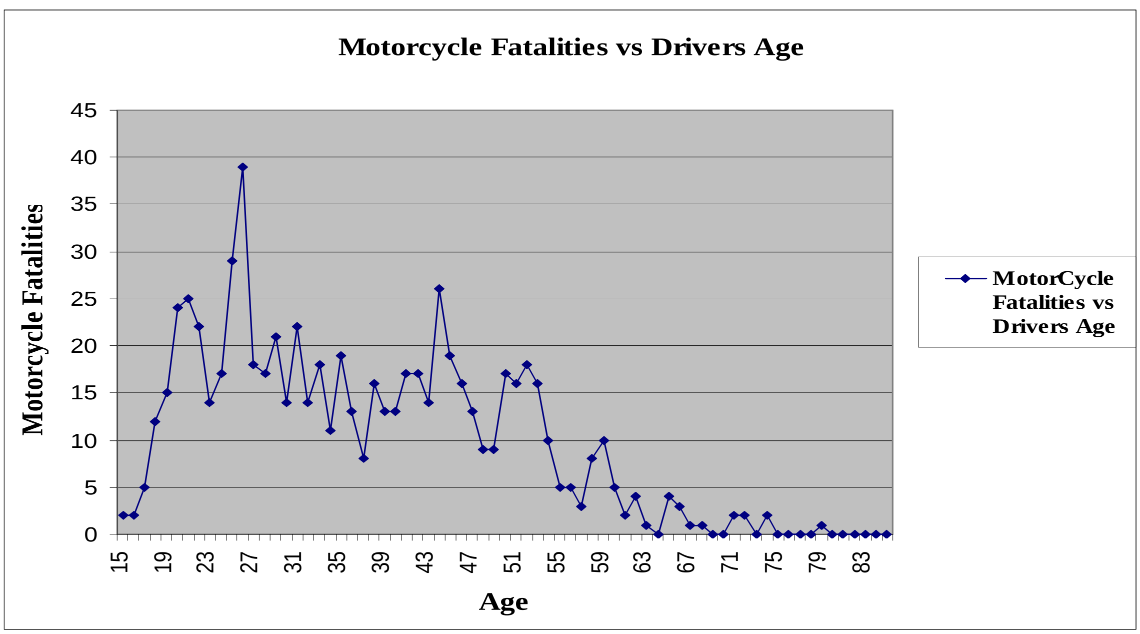
```
SELECT [ForMotorCycleCrashes*(AllYears)].crash_tb_CRASH_NUM,
[ForMotorCycleCrashes*(AllYears)].CRASH_DATE,
[ForMotorCycleCrashes*(AllYears)].NUM_TOT_INJ,
[ForMotorCycleCrashes*(AllYears)].NUM_TOT_KIL,
[ForMotorCycleCrashes*(AllYears)].DR_AGE,
[ForMotorCycleCrashes*(AllYears)].Expr1 FROM [ForMotorCycleCrashes*(AllYears)]
WHERE ((([ForMotorCycleCrashes*(AllYears)].DR_AGE) Between 15 And 21));

WHERE ((([ForMotorCycleCrashes*(AllYears)].DR_AGE) Between 22 And 45));

WHERE ((([ForMotorCycleCrashes*(AllYears)].DR_AGE) Between 46 And 64));

WHERE ((([ForMotorCycleCrashes*(AllYears)].DR_AGE) Between 65 And 85));

SELECT distinct Query8.crash_tb_CRASH_NUM, Query8.CRASH_DATE,
Query8.NUM_TOT_INJ, Query8.NUM_TOT_KIL, Query8.Expr1
FROM Query8;
```

Distribution of Motorcycle Crashes with Driver Age at Different Severity Levels

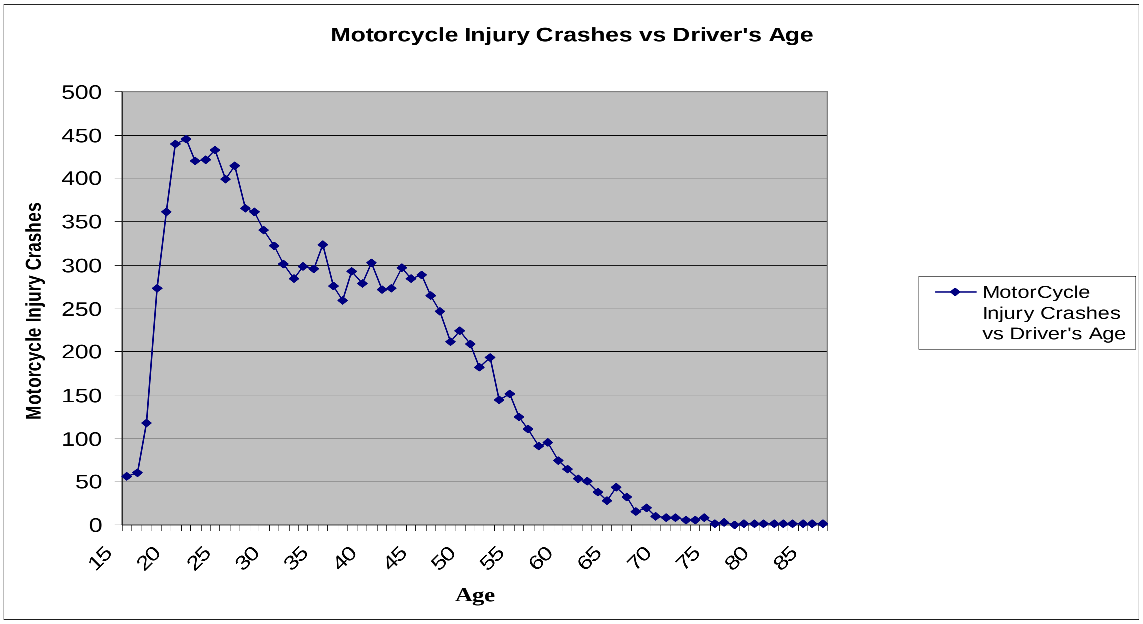
Distribution of Motorcycle Crashes with Driver Age



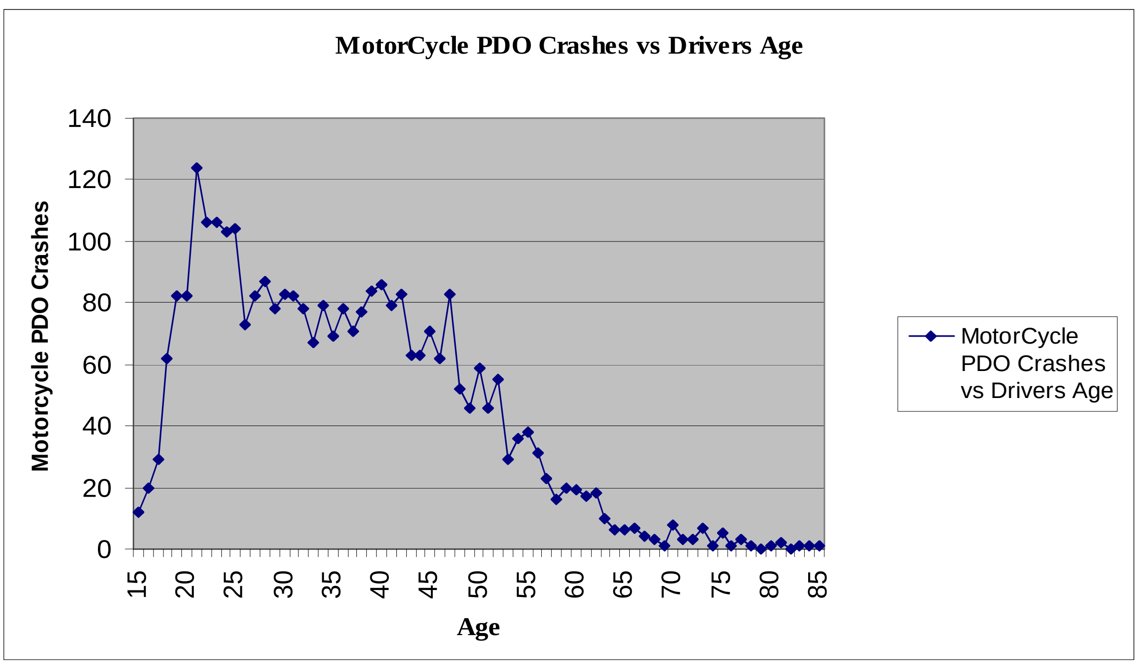
Distribution of Motorcycle Fatalities with Driver Age



Distribution of Motorcycle Injury Crashes with Driver Age



Distribution of Motorcycle PDO Crashes with Driver Age



VITA

Vamshi Krishna Mudumba was born in the year 1982, in the beautiful city of Hyderabad. He completed his high school from V.D. Prasad Rao Memorial High School. He obtained his Bachelor of Engineering degree from Vasavi College of Engineering, Osmania University, in June 2004, and later worked as an assistant engineer for a construction company in Hyderabad, India. He joined Louisiana State University, Baton Rouge, in August 2005, where he will receive his degree of Master of Science in Civil Engineering in May 2008.