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EXPLORING THE METHODS TO INCREASE SEAT BELT USAGE IN KANSAS

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16 Abstract

Seat belt usage has frequently been identified as one of the most effective ways of improving highway safety and considered to be particularly useful in reducing fatalities. However, the state of Kansas experiences considerably lower safety belt usage rates compared to many other states and the national average. The Kansas Department of Transportation and other involved parties are interested in improving the usage rates and thereby improve safety of road users in Kansas. Accordingly, the main objective of this study was to explore the methods to increase seat belt usage in Kansas with the intention of reducing huge economic losses to the state in the form of traffic crashes. This objective was achieved by two parallel approaches: (1) By identifying the factors that affect safety belt usage in Kansas so that more effective programs could be developed. (2) By gathering information on attitudes, perceptions, understanding and other related characteristics of Kansans in relation to safety belt use. During the first approach, statistical models were developed to predict state seat belt usage rates based on factors that include demographic characteristics, socio-economic factors and policies/regulations. To supplement this, statistical models predicting traffic fatalities and unrestrained vehicle occupant fatalities as a function of seat belt law and other characteristics mentioned previously were also developed. These models could be used to quantify the effects of enforcing primary seat belt law in saving lives in Kansas. During the second approach, focus group surveys were conducted among Kansans to identify more direct human factor related issues and seat belt usage in Kansas.

Focus group surveys of Kansas drivers were a real eye opener, indicating very low understanding regarding the seat belt law, where lower income groups, younger drivers, and minority groups particularly lagged. Stated belt use behavior revealed that females versus males, van users versus pick-up truck drivers, older drivers versus young drivers, non-Hispanics versus Hispanics are more likely to use seat belts. Reasons for non-use included absence of factors which positively affect the decision, types of trips. Even though some of these factors are beyond control, other findings indicate that a considerable percentage of drivers suggest stricter laws and other punishments to improve their own safety, perhaps because they are not able to maintain a high level of self-discipline by themselves.

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PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

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ABSTRACT

Seat belt usage has frequently been identified as one of the most effective ways of improving highway safety and considered to be particularly useful in reducing fatalities. However, the state of Kansas experiences considerably lower safety belt usage rates compared to many other states and the national average. The Kansas Department of Transportation and other involved parties are interested in improving the usage rates and thereby improve safety of road users in Kansas. Accordingly, the main objective of this study was to explore the methods to increase seat belt usage in Kansas with the intention of reducing huge economic losses to the state in the form of traffic crashes. This objective was achieved by two parallel approaches: (1) By identifying the factors that affect safety belt usage in Kansas so that more effective programs could be developed. (2) By gathering information on attitudes, perceptions, understanding and other related characteristics of Kansans in relation to safety belt use. During the first, approach statistical models were developed to predict state seat belt usage rates based on factors that include demographic characteristics, socio-economic factors and policies/regulations. To supplement this, statistical models predicting traffic fatalities and unrestrained vehicle occupant fatalities as a function of seat belt law and other characteristics mentioned previously were also developed. These models could be used to quantify the effects of enforcing primary seat belt law in saving lives in Kansas. During the second approach, focus group surveys were conducted among Kansans to identify more direct human factor related issues and seat belts usage in Kansas.

Findings of this research suggest switching to primary seat belt law as the single most effective way of increasing seat belt usage rate in Kansas, where it could be

expected to go up by 11.5%. The second most effective actions toward increasing the usage rate would be to increase the penalty for seat belt law violation. A $10 increase in penalty could raise the usage rate by 4.8 %. Additionally, increased interstate mileage, fuel tax, crime rate, and median household income tend to increase the usage rate. Higher percentages of African American population and rural highway mileage tend to decrease the usage rate in a state, and could be identified as needing focused attention. Unrestrained Occupant Fatality and Fatality Rate models also identified the seat belt law as the most crucial measure in saving lives while other important factors included median household income, ethnicity, young drivers, BAC law, unemployment level, maximum speed limit law, and mean travel time.

Focus group surveys of Kansas drivers was a real eye opener, which indicated very low understanding regarding the seat belt law, where lower income groups, younger drivers, and minority groups particularly lagged. Stated belt use behavior revealed that females vs. males, van users vs. pick-up truck drivers, older drivers vs. young drivers, non-Hispanics vs. Hispanics are more likely to use seat belts. Reasons for non-use, factors positively affecting the decision, types of trips and roads belt use are more likely, and factors that could motivate the use were also identified. Even though some of these factors are beyond control, other findings indicate that considerable percentage of drivers suggest stricter laws and other punishments to improve their own safety, perhaps because they are not able to maintain high level of self-discipline by themselves.

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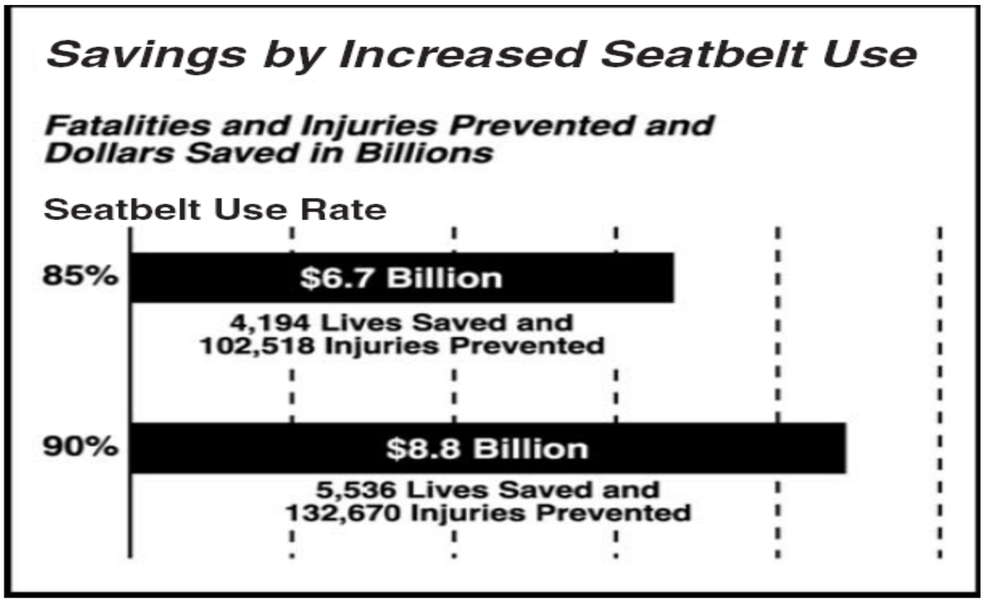
CHAPTER ONE - INTRODUCTION

1.1 BACKGROUND

Motor vehicle travel is the primary means of transportation in the United States, providing an unprecedented degree of mobility. Even though motor vehicle transportation has a lot of advantages, traffic fatalities are one of the leading causes of death in the United States. In 2003, 42,643 people lost their lives in motor vehicle crashes, which converts to an average of 117 lives per day or one life every 12 minutes (NHTSA, 2004). Statistics show that 87 percent of these fatalities involved vehicle occupants while the remaining 13 percent involved pedestrians, bicyclists and other non-occupants. Additionally, each year there are millions of unintentional injuries due to automobile crashes. Various factors like non-use of safety belts, driving under the influence of alcohol, speeding, lack of attention, failure to yield etc. among many others might be contributing to these fatalities and injuries.

It has been estimated that safety belts saved 179,756 lives from 1975 to 2003. If all passenger vehicle occupants over age of 4 years wore safety belts, 20,984 lives (an additional 6,081 lives) could have been saved in 2003 alone (NHTSA, 2004). Figure 1.1 shows an estimated savings in life and associated economic impact, if national seat belt use were to increase to 85 percent and 90 percent respectively. Previous research has found that usage of lap/shoulder safety belts reduce the risk of fatal injury to front-seat passenger car occupants by 45 percent and the risk of moderate-to-critical injury by 50 percent. For light truck occupants, safety belts reduce the risk of fatal injury by 60 percent and moderate-to-critical injury by 65 percent (NHTSA, 2004). When considering fatal crashes in 2003, 74 percent of passenger vehicle occupants who were ejected from the vehicle were fatally injured. Safety belts are effective in preventing total ejections: only one percent of the occupants reported to have been using restraints were totally ejected, compared with 29 percent of the unrestrained occupants (NHTSA, 2003)



(Source – NCHRP Report 500)

Figure 1.1: Expected Savings due to Increased Seat Belt Usage in US

Even though the effectiveness of seat belts is widely known and accepted, seat belt use remains low in the United States compared to Australia, Canada and some Northern European countries, which have average usage rates above 90 percent. Seat belt use rates in US vary from state to state reflecting the public attitude, seat belt laws, enforcement practices, legal provisions, education programs etc (Balci et al, 2001).

In the United States, mandatory seat belt law was first enacted in New York in 1984. Lund et al (1987) found a 9 percent decline in traffic fatalities in the first 9 months when New York enacted mandatory seat belt law. By 1996 all states except New Hampshire had enacted mandatory seat belt laws, which consist of two categories i.e.

Primary Seat Belt Law and Secondary Seat Belt Law. Primary law has more power and allows police officers to stop and cite motorists solely for not wearing seat belts. However, under the secondary law, police officers can penalize motorists for not wearing seat belts only if they are stopped for some other traffic infraction. As of 2003, twenty states plus District of Columbia had primary seat belt law and thirty states had secondary seat belt law. New Hampshire is the only state where adults are legally not obliged to wear seat belts. Table 1.1 compares seat belt usage rates among states with primary and secondary seat belt law. General effectiveness of primary seat belt law in increasing seat belt usage is evident from the fact that average seat belt usage rate for states with primary law is 84 percent whereas for states with secondary law the average is only 73 percent.

Being a state with the secondary seat belt law, Kansas seem to be particularly lacking in terms of seat belt usage. Seat belt use in Kansas in 2004 was only 68% compared to an average of 80% for the whole United States. Comparison of seat belt usage rates for Kansas and average usage rates for USA for 2000-2004 time period are shown in Figure 1.2, which indicates that the seat belt usage rates in Kansas have been consistently lower than the average usage rate in the country. This situation seems to be playing an important role in the efforts to reducing fatalities in Kansas. For example, from 459 people who were fatally injured in 2004, only 34 percent were reported to be restrained. However, from all those who were injured in crashes during the same year, 75% were reportedly restrained. In comparison, 84 percent of all occupants who were involved in crashes were reported to be restrained. It is important to note that these usage rates reported in crashes differ from the rates obtained through observational surveys.

Table 1.1: Seat Belt Usage Rates in the United States in 2003

Type of Seat Belt Law					
Secondary Law			**Primary Law**		
No	State	Usage Rate (%)	No	State	Usage Rate (%)
1	Alaska	79	1	Alabama	77
2	Arizona	86	2	California	91
3	Arkansas	63	3	Connecticut	78
4	Colorado	78	4	District of Columbia	85
5	Florida	73	5	Georgia	85
6	Idaho	72	6	Hawaii	92
7	Kansas	64	7	Illinois	80
8	Kentucky	66	8	Indiana	82
9	Maine	52 *	9	Iowa	87
10	Massachusetts	62	10	Louisiana	74
11	Minnesota	79	11	Maryland	88
12	Mississippi	62	12	Michigan	85
13	Missouri	73	13	New Jersey	81
14	Montana	80	14	New Mexico	87
15	Nebraska	76	15	New York	85
16	Nevada	79	16	North Carolina	86
17	North Dakota	64	17	Oklahoma	77
18	Ohio	75	18	Oregon	90
19	Pennsylvania	79	19	Texas	84
20	Rhode Island	74	20	Washington	95
21	South Carolina	73		**Average for All Primary States**	**84.45**
22	South Dakota	70			
23	Tennessee	69			
24	Utah	85			
25	Vermont	82			
26	Virginia	75			
27	West Virginia	74			
28	Wisconsin	70			
29	Wyoming	61 *			
30	Delaware	75			
	Average of All Secondary States	**73.46**			
	**Usage Rate for 2003 not available at the time of analysis, so 2002 usage rate was used.*				

(Source – National Center for Statistics and Analysis)

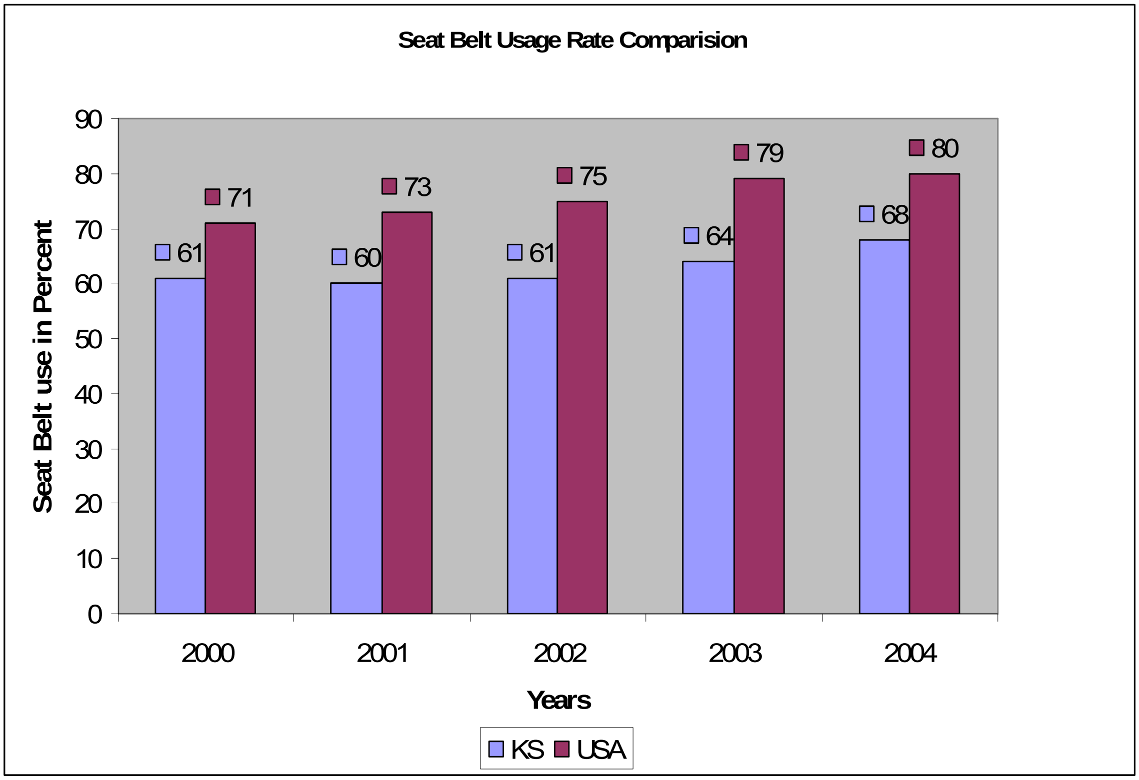


Figure 1.2: Seat Belt Usage Rate Comparisons between USA and Kansas

1.2 OBJECTIVES

The main objective of this study was to identify the factors that affect the seat belt usage in Kansas. Based on the factors that are significant in changing the usage rate, recommendations were also made for developing more focused programs. In addition to the existing seat belt law, other characteristics such as demographics, socio-economic factors and policies/regulations in a region or a state could also affect the average usage rate in a given state. Accordingly, all these potential factors were considered and critical ones were identified through statistical modeling, which also makes it possible to evaluate and quantify the effect of change in any factor such as a change in seat belt law from secondary to primary. In addition focus group surveys were conducted in achieving the objectives since the statistical models may not be able to capture all human factor related issues important to seat belt use. Perceptions, understandings, stated compliance levels, potential motivators etc. of Kansans obtained through the surveys are corroborated with the statistical models developed in this study to suggest effective countermeasures to improve seat belt use in Kansas.

1.3 OUTLINE OF THE REPORT

This report consists of five chapters. Chapter 1 sets the stage for the research by introducing the background of the issue, objectives and scope through the comparison of the national scenario with that of Kansas. Chapter 2, Literature Review, provides a summary of the previously conducted important studies. Data collection and methodologies adopted in this project are described in Chapter 3. The procedure used to collect and prepare data for statistical analysis is explained here. Latter part of the chapter describes the statistical methodology applied in modeling the data and conducting the focus group surveys. Chapter 4 presents the results obtained by data analysis. Three multiple linear regression models were developed and practicality and meaning of the results obtained are discussed. Findings of the survey are also presented in this chapter and they are compared to the statistical modeling results. Specific problems related to Kansas situation are identified and discussed. Chapter 5, Summary, Conclusions and Recommendations, summarizes the findings and shows how the study contributes to the body of knowledge. Based on the modeling results and surveys, critical user groups, locations, types of facilities and other characteristics contributing to low seat belt use are identified and effective countermeasures are suggested.

CHAPTER TWO - LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the literature on factors related to seat belt use and motor vehicle occupant fatalities in the United Sates. Based on the literature review, variables considered to be affecting average seat belt use and total number of occupant fatalities in a region or state can be broadly divided into four categories as follows.

- **Demographic and Socio-Economic** – Variables such as age distribution of drivers, percent of male/female and young drivers, urban-rural population, race/ethnicity of population (eg. percent of African Americans and Hispanics), socio-economic factors like income, unemployment rate, crime rate, etc. are considered in this category.
- **Policy and/or Regulation** – Considers factors like seat belt law, blood alcohol concentration law, maximum speed limit law, fuel tax, penalty for seat belt law violation etc.
- **Roadway and Traffic** – This category considers variables that directly or indirectly represent the status of roadway infrastructure such as total number of highway miles, and various subcategories like interstate roads, miles of rural/urban roads, vehicle miles traveled on rural/urban roads, travel time for commuting to work, etc are considered here.
- **Other** – Other miscellaneous factors like number of fatalities, fatalities per 100 million vehicle miles traveled, etc are considered under this category.

2.2 LITERATURE ON SEAT BELT USE AND OCCUPANT FATALITIES

Following two sections summarize the literature related to factors affecting seat belt use and occupant fatalities.

2.2.1 Factors Related to Seat Belt Use

Various studies in the past have related seat belt use with policies and regulation as well as demographics, socio-economic characteristics and attitudes of road users. Some other studies have considered various physical characteristics of infrastructure, traffic, and vehicle types etc. to understand the situation. Among demographics, age has been found to be an important factor related to seat belt use. Previous studies have found that seat belt use among younger drivers as lower than that of the older drivers (Lawson et al, 1982; Preusser et al, 1987; Mayrose et al, 2002). Along with age, gender has also been studied and findings suggest that females are more likely to use seat belts compared to males (Hunter et al, 1988; Preusser et al, 1989; Reinfurt et al, 1990; Wagenaar et al, 1987). An empirical study based on ordered probability modeling found that female drivers strongly believe in the effectiveness of seat belts compared to male drivers (Hamed et al, 1998). Moreover, a study to determine characteristics of drivers not wearing seat belts found that non-users are more likely to be males and aged younger than 35 years (Reinfurt et al, 1996). It has been consistently found that females have higher seat belt usage rates compared to males across all age groups, all vehicle types, all ethnic/racial groups, and in both primary and secondary states (Nelson et al. 1998, Ulmer et al. 1995, Eby and Vivoda 2001, Wells et al. 2002)

Correlation between socio-economic conditions and seat belt use has also been studied. These socio-economic conditions are primarily defined by income, education level and type of occupation i.e. white-collar job or blue-collar job. Seat belt use was found to be higher among people with higher education and income level (Hunter et al, 1988; Preusser et al 1989; Wagenaar et al, 1987). Research by Snyder et al (1990) found that seat belt use is higher among people who are satisfied with their job and life in general. A study by Shinar (1993) found that there were consistent demographic and socio-economic correlates of use and non-use of seat belts. In this analysis, a detailed study of various sites in Ohio was carried out and different characteristics of non-users were identified by comparing low and high seat belt use sites. Some of the findings of this study revealed lower seat belt use was associated with higher proportion of people with blue collar jobs, lower population of elderly people, high percentage of people with lower then high school education and greater proportion of African American population. Bester (2001) studied the records of vehicle occupants admitted to trauma centers after being involved in crashes, where belt use among injured vehicle occupants was analyzed. Based on this analysis, it was found that only 45% of injured occupants below the age of 25 were wearing seat belts. The analysis also showed that 45% males as compared to 63% females, 34% African Americans as compared to 56% Caucasians, and 33% of people having income below $20,000 as compared to 55 % having income above $20,000 were wearing seat belts at the time of crash. These results were consistent with the results of empirical studies mentioned earlier.

It is a wide spread perception that African American and Hispanic populations have lower seat belt use compared to Caucasian whites. Various researchers have analyzed this and mixed results have been reported. The National Occupant Protection Use Survey (NOPUS), which is based on observations of seat belt use, has never detected a statistically significant difference in seat belt use between ethnic groups. According to the 2002 NOPUS, seat belt use among African Americans rose to 77% in 2002 from 69% in 2000 compared to 76% among whites in 2002. In spite of this increase, almost one out of every four African Americans still does not buckle up on every trip (NHTSA, 2003). A study by Meharry Medical College that reviewed literature found inconsistent results about seat belt usage among African Americans as compared to whites, with some research reporting no differences and others reporting higher or lower seat belt use. On examining records of fatally injured vehicle occupants, lower seat belt use among African Americans was observed by some researchers (Mayrose J, 2002; Voas et al, 2000; Lee P, 1991). Some other studies show no significant difference in seat belt usage among African American population and other races/ethnicities. These studies include NOPUS as mentioned earlier as well as state-level studies in North Carolina and Connecticut (Benjamin et al, 1994; Schichor et al, 1990). Another research, which considered the panel data for 50 states, found that African American and Hispanics do not significantly affect average seat belt usage rates, which was contradictory to the common view of lower seat belt use among African Americans (Cohen et al, 2002). Even though conflicting information exists, most of the research suggests that African Americans are less likely to buckle up. In states with primary law, no difference was found in seat belt use by race. But, in states with secondary law, seat belt use is the highest for Caucasians followed by Hispanics and African-Americans (Wells et al, 2002). From analysis of FARS data for 1995, Braver (2003) found lower seat belt use is associated with lower education level. Moreover for Hispanics, combination of not wearing seat belts and having a high BAC was more prevalent compared to Caucasian men.

Along with demographics, policies and regulations also play a major role in seat belt use behavior. Research has found that seat belt law, blood alcohol concentration law, maximum speed limit law, and fuel tax as some of the factors that significantly affect seat belt use. Among these, seat belt law is the most important factor. All states in U.S except New Hampshire have mandatory seat belt law, which consists of primary law and secondary law. In a national telephone survey, 58 percent of people from states with primary seat belt law as compared to 42 percent of people in states with secondary seat belt law thought that it is likely that someone not wearing a seat belt law could be stopped and cited (Cammisa et al, 2000).

Some studies have measured the effect of switching from secondary law to primary law on seat belt use. One such study suggested 14% increase in seat belt use due to such a change (Shults et al, 2004). Seat belt law was found to be the strongest predictor of higher observed seat belt use in fatal crashes (McCartt et al, 2003). Twenty five percent of drivers who do not use seat belts also engage in high-risk behaviours, such as drinking and driving. Primary seat belt laws also increase usage rates for higher-risk drivers to a greater extent than that of the average driver (Vaos, 1998).

Blood alcohol concentration is another factor affecting seat belt use. Some studies reveal that those who drink and drive are less likely to wear seat belts (Lawson et al, 1982; Preusser et al, 1987). Similarly it has been found that when perceived risk of injury or crash is high, drivers tend to wear seat belts more often. This is specifically true while traveling at high speeds (NYDOT, 1963; Raeder et al, 1968). Considering state level data, seat belt usage rate was modeled against variables perceived to affect usage rate by Cohen et al (2002) and the findings suggested that speed limit law, blood alcohol concentration law and fuel tax significantly affect seat belt usage rate. Likelihood of teenage drivers using seat belts is 60% less when BAC > 0.10 as compared to drivers with BAC < 0.10 (McCartt, 2004). According to traffic safety facts for 2002, from the 57,803 drivers who were involved in fatal crashes, about 22 % were detected to have BAC levels above 0.08 and 31 % of drivers with BAC > 0.08 were fatally injured.

In observational studies in Minnesota, Illinois, Utah and elsewhere it has been consistently found that seat belt usage is higher on interstate roads. Utah safety belt observational survey in 2003 showed that more people were found to use seat belts on interstates compared to local roads. One study revealed that drivers exiting from the freeway had higher belt use than drivers on other roads (Lund, 1985). One of the reasons for this could be traveling at higher speeds, which increases the perceived risk of a crash. Another common view is that rural roads have lower seat belt use compared to urban roads which could be due to lower law enforcement among vast stretches of rural roads. As per the report by NHTSA (1996), 10.6 percent of urban drivers involved in crashes were not restrained compared to 35.3 percent of rural drivers. Teenage drivers involved in fatal crashes are 1.2 times more likely to wear seat belts if the crash occurred on an urban road as compared to a rural road (McCartt, 2004).

Various other factors have also been found to affect seat belt usage. Analysis of 1996 crash data for Washington State using binary logit model has revealed that for given crashes, drivers, out-of-state travelers, older occupants and females were more likely to have been wearing seat belts. The model also controlled for driving conditions.

The findings also suggested that when the road surface was dry, the vehicle was older, the road was less used or rural, the hour was late (midnight to 4 AM), or it was light outside, travelers in crashes were less likely to be found wearing seat belts. Speed limits were not a useful predictor, though one might expect that persons traveling (and then crashing) on high-speed roads would be more likely to wear seat belts, since the risks of severe injury are so much greater so that the precautions like seat belts are more valuable (Kweon et al, 2003)

2.2.2 Factors Related to Vehicle Occupant Fatalities

Motor vehicle crashes are a major cause of death and serious injuries in the United States. Data from 2002 from National Center for Health Statistics showed that motor vehicle traffic crashes were the leading cause of death for every age 3 through 33 years. Various studies in the past have attempted to develop a relationship between occupant fatalities and seat belt usage and other related factors. Some of the variables acknowledged to influence motor vehicle fatalities and seat belt use are common and fall into the same categories described earlier.

Some demographic characteristics like age, sex, race/ethnicity, urban/rural population, have been found to be correlated with fatalities. It has been found that young drivers are more prone to fatalities because of aggressive and risk taking behavior as well as inexperience (McCartt, 2004). Motor vehicle fatalities increase as the percentage of population between ages 18-24 years increases (Derrigh et al, 2000). It has been estimated that teenage drivers have a higher crash risk than any other age group in US regardless of whether it is measured in terms of population or miles driven (McCartt, 2004). Race and Ethnicity are also critical factors affecting fatalities. Baker et al (1998) found that African American and Hispanic male teenagers are twice more likely to be involved in fatal crashes. Lower seat belt use among these groups as found by previous studies might have contributed to this situation. Similar results of high motor vehicle fatality rates among minorities have been reported by some other studies as well (Peek et al, 1991; Sewell et al, 1989). Using logistic regression, Harper et al (2000) tried to link Hispanic and Non-Hispanic fatalities with various predictors like age, sex, location (rural or urban), speeding, and alcohol intoxication using 5-year data from 1991 to 1995 in Colorado. Results revealed that alcohol intoxication and driving without license as significant factors affecting Hispanic fatalities. Lower per capita income has been identified as a determinant of overall injury mortality (Baker et al, 1992). This is directly related to lower income groups like African Americans and Hispanics. Some studies have also found differences in fatality rates among males and females. Research by Mayrose et al (2002) on demographic characteristics affecting motor vehicle fatalities suggested that younger males and African Americans are at higher risk of fatal motor vehicle crashes. A study on motor vehicle crashes in Connecticut found that males are at higher risk of fatality (Foland, 2000). Death due to traffic fatalities ranked 6th for males and 10th for female among all causes of death, as per NHTSA (2005).

Along with demographic characteristics, there are various factors related to policies that affect motor vehicle fatalities. Among all factors, the effect of seat belt usage and seat belt law on occupant fatalities is of prime importance in this study. A study by Cohen et al (2003) used regression analysis to model various factors against the response variable of occupant fatality. The relationship developed between these variables shows a reduction in occupant fatalities with increase in seat belt use. Moreover, this study predicts that 1% increase in seat belt usage rate is saving about 136 lives. Various studies in the past have predicted that mandatory seat belt law decreases occupant fatalities (Bhattacharya et al, 1979; Huston et al, 1995; Garbacz, 1990; Loeb, 1995). Literature review by Dinh - Zhar et al (2001) and Riviera et al (1999) concluded that both primary and secondary laws reduce fatal and non-fatal injuries, but the effect due to primary law as greater. It has been found that changing from secondary to primary seat belt law reduces fatalities. California experienced a reduction in fatalities by 16 % within the first five months after changing from secondary to primary law (Ulmer & Preusser, 1994). Some studies have found direct correlation between driving under the influence of alcohol and traffic fatalities. Considering two types of Blood Alcohol Concentration (BAC) law i.e. 0.08 (allowing no more than 0.08 g/dl of alcohol concentration in blood by law while driving) and 0.10 (allowing 0.10 g/dl), Cohen et al (2002) found that motor vehicle occupant fatalities decrease with lower blood alcohol concentration i.e. 0.08 BAC law. In a national survey on drinking and driving in US, it was found that though number of drivers with BAC below 0.05 has decreased, there has been no significant reduction in drivers with BAC of 0.05 g/dl or above. About 33.7% rural drivers involved in fatal crashes had BAC > 0.10 as compared to 9.9% urban drivers. This could be one of the reasons for higher fatality rates on rural highways. In 2003, a total of 38,252 fatal motor vehicle traffic crashes were recorded in the United States that accounted for 42,643 fatalities. Of these crashes, an estimated 40 percent were alcohol related, i.e., at least one driver, pedestrian or pedal cyclist had a Blood Alcohol Concentration (BAC) of 0.01 g/dl or greater. Alcohol-related crashes accounted for about 40 percent of all fatalities in traffic crashes (NHTSA, 2003). Maximum speed limit law, which regulates the highest speed on roads, is another variable under the category of policies and regulation that is generally perceived to affect motor vehicle fatalities. Usually highest speed in any state is typically found on interstate roads. A study found that if maximum speed limit law limits highest speed on any road to 65 miles per hour or less, then it reduces vehicle occupant fatalities (Cohen et al, 2002). In addition, from the literature reviewed, factors like crime rate, vehicle miles traveled on rural and urban roads, fuel tax (Cohen et al, 2002) as well as unemployment (Leigh et al, 1991) significantly affected vehicle occupant fatalities and were considered in this study for analysis.

Along with these variables, many other variables were selected for modeling occupant fatalities and seat belt use in individual states. All these variables are defined and summarized in the next chapter, which deals with the data collection and methodology adopted for modeling.

CHAPTER THREE - DATA COLLECTION AND METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodology used in achieving the objectives of this research i.e. identifying the factors affecting seat belt use and effects of seat belt usage on traffic fatalities. Statistical models were used to identify the effects of socio-economic, demographic, policy and physical characteristics affecting seat belt usage rate in a given state. Surveys were also conducted to collect information, opinions and perceptions about seat belt use among the general public in Kansas. These surveys were designed to identify characteristics of people with low seat belt use, to collect public opinions regarding seat belts and associated laws, to identify issues related to non-use of seat belts and to identify factors that would motivate people to use seat belts more often. Accordingly, this chapter is broadly divided into three sections as follows:

1. Data Collection and Variable Selection for Statistical Modeling
2. Data Analysis and Modeling
3. Design of Survey Form and Conducting Survey

First section, data collection and variable selection, describes the variables that were considered in modeling and reasons for selecting these variables. Three statistical models were developed which were named as Seat Belt Usage Rate Model, Unrestrained Occupant Fatality Model and Fatality Rate Model. Data analysis and modeling section describes the method used for developing these models and criteria used for checking the robustness of the model. Last section of the chapter describes the procedure used in conducting road user surveys in Kansas.

3.2 DATA COLLECTION AND VARIABLE SELECTION

All variables that were considered in developing the models are summarized in Table 3.1 where State level data were collected for each variable. These data were collected for year 2002 (most recent year for which complete data were available at the time of this study) for all 49 states excluding New Hampshire, which has no mandatory seat belt law. Some variables were selected based on previous research findings whereas other variables were selected through professional judgment. These variables are described here and the sources of the variables can be found under 'Data References'.

Blood Alcohol Concentration Level Law (BAC LAW) – In 2002, 41% of the 42,815 motor vehicle deaths were alcohol-related whereas 54.1% of those people involved in fatal crashes were unrestrained (NHTSA, 2004). Driving under influence of alcohol significantly impairs driving skills and a driver is less likely to wear a seat belt when under the influence of alcohol. Motive for considering BAC law as a candidate variable in statistical modeling was to develop a relationship, if any, between seat belt usage, vehicle occupant fatalities and degree of intoxication. BAC law is defined on the basis of concentration of alcohol in the blood and is expressed as the weight (grams) of alcohol in a fixed volume of blood (deciliter). It is used as a measure of the degree of intoxication for a particular individual. There are two types of BAC laws in US, one which allows maximum of 0.08 g/dl alcohol in blood and other which allows maximum of 0.10 g/dl of alcohol in blood. This variable was treated as a dummy variable in the modeling process that helps to introduce variables with dichotomous responses into analysis (Parsons, 1978). Variable takes value equal to “1” for those states complying with 0.08 BAC law and takes value equal to “0” for other states.

Table 3.1: Candidate Variables Selected for Statistical Modeling

No	Variable	Variable Label	Variable Type	Units
1	Blood Alcohol Concentration Law	BAC LAW	Categorical	N/A
2	Crime Rate	CR	Continuous	Crimes/100 Million Population
3	Fatality Per 100 Million Vehicle Miles Traveled	FVMT	Continuous	Fatalities/100 Million Vehicle Miles Traveled
4	Fuel Tax	FT	Continuous	Cents/Gallon
5	Highway Mileage of Rural Roads	HMR	Continuous	Miles (In Ten Thousands)
6	Log of Percentage of African American and Hispanic Population	LHAF	Continuous	N/A
7	Log of Percentage of African American Population	LAFAM	Continuous	N/A
8	Median Household Income	MHI	Continuous	Dollars (In Ten Thousands)
9	Log of Penalty for Seat Belt Violation	LPEN	Continuous	N/A
10	Percentage of Fatalities with driver having BAC >0.08 g/dl	PBAC	Continuous	Percent
11	Percentage of High School Graduates	HIGHSK	Continuous	Percent
12	Seat Belt Law	LAW	Categorical	N/A
13	Speed Limit Law	MAX SPEED	Categorical	N/A
14	Total Interstate Mileage	TI	Continuous	Miles (In Hundreds)
15	Unemployment rate	UNEMP	Continuous	Percent
16	Vehicle Miles Traveled on Rural Roads	VMTR	Continuous	Miles (In Thousands)
17	Young Drivers	YD	Continuous	Percent

Crime Rate (CR) – The variable crime rate is defined in this study as the total number of crimes per 100,000 population in a given state. Crime here refers to the sum of violent crimes and property crimes in each state. Violent crimes consist of murders, aggravated assaults, forcible rapes and robberies whereas property crimes consist of burglaries, larceny-thefts, motor vehicle thefts and crimes of similar nature. Seat belt usage could be expected to be possibly low in places where law is not properly enforced or in places where people are less likely to obey law, even if it is strictly enforced. As crime rate is generally high in such situations, it is used as an indirect measure of law enforcement and public attitude.

Fatality Rate Per 100 Million Vehicle Miles Traveled (FVMT) -This variable is defined as total number of fatalities per 100 million vehicle miles traveled. Number of fatalities refers to the total number of fatally injured vehicle occupants. Since it is a common view that seat belts save lives, this variable could have a direct relationship with the seat belt usage rate. Main intention for considering this variable however was to evaluate the effect of seat belt use on fatalities by adjusting for vehicle miles traveled so as to make a fair comparison between different states.

Fuel Tax (FTD) - Fuel tax is the amount of tax charged per gallon of fuel. A portion of the fuel tax collected is used for highway development, maintenance and repair. This variable was considered in modeling to identify if any relationship exists between improved highways and seat belt usage rate assuming higher amount spent on highways would result in better highways.

High School Graduates (HIGHSK) – This variable represents the percentage of high school graduates in each state. Previous research findings suggest that the level of education could be one of the important factors that affect seat belt usage and vehicle occupant fatalities. Seat belt use was found to be higher among people with higher education and income levels (Hunter et al, 1988; Preusser et al 1989; Wagenaar et al, 1987). A study found that 89% of the fatalities among Hispanics had less than twelve years of education as compared to 15% of fatalities among non-Hispanic Caucasians (Harper et al, 2000). Based on findings of past research, this variable was considered in developing the three models mentioned previously.

Highway Mileage of Rural Roads (HMR) –This variable considers the total miles of rural roads in each state, which was converted into ten thousands of miles for use in the model. Studies have shown that there are higher numbers of fatal crashes on rural roads. Percentage of fatal crashes is higher in rural areas as compared to urban areas and the probability of fatal crashes on rural roads significantly increases if seat belts are not used (Dissanayake, 2004). Due to this, highway mileage of rural roads was considered as an important variable for using in the fatality rate models and seatbelt usage rate model.

Log of Percentage of African American Population (LAFAM) – As mentioned in the literature review, African Americans have been found to significantly affect seat belt usage rates. Initially this variable was treated as the percentage of African American population in a given state. But from the scatter plot of seat belt usage rate and African American population, it was found that the relationship is not linear. If the scatter plot does not seem to be linear by itself, it can be "straightened out" by transforming either the dependent variable (seat belt usage rate in this case) or the independent variable (African American population) (Ott and Longnecker, 2001). Since linearity is important for developing Multiple Linear Regression models, African American population was transformed into logarithmic form, which was found to have a linear relationship with the seat belt use and fatalities. On examining records of fatally injured vehicle occupants, lower seat belt use among African Americans was found (Mayrose J, 2002; Voas et al, 2000; Lee P, 1991). A survey by Florida Department of Transportation showed that African American females have a usage rate of 61% compared to 72% for Caucasian females and the corresponding figures for African American and Caucasian males were 54% and 67% respectively. Nelson et al (1998), in a study on seat belt use and demographics found that overall safety belt use increased by an average of 2.7 ± 0.1 percentage points per year and varied little across most demographic groups, but there was no significant increase for African American males aged 18 through 29 years. Considering all these understandings, this variable was selected as a candidate variable.

Log of Percentage of Hispanic and African American Population (LHAF) - This variable represents the logarithmic value of percentage of African American and Hispanic populations combined. Seat belt usage rate and combined population of Hispanics and African Americans did not show a linear relationship with the dependent variables fatality rate and unrestrained occupant fatalities. Due to this, Hispanic and African American population was transformed to a logarithmic form. Based on a past study, African-Americans had the highest exposure-based fatality rate per billion vehicle-miles of travel, while Hispanic rates were 43% lower than the rate for African-Americans but 72% greater than the rate for Caucasians. (Hallmark et al, 2004). However, due to the wide variation in Hispanic population across states, it was not possible to treat it as a separate variable. To analyze the impact of minorities in this situation, LHAF was considered in fatality rate and unrestrained occupant fatality models.

Median Household Income (MHI) – This variable represents the median household income in each state. Values were used in tens of thousands of dollars for analysis purpose. Previous research suggests strong correlation between seat belt usage rate and socio-economic conditions, where findings reveal that seat belt use increases with increase in income level (Hunter et al, 1988; Preusser et al 1989; Wagenaar et al, 1987). By considering this variable in the model, this correlation was analysed.

Log of Penalty for Seat Belt Violation (PENALTY) – Penalty represents the amount of fine charged in dollars when cited for not wearing a seat belt. Mean values of penalties were taken, if any state had a range of values. For example, penalty for seat belt violation in New York varied from $50-$100, so a value of $75 was used in the analysis. As penalty and seat belt usage did not show a linear relationship, penalty values were transformed into logarithmic values. Generally, higher fines could increase seat belt usage, and log values of penalties were used to verify this relationship. Therefore, by using this variable, it was attempted to find out whether an increase in penalty causes an increase in seat belt use and decrease in number of fatalities.

Seat Belt Law (LAW) - This variable is used to evaluate the effects of the existing seat belt law in each state. There are two types of seat belt laws in USA, namely primary seat belt law and secondary seat belt law. In states with primary seat belt law, police officer can stop and cite violators for not wearing seat belts. In states with secondary seat belt law, police officers cannot stop a vehicle even if occupants violate the law unless they are involved in some other traffic infraction. Seat belt law is used in this study as a categorical variable which takes value equal to "1" when the seat belt law is primary and value equal to "0" when the seat belt law is secondary. Seat belt law is considered as a critical factor for increasing seat belt usage. This is evident from the fact that average usage rate for secondary law states in 2002 was 73 % as compared to 84% for states with primary laws. Compared with secondary laws, primary laws are hypothesized to have a greater effect on motorists' perceived risk of detection and punishment as well as on the public's view of the importance of safety belt use. Therefore, primary laws may lead to higher rates of safety belt use and lower rates of crash-related fatal and nonfatal injuries (Dinh-Zarr et al, 2001).

Median increase in seat belt use in states with primary law relative to states with secondary law was 14 percentage points for observed use (Dinh-Zarr et al, 2001). Increased usage of seatbelt also decreases traffic fatalities. Relative risk of death for a belted front seat passenger was estimated to be 0.58 compared to unbelted front seat passengers (Evans, 1986). Considering the above-mentioned facts, this variable was used in the modeling process to evaluate the effect on seat belt usage rate due to the change in law from secondary to primary.

Seat Belt Usage Rate (UR) – Seat belt usage rate for each state, which is a continuous variable, is used as the response variable for developing the seat belt usage rate model. Usage rate for each state is calculated based on probability based surveys conducted throughout the United States. These surveys are observational surveys conducted in accordance to Section 157 of Title 23, United States Code. Some of the criteria's for calculating seat belt usage rate include:

- Actual observation of use of shoulder belts by vehicle occupants
- Employing statistical procedure to select site for observational surveys
- Calculating usage for driver and front seat passenger, all type of vehicles, all days of week and all daylight hours.
- Conducting observational surveys so as to include 85% of the population
- Estimating shoulder belt use with a relative precision of +/- 5 percent

Survey design and the observations have to be well documented to submit to the NHTSA for evaluation of its compliance with the code. As the usage rate value is one of the most crucial data elements used in this study, it was important to verify that seat belt usage rate is calculated by each state by a uniform procedure so that 'fair' comparison can be made between usage rates in different states. This data was obtained from NCSA for the year 2002, which states, "The rates were obtained by surveys conducted in accordance with criteria established by NHTSA. These criteria assure a certain degree of uniformity and accuracy" (Glassbrenner, 2003). A review of several published reports from different states regarding observed usage rates appeared to conform this fact.

Speed Limit Law (MAXSPEED) – Speed limit law is a categorical variable, which considers the maximum speed limit in each state. MAXSPEED takes value equal to "1" when maximum speed limit in the concerned state is above 70 mph and takes value equal to "0" when the maximum speed limit is equal to or below 70 mph. 27 states had speed limit above 70 miles per hour on interstate and 23 states had below 70 miles per hour. It is generally perceived that higher speed limits cause more fatal crashes. But according to NHTSA (2003), from a total of 13,713 speeding related fatalities, 6,129 fatalities occurred on roads with posted speed limits between 55 and 65 mph, and 907 fatalities occurred on roads with speed limits above 65 mph. Even though exposure needs to be considered in making a true comparison, this variable is considered in developing the models to evaluate its effects on fatal crashes and seat belt usage rates.

Total Interstate Mileage (TI) – This variable represents the total miles of interstate roads in each state. Typically, speed limits on interstate roads are the highest among all road types. It could be possible that while driving on interstates making relatively longer trips at higher speeds, drivers might be more cautious and wear seat belts more frequently. Therefore, total interstate mileage is a surrogate variable, which is used to identify any relationship that might exists between driving on higher speed limit roads, seat belt usage and traffic fatalities.

Unemployment Rate (UNEMP) – This variable represents percentage of labor force that is unemployed. Generally, with higher unemployment rates there could be a decrease in the amount of travel, which might affect the total number of fatalities and observed seat belt use. Safety belt use is higher among people with higher education and socio-economic levels (Hunter et al, 1988; Preusser et al., 1989). Accordingly, as seat belt use increases and fatalities decrease with median income, unemployment could be expected to cause an opposite effect. Because of this background, this variable was considered in the modeling process.

Unrestrained Passenger Car Occupant Fatalities (UOF) – This variable represents unrestrained passenger car occupant fatalities as a percentage. It was used as a response variable in unrestrained occupant fatality model to identify the factors contributing to increased unrestrained occupant fatality percentages. Particularly it was intended to investigate if seat belt law has an affect on unrestrained occupant fatalities and if so, to quantify the change in safety situation that could be expected by switching from secondary to primary law.

Vehicle Miles Traveled Rural (VMTR) – This variable represents the total vehicle miles traveled on rural roads. As mentioned previously, fatal crashes are more common and also seat belt use is perceived to be low in rural areas. So, this variable served the dual purpose in this research of investigating whether rural areas have higher number of fatal crashes and lower seat belt use. This variable was considered to be particularly important for Kansas where there is a high percentage of rural areas.

Young Drivers (YD) – The variable represents percentage of young male and female drivers aged between 16-24 years. Many studies in the past have found that young drivers are the least likely to wear seat belts among all age groups (Lawson et al, 1982; Preusser et al, 1987). Moreover, younger drivers are at the highest risk of traffic fatalities as compared to any other group. It is generally perceived that young drivers are aggressive and have lesser driving experience. Considering these facts, it is likely that this age group could be more involved in traffic violations and hence considered in the models.

All these variables were considered in developing the three models: Seat Belt Usage Rate Model, Unrestrained Occupant Fatality Model and Fatality Rate Model. The variables were not necessarily used together in developing any particular model because of very high correlation among some of the variables. For example, the variable Log of Hispanic and African American population and log of African American population were not used together in any model as they are highly correlated. In such cases, the two variables were used alternatively while keeping all the other variables the same and better model was selected. When high correlations between more than two variables resulted in multi-colinearity, variables were selected based on a procedure described in sections 3.2.1 and 3.2.2.

3.3 DATA ANALYSIS AND MODELING

This section describes the statistical modeling methodology used for developing the three models, namely, Seat Belt Usage Rate Model, Unrestrained Occupant Fatality Model and Fatality Rate Model. Multiple Linear Regression procedure was utilized using Statistical Analysis Software (SAS 8.1) to identify different factors affecting response variables such as seat belt usage rate and occupant fatalities.

Multiple Linear Regression (MLR) uses the values of several explanatory variables x_1 to x_k to predict the response variable y (Lucko, 2003). Linear in this context does not mean that a model necessarily can only work with terms of the first order, but refers to the linear additive nature of the terms in the basic MLR model. In mathematical form, the basic MLR model could be expressed as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \in \qquad \text{Equation 3.1}$$

Where,

y = Response variable

β_0 to β_k = Regression coefficients or parameters to be estimated

x_1 to x_k = Explanatory variables

k = Number of explanatory variables

ε = Error term.

Equation 3.1 can define the extent and type of effect each explanatory variable would have on the response variable. Sign (negative or positive) of the parameter estimate (β's) signifies the type of relationship between that particular variable and the response variable, i.e. if the sign is positive, the response variable increases with the increase in value of the explanatory variable. Like wise value of the response variable decreases when the sign is negative. Similarly the magnitude of parameter estimate signifies the extent of influence explanatory variable has on the response variable. Different types of procedures could be used to identify and isolate those variables, which have the largest and significant effect on the dependent variable. The following six steps were followed to develop and validate MLR models utilized in this study.

3.3.1 Step One – Linear Correlation Matrix

Once the candidate variables are selected, the first step in model building process is to develop and check the linear correlation matrix. Correlation means a relationship or association between the variables and the correlation coefficient describes the magnitude of this association. A high correlation coefficient between the response variable and the predictor variable would result in a better prediction for the response variable (Ott and Longnecker, 2001). Conversely high correlation between the predictor variables implies that there is some overlapping information. In that case, it becomes difficult to disentangle the effects of one predictor variable from another, and the parameter estimates may be highly dependent on which variables are used in the model. If two independent variables have a correlation of 1.0, it is impossible to separate their effects (SAS 8.1 User Guide, 1999). For multiple regressions, it is important that the predictor variables are independent of each other so that the analysis is not distorted. Hence it is necessary to include only those predictor variables, which do not have high correlations among them. Therefore, a correlation matrix was developed for those variables mentioned in Table 3.1 using the SAS software. Independent variables that had a correlation coefficient higher than 0.65 (or 65% correlation) were removed from the variable set considered for final modeling.

3.3.2 Step Two - Checking for Multi-Collinearity

Sometimes one predictor variable could be correlated with more than one other predictor variable, which is called multi-collinearity. Multi-collinearity results in overlapping information between more than two predictors, where one predictor would explain the same variability that is explained by the other predictors. As a result, some predictors may not provide any additional information. Presence of multi-collinearity results in significant changes in the slope coefficients. As the magnitude of correlation between predictors increase, standard error of regression coefficients also increase (Ott and Longnecker, 2001). This will result in highly inaccurate and misleading estimates of regression coefficients, which misinterpret the importance of predictor variables. Multi-collinearity could be measured by variance inflation factor (VIF). It measures the increase in variability of a coefficient due to collinearity. Variance here is referred to as square of the standard error. If variation inflation factor is 1.0, it implies that there is no multi-collinearity among the independent variables. Critical value used for variation inflation factor is generally 10 and variables having VIF above 10 are considered to be highly correlated with other predictors (Ott and Longnecker, 2001). All those variables that had VIF above 10 were therefore removed from the model. This is done in a stepwise procedure where the variable having highest VIF is removed first and then VIF for all other variables are calculated. This procedure is repeated until all variables have VIF lesser then 10.

3.3.3 Step Three - Stepwise Model Selection

Next step in model building process is the model variable selection procedure. SAS provides various different types of selection procedures like stepwise selection, backward selection, forward selection, highest R^2 etc. Stepwise selection procedure was used here for modeling. During the stepwise procedure, the variable, which is most significant, enters into the model first. After that, the software automatically identifies the other significant variables in a step-by-step manner. There are two criteria to help the model select the variables. These are known as significant level for entering into the model (SLE) and significant level for staying into the model (SLS). After detailed experimentation, SLE was specified as 0.15 and SLS as 0.10. Accordingly, at each step, model selects the variable that satisfies the SLE criteria and enters that variable into the model. After this variable enters the model, it checks all other variables already in the model to see if they satisfy SLS criteria to stay in the model. If any variable already in the model does not satisfy SLS criteria, then it is removed from the model. So, at each and every step only those variables that are significant at the SLE level are entered into the model and those variables that are significant at the SLS level remained in the model, while all other variables are removed. This procedure continues till no other variable outside the model satisfies the entry criteria or if the variable that is entered is the variable, which was just removed (SAS 8.1 User Guide, 1999). The advantage of this procedure over forward selection procedure is that in forward selection all those variables, which have already entered into the model, remain in the model even if they do not satisfy the level of significance required to enter the model. For example, a variable, which enters the model at level of significance of 0.04, would have a significance level of 0.12 after a few more variables are added to the model. However, since the variable is already in the model, it stays in the model even if it no longer satisfies the entry criteria. The reason for this drawback is that the level of significance for a variable to stay in the model cannot be specified in the forward selection method. Similarly, in backward selection procedure, only a stay level criterion can be specified. So, in a backward procedure, model starts with all variables in step one and removes variable, which do not satisfy the criteria for staying in the model. Due to this drawback in forward and backward selection procedures, stepwise selection was used for modeling. It should be noted that some variables were transformed to logarithmic form, square root and natural logarithmic form. This was done when the relationship between dependent and independent variables are not linear, but transformation provided a more linear relationship. In such cases, the transformed variable was simply treated as another variable (Ott and Longnecker, 2001).

3.3.4 Step Four - Analysing the Variables in the Model

Models were developed by considering all those variables that were significant up to 0.10. After the model is developed, it is necessary to check if all the variables in the model significantly affect the dependent variable and have not entered the model by chance. This is done using the p-value obtained during the modeling process. In a statistical hypothesis test, the p-value is the probability of observing a test statistic at least as extreme as the value actually observed, assuming that the null hypothesis is true. This probability is then compared to the pre-selected significance level of the test. If the p-value is smaller than the significance level selected, the null hypothesis is rejected and the test result is termed significant. Null hypothesis states that there is no difference between the hypothesized value of parameter and its true value or in simple words it states that the results obtained are merely due to chance or co-incidence. Accordingly, the p-value is a measure of how much evidence we have against the null hypothesis. Lower p-values mean higher chances of rejecting the null hypothesis and concluding that results are not obtained by mere co-incidence.

Each variable can be tested to see if it adds significantly to the predictive power of the model. When a single variable is tested, p-value for the variable is compared with the α value, where α is the level of significance that is considered as 0.10 for this study. When p-value is less than α for the variable considered, the null hypothesis can be rejected with 90% (1- α = 1 - 0.10 = 90%) confidence, which means that the variable does add to the predictive power of the model. Similarly this test is done for a group of variables to test if several predictors have no value, given the other set of variables. When testing for a group of variables, null hypothesis would state that the true co-efficient of these variables would be zero (Ott and Longnecker, 2001). Testing a group of variables is based on comparison of the Sum of Square Regression (SSR) and/or R^2 of the model with and without this set of variables. If a set of variables being tested adds significantly to the predictive power of the model, then removing this set of variables will result in lower values for SSR and/or R^2 for the model. Suppose the group of variables being tested consists of “b” number of variables and the full model consists of “a” number of variables. Here, “b” is the number of variables in which coefficients are not hypothesized to be zero. So (a-b) is the total number of variables, which are hypothesized to have coefficients equal to zero. The main idea behind this is to find the SSR for model with “a” predictors (Full Model) and “b” predictors (Reduced Model). Using these SSR values F statistic is computed as follows (Ott and Longnecker, 2001).

$$F_{calc} = \frac{[\ SSR\ (\text{full model}) - SSR\ (\text{reduced model})\ ]\ /\ (a-b)}{SSE\ (\text{full model}) /\ (n-(a+1))}$$

Null Hypothesis H_o: Coefficients of a set of variables (a-b) is zero
Alternative H_a: H_o is not true

$F_{critical}$ = F- Statistics for degree of freedom $df_1 = (a-b)$, $df_2 = (n-(a+1))$

Where n = number of observations

a = Total number of variables in the model

b = Number or set of variables being tested

SSR = Sum of Square Regression

SSE = Sum of Square Error

Based on the above discussion, if $F_{calc} >$ Fcritical, then the null hypothesis is rejected, which suggests that the variables have coefficients significantly different from zero and it can be concluded that the set of variables cannot be dropped from the model simultaneously as they together add to the predictive power of the model.

If $F_{calc} <$ Fcritical, then null hypothesis cannot be rejected and it suggests that the coefficients of set of variables are not significantly different from zero and it can be concluded that this set of variables can be dropped simultaneously from the model, as they do not provide any more information or explain any more variability in the model other than that provided by the model without these variables.

3.3.5 Step Five– Checking Model Assumptions

Once the model is developed, robustness of the model needs to be checked. It is important to evaluate if the model is capable of predicting the dependent variable within a certain range. For example, in case of seat belt usage rate model, if the model predicts a seat belt usage of 70% for a certain state while the actual rate is farther away from that, the model is not robust. Robustness of the model is checked by verifying that the model satisfies the four basic assumptions of a Multiple Linear Regression model, which are as follows (Ott and Longnecker, 2001).

Assumption 1 – Zero Expectation of Errors; E (ε_i) = 0 for all i

Multiple regression is based on the assumption that all variables that are important are included in the model and no important predictor has been left out of the model, while considering the data used in the modeling process. If step four described earlier is followed, expected error will be zero and this assumption will be valid for the developed model.

Assumption 2 – Constant Variance of Errors; V (ε_i) = σ^2 for all i

This assumption deals with the variance of the error. A Multiple Linear Regression model assumes that the variance is constant. Variance is usually estimated from a sample drawn from a population. The unbiased estimate of population variance calculated from a sample is as follows (SAS User Guide, 1999)

$$s^2 = \frac{\sum (x-\bar{x})^2}{n-1}$$ Equation 3.2

Where,

x = Observation from the sample,

$\bar{x}$ = Sample mean,

n = Sample size

Variance is defined as the measurement of spread about the mean. Assumptions of linear regression model are specified in terms of random errors, and one way to detect non-constant variance is by examining the residual plots (Ott and Longnecker, 2001). Residual refers to the difference between the actual value and value predicted by the multiple linear regression model for any particular observation. If the residuals are evenly distributed about the horizontal reference line (residual = 0), variance can be assumed to be constant. Non-constant variance of error is called heteroscedasticty, which results in a very high or very low prediction interval depending on the variance. Due to this effect regression coefficients do not yield consistent results.

Assumption 3 – Normality; ε_i is normally distributed.

Multiple linear regression models assume that the residuals are normally distributed. Non-normality may usually occur due to outliers in the data. Outliers are defined as those data points, which are too far away from rest of the data. If an observation has an extreme value on both x and y coordinates compared to the rest of the data, then it can be considered as an outlier. In this study, as each data point represents a state and each state has different characteristics, for example, Texas has a very high population of Hispanics and California has high number of fatalities, there are chances of such states being identified as outliers. Outliers can be detected using normal probability plots, Histograms, stem and leaf plots, Anderson-Darling tests, Kolmogorov-Smirnovs etc. Even though all of the above tests and plots could be obtained by the SAS software, histograms and normal probability plots were plotted using SPSS software as they could be obtained in a more user friendly and easy to understand format.

Outliers tend to influence the movement of regression line away from the rest of the data causing serious errors in model fitting. In a normal probability plot, if the line shows a strong linear trend, it conforms that the errors are normally distributed and it could be expected that there are no outliers. Moreover, the lower most and upper most points of the trend line do not deviate much from the straight line when there are no outliers. Another way of detecting outliers is by using histogram. If the bars of a residual histogram are symmetrical about the central axis, then the residuals can be assumed to be normally distributed. If they are not symmetrical and the histogram shows extremely high or extremely low values on y-axis, it raises suspicion of outliers, which requires further investigation to identify these observations.

As per NIST/SEMATECH e-Handbook of Statistical Methods, quantitative statistics like kurtosis and skewness could also be used to check for normal distribution. Kurtosis is a measure of the heaviness of the tails of a distribution, with larger values indicating heavier tails. This implies that the data contains some values that are distant from the mean as compared to most of the other values. Skewness is a measure of the tendency of the distribution to lack symmetry or to be more spread out on one side than the other. Positive skewness indicates that values located to the right of the mean are more spread out than the values located to the left of the mean. Negative skewness indicates the opposite (SAS User Guide, 1999). Ideally value of kurtosis and skewness should be zero or as close to zero as possible.

Assumption 4 **– Independence; The errors ε_i are statistically independent and hence uncorrelated**.

This assumption deals with identifying if any serial co-relation exists between the independent variables. In situations where observations are taken at successive points in time, the plot of residuals versus time could be used to identify serial co-relation from some pattern, which might reflect from the plot. Usually a wavy trend, which is identical above and below the reference line passing thorough zero would represent serial correlations. This assumption is critical for time series data and as data used in this study consisted of only one year of data, this test is not relevant for any models developed.

3.3.6 Step Six – Identifying Influential Observations

After checking the models assumptions, if outliers are suspected, they can be identified by the statistics described below. Usually outliers are those points which have extreme values for x and y and hence have a high influence on the fit of regression line. Next step deals with checking the influence of each observation on the parameter estimates. Those observations, which have a large influence on the parameter estimates of the model, are termed as influential observations (SAS 8.1 User Guide, 1999). Basically, four types of statistics are used for identifying the influential observations. These statistics, as represented in SAS 8.1 software are as follows.

$\boldsymbol{h_i}$ – It is represented as Hat Diagonal H in the SAS output. This statistic is used to identify the observations, which have high influence on model fitting. All observations that do not satisfy the criteria for size-adjusted data shown in Equation 3.3 should be investigated as possible outliers as per recommendation by Belsley, Kuh, and Welsch (SAS 8.1 User Guide, 1999)

$$h_i \leq 2p/n \qquad \text{Equation 3.3}$$

Where,

n = Number of observations used to fit the model and

p = Number of parameters in the model.

COVRATIO – The COVRATIO statistics measures the change in the determinant of the covariance matrix of the estimates by deleting the i^{th} observation. Observations that do not satisfy the criteria for size-adjusted data, shown in Equation 3.4 should be investigated as possible outliers as per recommendation by Belsley, Kuh, and Welsch (SAS 8.1 User Guide, 1999)

$$\left| \text{COVRATIO-1} \right| \leq 3p/n \qquad \text{Equation 3.4}$$

Where,

p = Number of parameters in the model

n = Number of observations used to fit the model.

DEFITS – The DFFITS statistic is a scaled measure of the change in the predicted value for the i^{th} observation and is calculated by deleting the i^{th} observation. A large value indicates that the observation is very influential in its neighborhood of the **X** space. A general cut-off to consider is 2; a size-adjusted cut-off recommended by Belsley, Kuh, and Welsch is $2\sqrt{p/n}$ where p and n are as described above (SAS 8.1 User Guide, 1999)

DFBETAS – DFBETAS statistics are the scaled measures of the change in each parameter estimate and are calculated by deleting the *i*th observation: In general, large values of DFBETAS indicate observations that are influential in estimating a given parameter. Belsley, Kuh, and Welsch recommend 2 as a general cut-off value to indicate influential observations and $2/\sqrt{n}$ as a size-adjusted cut-off (SAS 8.1 User Guide, 1999).

By using these influential statistics it is possible to detect influential observations and check the model fitness after removing these observations.

3.4 METHODOLOGY FOR SURVEYS

Surveys were conducted in Kansas for identifying the human factors related to seat belt use among Kansans. The survey was expected to directly capture general understandings, compliance, attitudes and behaviors of road users in Kansas and tie those with the characteristics of the respondents. A survey questionnaire was prepared, which consisted of 37 questions as shown in Appendix A. These questions can be divided into mainly four categories i.e. general characteristics, awareness about seat belt issues, seat belt use patterns and related factors, and others. For example, category of 'general characteristics' included questions like gender, median income, age group, marital status etc. 'awareness of seat belt issues' category included questions like type of seat belt law in Kansas, penalty for not wearing seat belts etc. Similarly the category 'seat belt use patterns and related factors' included questions about frequency of seat belt usage, factors that would motivate higher seat belt use, factors influencing seat belt usage negatively etc. Each category of question consisted of reasonable amount of options to accommodate various types of responses. The survey form was developed considering factors affecting seat belt usage in United States, as discussed in the literature review while referring to compendium of surveys (Huang et al, 2004) which consists of questionnaires prepared in various countries for similar purposes.

These surveys were conducted at six locations in Kansas i.e. Hutchinson, Oakley, Manhattan, Junction City, Salina, Wamego by a group of four people by going door to door in residential areas. The purpose of the survey was explained and the general public was requested to complete the survey form, where a reasonably satisfactory response rate was observed. Residential communities and other areas were selected randomly and a total of 794 surveys responses were obtained. After discarding incomplete survey forms, about 753 survey forms were used for the analysis purposes.

CHAPTER FOUR - RESULTS

In this study, Multiple Linear Regression (MLR) analysis was used to develop three statistical models for evaluating relationships among seat belt use and other important factors. Results obtained and their practicalities are described in this chapter. The three sets of statistical models that were developed are as follows:

1) Seat Belt Usage Rate Model and Modified Seat Belt Usage Rate Model

2) Unrestrained Occupant Fatality Model

3) Fatality Rate Model and Modified Fatality Rate Model

The latter part of the chapter describes the analysis of 753 surveys, in which opinions of Kansans were collected with regard to seat belt usage.

4.1 SEAT BELT USAGE RATE AND MODIFIED SEAT BELT USAGE RATE MODELS

Seat Belt Usage Rate model, hereby referred to as seat belt model was developed to evaluate the effect of policies, socio-economic, demographic and various other physical characteristics on average seat belt usage rate in a given state in the USA. Using the methodology described in the previous chapter, Multiple Linear Regression Models were developed using SAS software and six factors as presented in Table 4.1 were identified as significantly affecting seat belt usage rate in a given state. By examining the statistics of the developed model, some extreme observations or outlier states were detected that influenced the overall model fitness, leading to biased regression coefficients. Since the intention was to develop a model to represent average states that include Kansas, these outlier states were removed and another model referred to as modified seat belt usage rate model was developed. This section describes this process and later discusses the practicality of results obtained by the modified seat belt model.

4.1.1 SEAT BELT USAGE RATE MODEL

Seat belt usage rate model was developed by considering 13 candidate variables as mentioned earlier in section 3.1. The model identifies six independent variables that significantly influence usage rates. These variables and their corresponding parameter estimates are summarized in Table 4.1. Complete explanation of these variables is given in section 3.1.

Table 4.1: Seat Belt Usage Rate Model

Variable Name	Variable Label	Parameter Estimate	Standard Error	t-value	Pr > t
Intercept	---	52.67	6.72	7.84	<0.000
Seat Belt Law	LAW	12.67	2.05	6.17	<0.000
Total Miles of Interstate Road	TI	0.40	0.15	2.65	0.011
Log of Percentage of African American Population	LAFAM	-4.67	1.45	-2.25	0.029
Highway Miles of Rural Road	HMR	-0.64	0.29	-2.15	0.037
Fuel Tax	FT	0.39	0.21	1.90	0.065
Crime Rate	CR	2.77	1.10	2.50	0.016
R^2 = 0. 617					

In the mathematical form the model could be written as follows:

Usage_Rate = 52.67 + 12.67 (LAW) + .40 (TI) – 4.67 (LAFAM) - 0.64 (HMR) +

0.39 (FTD) + 2.77 (CR) Equation 4.1

Where,

Usage_Rate = Seat Belt Usage Rate as a percentage

LAW = Seat Belt Law (“1” for primary law and “0” for secondary law)

TI = Total miles of interstate roads, in hundreds

LAFAM = Log of percentage of African American population

HMR = Rural highway mileage, in ten thousands

FT = Fuel tax in cents per gallon

CR = Crime rate in crimes per one million population

Based on equation 4.1, estimated increase in seat belt usage rate by changing from secondary to primary seat belt law is 12.67 %. This is a point estimate and actual increase can be better represented using a confidence interval, which is an estimated range of values. A 90 percent confidence interval was used in this study for all models. Accordingly, the confidence interval for increase in seat belt usage, if law is changed from secondary law to primary law is 9.21 to 16.21 percentage points. Similarly increase in seat belt usage rate due to the individual effect (increasing only one response variable at a time while keeping the other variables constant) of all response variables are described in Table 4.2.

Table 4.2: Individual Effects of Response Variables on Seat Belt Usage Rate

Response Variable	Increase in Response Variable	Percent Increase in Seat Belt Usage Rate	90% Confidence Limit	
			Lower Bound	Upper Bound
Law	1 (primary law)	12.67	9.21	16.12
Total Interstate (TI)	100 Miles	0.40	0.14	0.66
African American Population	1 Percent	-0.47	-0.82	-0.12
Highway Miles of Rural Road	10,000 Miles	-0.64	-1.14	-0.13
Fuel Tax (FT)	1 cent	0.39	0.04	0.75
Crime Rate (CR)	1 percent	2.77	0.90	4.63

After developing the model, it is necessary to evaluate the robustness of the model, where a good model predicts values within a reasonable range of the actual value. For example, if observed value of seat belt usage rate is 51% and the model predicts 68%, then there could be a serious problem in the overall model fitness. Methods explained in the methodology section were used in evaluating the robustness of the model. Figure 4.1 shows a plot of observed usage rate values vs. predicted values, where potential outlier states are marked. These observations have been identified as Louisiana, Maine, Massachusetts and Vermont and their significantly large residual values are shown in Table 4.3. This suggests that the model does not predict seat belt usage rate accurately for all the states, for which there could be several reasons, one of them being outliers in the dataset. Accordingly, further investigation was carried out and the assumptions of MLR models mentioned in section 3.2.5 were verified.

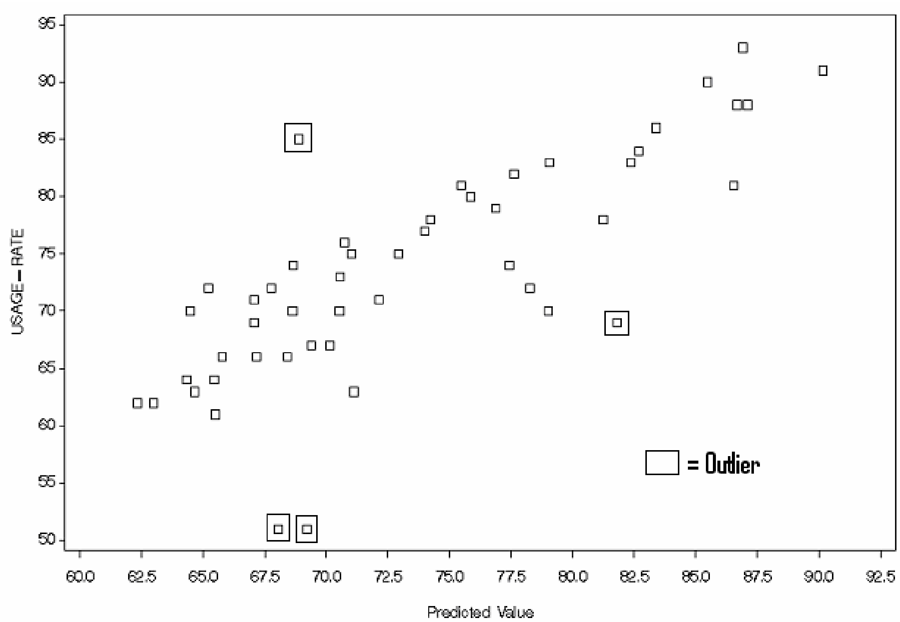


Figure 4.1: Observed Vs. Predicted Values for Seat Belt Usage Rate Model

Table 4.3: States with High Residuals in Seat Belt Usage Rate Model

State	Observed Value of Seat Belt Usage Rate	Predicted Value of Seat Belt Usage Rate	Residual (Observed – Predicted)
Louisiana	69	81.83	-12.83
Maine	51	69.20	-18.20
Massachusetts	51	68.08	-17.08
Vermont	85	68.89	16.10

Generally, MLR models have four basic assumptions as presented in section 3.3.5 However, in this situation, assumptions of constant variance and normal distribution of errors are the only two assumptions that need to be verified. Assumption of adequacy of linear regression model is automatically verified by using stepwise linear regression and assumption of independence of errors is usually critical for time series data. Assumption of constant variance of errors was verified by examining the standardized residual plot shown in Figure 4.2. If the assumption is satisfied, residuals should be evenly distributed about the horizontal reference line, which represents zero residual. Some patterns of residuals like U, inverted U or S shaped patterns indicate nonlinearity; a wedge pattern where the residuals are spread out more at one end of the x- axis than the other indicate non constant variance (SAS 8.1 User Guide, 1999). No particular trend or pattern exists in the residual plot shown in Figure 4.2, which confirms the fact that the assumption of constant variance is satisfied to a reasonable extent.

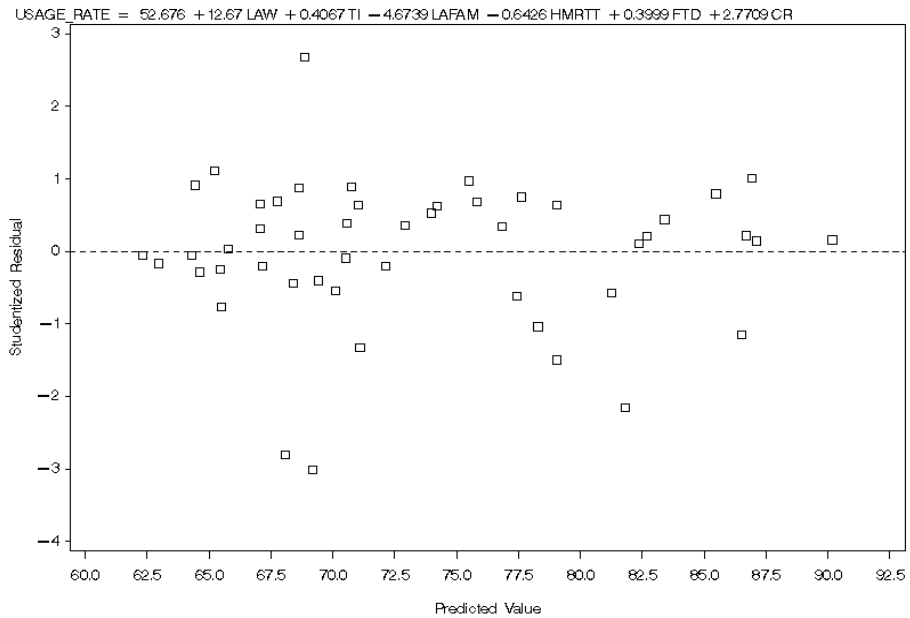


Figure 4.2: Standardized Residual Plots for Seat Belt Usage Rate Model

Another assumption is of normality of errors. Non-normality of errors usually occurs due to outliers. If observations with standardized residuals greater than ± 2 are present in a residual plot, then the possibility of outliers cannot be ruled out. Four observations were found with high residuals as shown in Table 4.3, where the standardized residual values were greater than ± 2 (see Figure 4.2). This required further investigation to check their influence on the model fitness. Outliers can also be identified by visual observation of normal probability plots and histograms, as explained in section 3.3.5. As seen in Figure 4.3, the Normal Probability Plot does not have a linear trend, with lower and upper most parts of the line deviating away from the straight line. This is a strong evidence of non-normality of errors. Histogram shown in Figure 4.4 is not symmetrical about the central axis giving further indications of non-normality of the errors. Additionally, value of kurtosis statistic is 2.38 and skewness statistic is -0.88

for this model. For standard normal distribution, these values should be close to zero, which again confirms non-normality of errors.

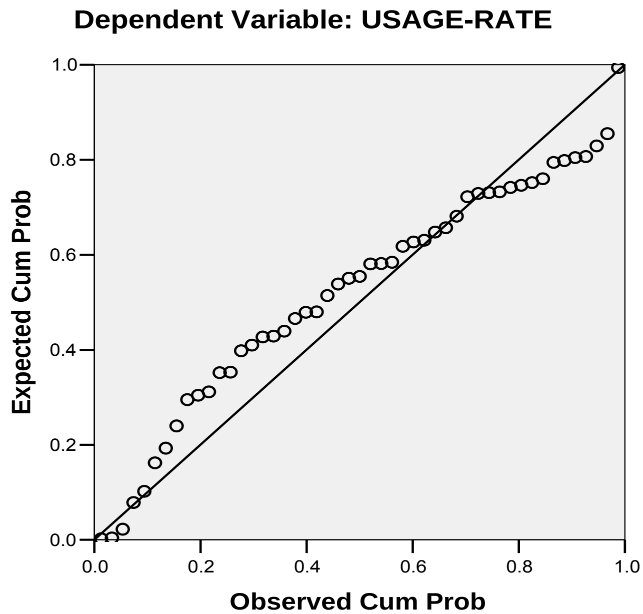


Figure 4.3: Normal Probability Plot for Seat Belt Usage Rate Model

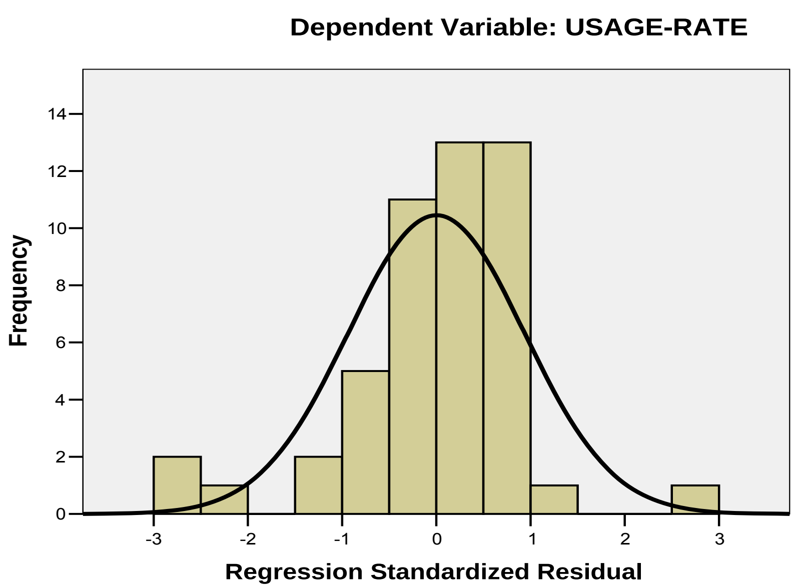


Figure 4.4: Residual Histogram for Seat Belt Usage Rate Model

Outliers with high leverage are termed as influential outliers. As explained earlier, these kinds of outliers distort the model and give biased results. To measure the influence of outliers DEFITS statistic was used, which measures the influence of i^{th} observation in its neighbourhood. Similarly, DFBETAS statistic was used to assess the effects of independent variables on the estimated regression parameters. DFBETA statistic helps to determine the reason for any state being identified as an outlier. All those variables, having DFBETAS value above the cut-off value are most likely the reason for any observation being identified as an outlier. Size adjusted cut off values of influence statistics for seat belt usage rate model are, DEFITS = $2\sqrt{p/n}$ = 0.70 and DFBETAS = $2/\sqrt{n}$ = 0.29. (Where p = parameters used in the model = 6, n = number of observations = 49). Table 4.4 summarizes outlier states, which had standardized residual values beyond ± 2 and did not satisfy the cut off criteria for DEFITS statistics.

Table 4.4: Outliers Based on Influential Statistics for Seat Belt Usage Rate Model

States	Standardized Residual Value	DEFITS Statistic
Louisiana	-2.14	-0.84
Maine	-3.01	-1.14
Massachusetts	-2.80	-0.95
Vermont	2.67	1.04

For outliers, variables taking unusually extreme values can be identified by DFBETAS criteria. Those above the cut-off criteria of 0.29, most likely are the reasons for these states being identified as extreme observations. As for example, average percentage of African American population in USA is 10.02 % and corresponding numbers are very low for Vermont (1%), Maine (~0) and very high (33%) for Louisiana. Due to this situation, DFBETA values for these states were above the cut-off criteria of

0.29. Similarly, law does not satisfy the DFBETA criteria in the state of Louisiana. One possible reason for this is that even though average usage rate for states with primary seat belt law is 85 % Louisiana has a usage rate of only 69% even with the primary seat belt law. This comparison can be done for other variables by comparing similar statistics in Table 4.5 and Table 4.6. Variables above the cut-off criteria for any observation are indicated in bold letters.

Table 4.5: Influence Statistics for Variables in the Seat Belt Usage Rate Model

State	**DFBETAS**					
	LAW	TI	LAFAM	HMR	FT	CR
Louisiana	**-0.31**	-0.16	**0.41**	-0.11	-0.20	**-0.31**
Maine	0.05	-0.03	**0.53**	**0.30**	0.07	**0.45**
Massachusetts	0.08	-0.26	-0.28	**0.58**	-0.04	**0.40**
Vermont	-0.07	-0.03	**-0.49**	**-0.32**	-0.25	**-0.38**

Table 4.6: Comparison of Variables of Outlier States with Average US Values for Seat Belt Usage Rate Model

State	Variables						
	UR	LAW	TI	AFAM	HMR	FT	CR
Louisiana	69	**1**	9.38	**33**	4.6963	20	**5.338**
Maine	51	0	3.85	**~0***	**2.0060**	22	**2.689**
Massachusetts	51	0	7.77	7	**1.2281**	21	**3.099**
Vermont	85	0	3.39	**1**	**1.2907**	20	**2.769**
US Average	73.53	NA	11.14	10.2	6.1435	20.19	4.033

**~0 = negligible value approaching zero*
NA – Not Applicable

UR = Usage rate, in percent

LAW = Seat belt law in the state

TI = Total miles of interstate road, in hundreds

AFAM = African American population, in percent

HMR = Highway miles of rural road, in ten thousands

FT = Fuel tax in cents per gallon

CR = Crime rate, in crimes per million population

Note that African- American Population in Table 4.6 corresponds to LAFAM in Table 4.5 but their units do not match as this variable was transformed to logarithmic form for model fitting purpose. For comparing the states, African American Population in percent, is used in Table 4.6.

Based on all these considerations, it is found that the developed model violates the basic assumptions of multiple linear regression modeling. Accordingly, the identified outliers were removed from the data set and another improved model was developed for representing the average states including Kansas, which is referred to as the Modified Seat Belt Usage Rate Model.

4.1.2 Modified Seat Belt Usage Rate Model

Modified model was developed after removing Louisiana, Maine, Massachusetts and Vermont from the original data set. New-Hampshire and Washington DC were not considered for analysis anywhere in this study, and hence total number of states included in the modified model development reduced to forty four. Variables included in the modified model are summarized in Table 4.7. Modified model showed better results with a higher R^2 value of 0.843 as compared to 0.617 in the original model. Median household income and log of penalty were two additional variables, which were identified as significant factors affecting seat belt usage rate in an average state. Results obtained are discussed in detail in section 4.1.3.

Table 4.7: Modified Seat Belt Usage Rate Model

Variable Name	Label	Parameter Estimate	Standard Error	t-value	Pr > t
Intercept	---	38.73	6.88	5.62	<0.00
Seat Belt Law	LAW	11.49	1.37	8.34	<0.00
Total Miles of Interstate Road	TI	0.36	0.09	3.94	0.000
Log of Percentage of African American Population	LAFAM	-3.53	1.29	-2.74	0.009
Highway Miles of Rural Road	HMR	-0.65	0.19	-3.33	0.002
Fuel Tax	FT	0.43	0.12	3.41	0.001
Crime Rate	CR	2.65	0.68	3.88	0.004
Log of Penalty	LPEN	4.79	2.76	1.73	0.091
Median Household Income	MHI	1.85	0.96	1.91	0.063
R^2 – 0.8439					

Robustness of the model was tested again using the methods explained earlier. The plot of observed versus predicted values for the modified model is shown in Figure 4.5, where it can be observed that the model shows a better linear trend without any evidence of extreme observations. No evidence of non-normality of errors can be found in the Normal Probability Plot and Histogram shown in Figures 4.6 and 4.7 respectively, as well. Kurtosis statistic is much closer to zero at -0.57 in the modified seat belt model compared to 2.38 in the original seat belt model with outliers. Similar comparison can be done for skewness statistics and corresponding figures are -0.42 and -0.88 respectively.

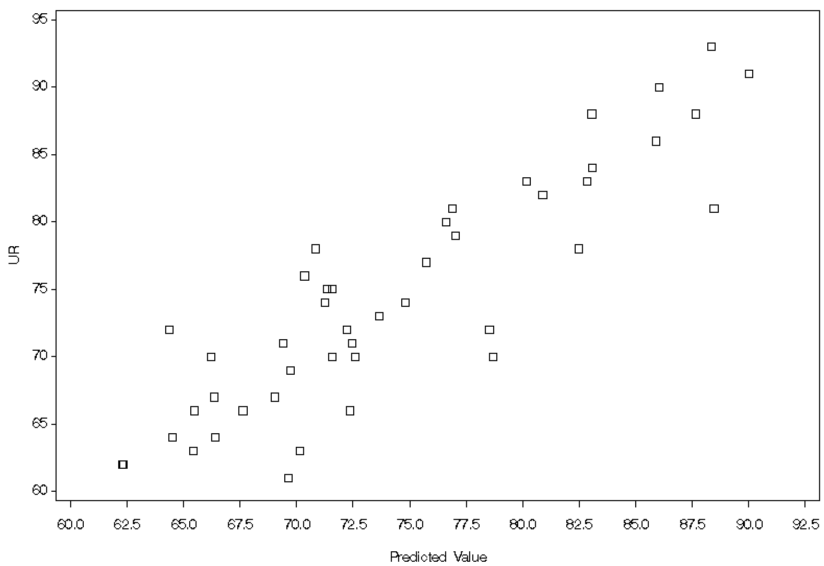


Figure 4.5: Observed Vs Predicted Values for Modified Seat Belt Usage Rate Model

Except for median household income and log of penalty, all other variables were common in both models. For the common variables, probability value (*p*-value) for the modified seat belt model is lower than that for seat belt model, which means variables are even more significant. As mentioned previously in section 3.2.4, lower *p*-value implies higher probability of rejecting a null hypothesis, which states that the results are obtained by mere co-incidence. Standard errors for all the variables also decreased in the modified model resulting in narrower and more precise confidence intervals for the regression coefficients.

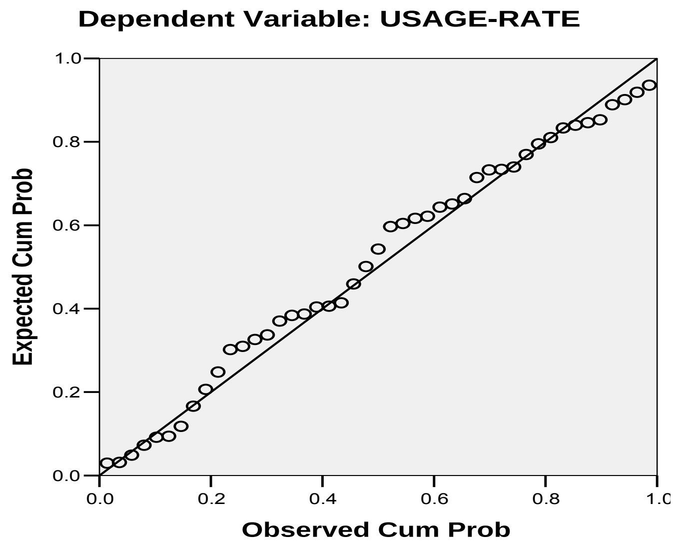


Figure 4.6: Normal Probability Plot for Modified Seat Belt Usage Rate Model

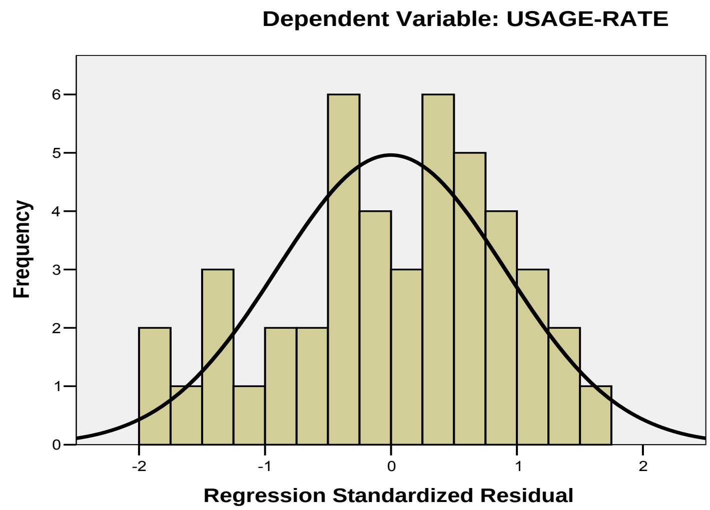


Figure 4.7: Residual Histogram for Modified Seat Belt Usage Rate Model

This model can be written in the form of equation as:

Usage_Rate = 38.73 + 11.49 (LAW) + 0.36 (TI) -3.53 (LAFAM) – 0.65 (HMR) +0.43

(FT) + 2.65 (CR) + 4.79 (LPEN) + 1.85 (MHI) Equation 4.2

Where,

Usage_Rate	= Seat belt usage rate
LAW	= Seat belt law,
TI	= Total miles of interstate roads in hundreds
LAFAM	= Log of percentage of African American population
HMR	= Highway miles of rural road in ten thousands
FTD	= Fuel tax in cents per gallon
CR	= Crime rate as total number of crime/one million population
LPEN	= Log of penalty charged for seat belt law violations
MHI	= Median Household Income in ten thousand dollars

Confidence interval for change in seat belt usage rate by one unit increase in an independent variable while keeping all other variables constant is calculated as shown in Table 4.8.

Table 4.8: Individual Effects of Response Variables on Seat Belt Usage Rate Identified using the Modified Model

Response Variable	Increase in Response Variable	Percent Increase in Seat Belt Usage Rate	90% Confidence Limit	
			Lower Bound	Upper Bound
Law	1 (Primary law)	11.49	9.16	13.82
Total Interstate (TI)	100 Miles	0.36	0.21	0.52
African American Population (LAFAM)	1 Percent	-0.35	-0.57	-0.14
Highway Miles of Rural Road	10,000 Miles	-0.65	-0.98	-0.32
Fuel Tax (FT)	1 cent	0.43	0.22	0.65
Crime Rate (CR)	1 percent	2.65	1.49	3.80
Penalty (LPEN)	10 Dollars	4.79	0.12	9.47
Median Household Income (MHI)	10,000 Dollars	1.85	0.21	3.49

4.1.3 Description of the Results

A statistical model may be robust in predicting the response variable, but it is also important that the variables make sense or represent what is generally perceived or expected. Hence, it is important to evaluate the obtained results in terms of the effect of each variable on seat belt use and check their practical implications. This section deals with serving that purpose.

Seat belt law (LAW) - As that could be expected, seat belt law has the most significant effect on seat belt usage rate in a state. According to the model results, seat belt usage rate could be expected to increase by 11.49 % (90% CI = 9.16 to 13.82), if secondary seat belt law is to be changed to primary seat belt law. This result matched closely with the past research and experience of other states in similar situations. Examples are states like Michigan, New Jersey and Alabama that switched from secondary to primary law in 2000 and showed 14 %, 11 %, and 13% increases respectively in seat belt usage rate (Traffic Safety Facts, 2004). State of Washington also had an increase in seat belt usage by 12% in 2003, within one year of switching from secondary to primary law. Similarly, Oklahoma, Maryland and Washington D.C all showed improvements of 9-14% after switching to primary law (NHTSA, 2001). Difference in seat belt usage rate due to seat belt law can be clearly seen by comparing the seat belt usage rate in states with primary law with that of secondary law. Average seat belt usage rate for secondary law states in 2002 was 73.46 % as compared to 84.45% for states with primary law. One of the potential reasons for this difference is that police officers are more likely to issue tickets if the law is primary, since it provides higher authority. Therefore, drivers in such states are more concerned about being penalized for violating the law and as a result of that, may wear seat belts more frequently. Previous research also confirms that a driver in a state with primary seat belt law perceives a higher risk of punishment or penalty compared to a driver in a state with secondary seat belt law (Shults et al, 2004). Accordingly, the results strongly suggest the need of enacting primary seat belt law in Kansas for increasing seat belt usage rate where the expected improvement is estimated to be around 11.49 % or within the range of 9.16 to 13.82 %.

Penalty for Seat Belt Violation (LPEN)– Another important factor that could considerably affect the seat belt usage rate in Kansas is the amount of the penalty for seat belt law violation, which currently stands at $ 10. According to the estimates using the modified seat belt model, by increasing the penalty by $10 the average usage rate could be expected to go up by 4.79% (90% CI 0.12 to 9.47). However, it should be noted that this variable was not identified as significantly important in the original seat belt usage rate model and also no past studies that studied the effect of the penalty on the seat belt behavior was available. But it conforms to the general perception that increased penalty would encourage more people to wear the seat belts.

Median Household Income (MHI) – The model provided a positive parameter for the variable on median household income, indicating that increased median household income is going to increase the seat belt usage rate in a state. Quantitatively, a $ 10,000 increase in median household income is estimated to increase the usage rate by 1.85 % (90% CI 0.21 to 3.49). This finding makes logical sense as higher income levels generally mean higher education levels and it could be expected that educated people are more likely to use better judgments in matters like seat belt use as well. Studies in the past have also found that people with lower socio-economic conditions are less likely to use seatbelts (Hunter et al, 1988; Preusser et al 1989; Wagenaar et al 1987; Shinar, 1993; Lerner et al, 2001).

Log of African American Population (LAFAM) – Model shows a negative parameter for the variable log of African American population. This indicates that African American population has an inverse relationship with seat belt usage rate. Modified model estimated that a 1 percent increase in African American population would result in a decrease in seat belt use by 0.35 % (90 % CI =0.57 to 14)

Results obtained by the model were found to be consistent with past research. A study done by Reinfurt et a. (1990) found that seat belt use is higher among Caucasian whites than among African Americans. Another study also found that percentage of African-American population is inversely proportional to seat belt use and accounts for 5-9 % variability in seat belt use (Shinar, 1993). According to a research by Meharry

Medical College, African American youth are 50 to 60% less likely to be buckled up than children from other racial/ethnic backgrounds (Gantz et al, 2003).

Crime Rate (CR) – Crime is associated with violation of law. Perception for considering this variable in the model was that if crime rate is high, there are more people violating laws and seat belt usage rate is also likely to be low. But the results obtained by the models, proved this to be otherwise. Modified model estimates that seat belt use would increase by 2.65 % (90 % CI =1.49 to 3.80), if crime rate increases by 1 %. One plausible reason for this situation is the feeling of insecurity people might have in areas with higher crime rate. This psychological fear of an unsafe environment might be increasing the seat belt use. Moreover, with increased crime rate, there could be more frequent patrolling by and visibility of law enforcement officers, which could lead to higher seat belt use by the general population.

Fuel Tax (FTD) – Fuel tax is the amount of tax charged per gallon of fuel. The model estimates an increase in seat belt use by 0.43 (90% CI = 0.22 to 0.65) percent, for an increase in fuel tax by one cent, which was as expected. One important fact that justifies this finding is the use of a portion of the collected fuel tax in funding safety programs and highway developments, repair, and maintenance projects. These safety programs include education and training programs for general public, higher enforcement of laws and media coverage of strict enforcement like “Click It or Ticket” campaigns. Dramatic increases in seat belt use were observed during “Click-It or Ticket” campaigns, in states like Hawaii, North Carolina, Illinois, and Michigan etc. A greater part of collected fuel tax is utilized for highway development, maintenance, and repair, which would result in better highways in terms of higher number of lanes, reduced congestion, comfortable ride, lesser travel times etc. Better highway infrastructure leads to driving at higher speeds and longer trips. Drivers who drive at higher speeds and longer distance are more likely to buckle up (Bohlin, 1967), which is also one of the reasons for higher seat belt usage on interstate roads.

Highway Miles of Rural Roads (HMR) – Results obtained by the model shows an inverse relationship between seat belt use and highway miles of rural roads. Model estimates a decrease in seat belt use by 0.65 % (90% CI =0.32 to 0.98) for 10000-mile increase in highway miles of rural roads. This finding reflects the characteristics of road users where drivers are less likely to wear seat belts in rural areas partly encouraged by the lower law enforcement levels on rural roads. According to Traffic Safety Center (2004), majority of people involved in fatal-rural crashes were those who live in rural areas and one reason for high fatality rate in rural areas is low seat belt use. Considering rural fatalities that experienced rollovers, it was found that 79 % of pickup truck occupants were unbelted and 68 % of SUV occupants were unbelted (NHTSA, 2002).

4.2 UNRESTRAINED OCCUPANT FATALITY MODEL

As per National Center for Statistical Analysis, most passenger vehicle occupant fatalities continue to be unrestrained (NHTSA, 2003a). In 2002, 56 % of fatally injured people were unrestrained. Since the seat belt usage rate model estimated that seat belt law significantly affects the seat belt use, it was decided to estimate how many unrestrained occupant fatalities could be avoided by enacting primary seat belt law. Multiple Linear Regression models were developed by considering percentage of unrestrained occupants among fatally injured as the dependent variable. Eight factors that were identified as significantly affecting unrestrained occupant fatality percentage are summarized in Table 4.9. Unrestrained occupant fatality model is hereafter referred to as UOF Model.

Table 4.9: Unrestrained Occupant Fatality Model

Variable Name	Variable Label	Parameter Estimate	Standard Error	t-value	Pr > t
Intercept	---	70.45	10.13	6.95	<0.00
Seat Belt Law	LAW	-10.34	1.64	-6.29	<0.00
Log of Hispanic and African American Population	LHAF	6.56	2.24	2.92	0.005
Young Drivers Between Age of 16-24	YD	0.84	0.48	1.74	0.089
Percentage of Fatalities with BAC > 0.08 g/dl	PBAC	0.46	0.13	3.52	0.001
Total Miles of Interstate Road	TI	-0.17	0.10	-1.74	0.088
Percent of Unemployed Labor Force	UNEMP	-2.88	0.81	-3.52	0.001
Median Household Income	MHI	-5.79	1.19	-4.84	<0.00
R^2 = 0.7586					

*Negative sign indicates decrease

This model describes the relationship as follows:

UOF = 70.45 – 10.34(LAW) + 6.56 (LHAF) + 0.84 (YD) + 0.46 (PBAC) – 0.17 (TI) – 2.88 (UNEMP) - 5.79 (MHI) Equation 4.3

Where,

UOF = Percentage of unrestrained occupants among fatally injured

LAW = Seat belt law, (“1” for primary law and “0” for secondary)

LHAF = Log of percentage of Hispanic and African American population

YD = Percentage of young drivers (16-24 years)

PBAC = Percentage of fatalities in which fatally injured driver/occupant had blood alcohol concentration above 0.08 g/dl

TI = Total miles of interstate roads, in hundreds

UNEMP = Percentage of unemployed labor force

MHI = Median household income, in ten thousands of dollars

Unrestrained occupant fatality model provided a reasonably good fit with an R^2 value of 0.7586. As explained previously, it is necessary to check the robustness of the model by verifying the two valid assumptions of Multiple Linear Regression i.e. assumption of constant variance and normality of errors. The assumption of constant variance is verified using the standardized residual plot shown in Figure 4.8, which does not show any pattern that would suggest presence of a non-constant variance or non-linearity. Hence it was concluded that the assumption of constant variance is valid. The other assumption is of normality of error. One extreme observation was found from preliminary examination of Figure 4.9 as highlighted in the plot and identified as Louisiana.

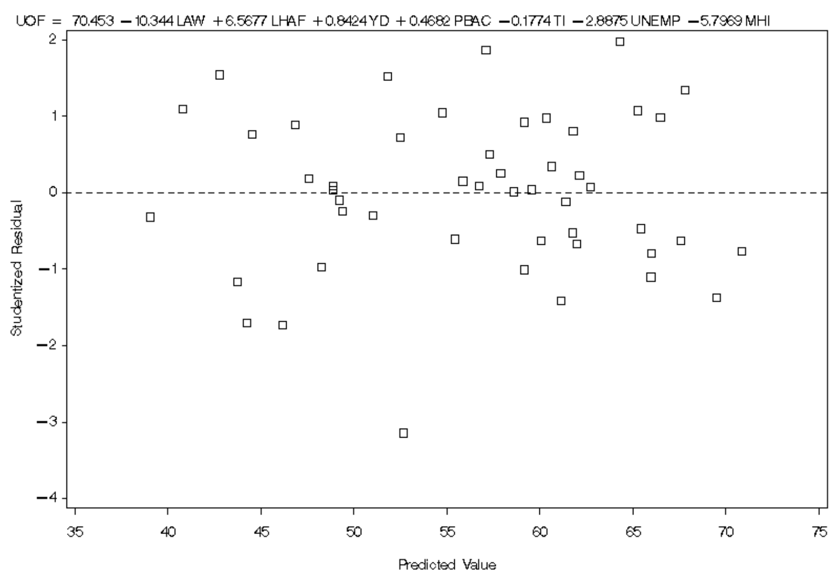


Figure 4.8: Standardized Residual Plot for UOF Model

However, errors seem to be normally distributed from the Normal Probability Plot and Histogram shown in Figures 4.10 and 4.11, respectively. Also, value of kurtosis statistic is 0.54 and skewness is -0.40, which is close to zero for standard Normal Distribution. Even though a model was developed by removing the outlier, no significant improvement was found with respect to normal distribution. Additionally, the model with this potential outlier observation did not show any serious problem of non-normality that would distort the analysis, as a few outliers did in the previous model. Taking these factors into consideration, potential outlier was not removed and unrestrained occupant fatality model with all states was considered in identifying critical factors.

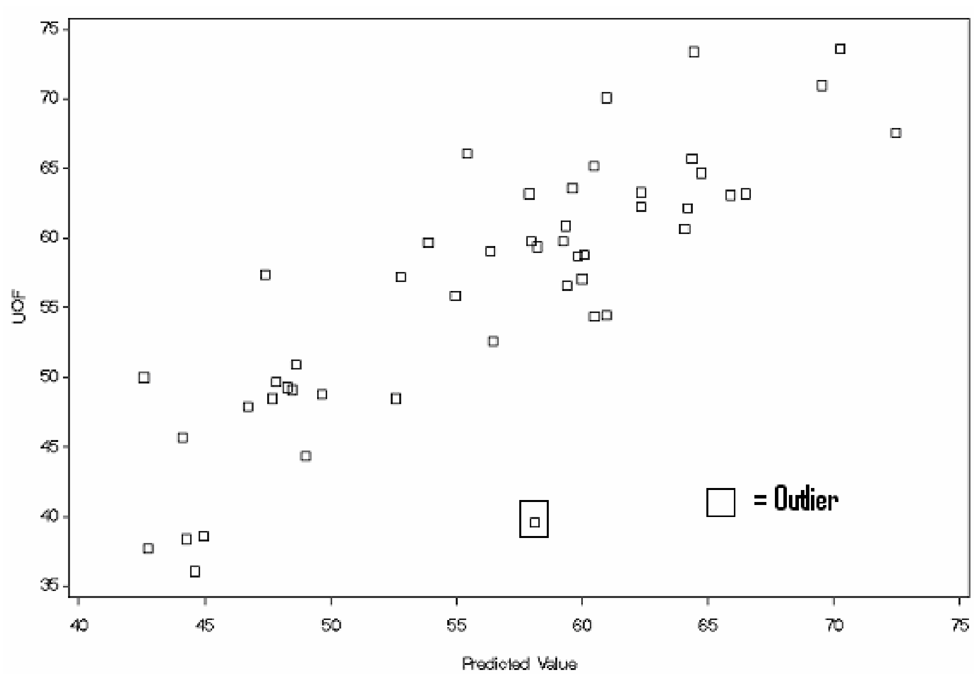


Figure 4.9: Observed Vs Predicted Values for UOF Model

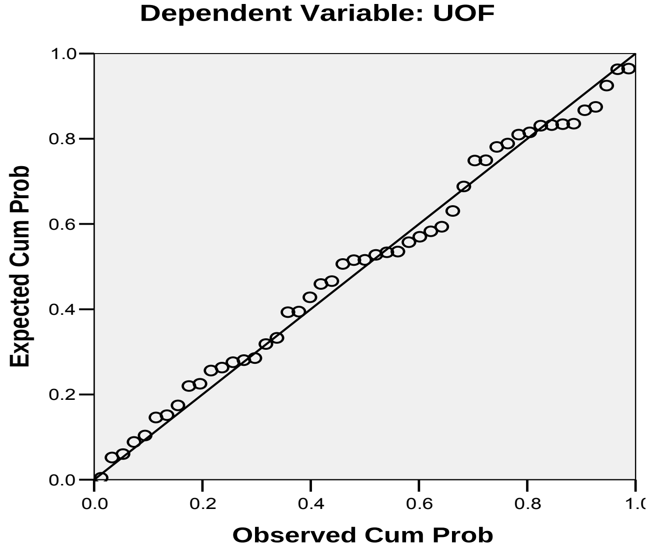


Figure 4.10: Normal Probability Plot for UOF Model

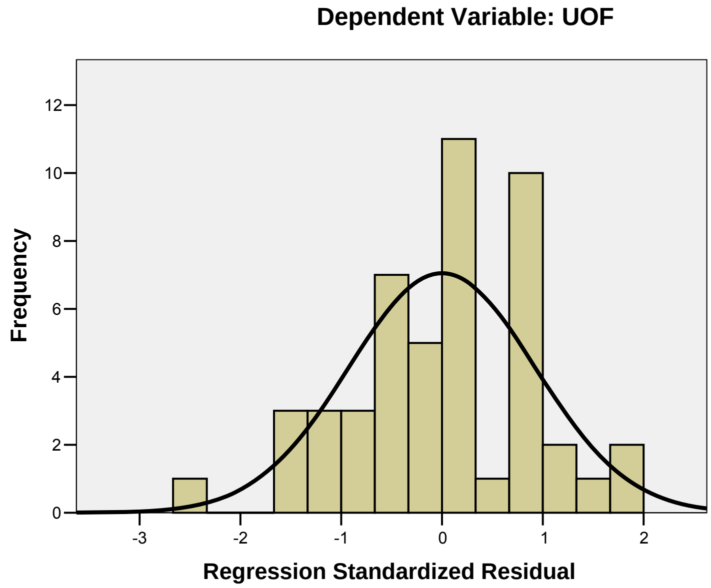


Figure 4.11: Residual Histogram for UOF Model

4.2.1 Description of Results

Equation 4.3 estimates an increase in percentage of unrestrained occupant fatalities with the increase in Hispanic and African American population, young drivers, and fatalities with high blood alcohol concentration. Similarly, unrestrained occupant fatality percentage decreases with primary seat belt law, total miles of interstate road, median household income, and percentage of unemployed labor force. Estimated changes are calculated with 90 % confidence as shown in Table 4.10.

Table 4.10: Individual Effects of Response Variable on Unrestrained Occupant Fatality Percentage

Response Variable	Increase in Response Variable by	Increase in Percent of Unrestrained Occupant Fatalities	90% Confidence Limit	
			Lower Bound	Upper Bound
Law	1 (primary law)	-10.34	-13.11	-7.57
LHAF	1 percent	0.656	2.78	10.34
YD	1 percent	0.84	0.02	1.65
PBAC	1 percent	0.46	0.24	0.69
TI	100 miles	-0.17	-0.34.	-0.006
UNEMP	1 percent	-2.88	-4.26	-1.50
MHI	10,000 dollars	-5.79	-7.81	-3.78

All variables identified by the unrestrained occupant fatality model closely matched with previous research findings and the trends in traffic fatalities. Moreover the variables also supported the seat belt usage rate model, described previously.

Log of Hispanic and African American Population (LHAF) – Seat belt use is low among African American and Hispanic populations compared to other groups as found using the seat belt usage rate model. As this is directly related to unrestrained occupant fatalities, it was expected that percentage of unrestrained occupant fatalities would increase as African American and Hispanic population increased. UOF Model yielded the expected results, estimating an increase in unrestrained occupant fatalities by 0.65 % (90 % CI = 0.27 to 1.03) for one percent increase in the population.

Research in the past has also found that Hispanics and African Americans are more likely to be involved in fatal crashes compared to other counterparts. Harper et al (2000) found that Hispanic drivers who were fatally injured had lower probability of wearing a seat belt compared to Caucasian whites. Similarly, a study by Braver (2003) found that both African American males and females who were fatally injured were less likely to wear seat belts. The model developed here estimated results consistent with these previous studies.

Median Household Income (MHI) – Median household income is directly correlated to the education level of the family members. Educated people are more likely to think and act logically, which might result in higher seat belt use. Based on this thinking, drivers with high socio-economic conditions are more likely to use seat belts and hence experience lower unrestrained fatalities compared to drivers with lower socio-economic conditions. Model yielded results consistent with this concept and estimated a decrease in unrestrained occupant fatalities by 5.79 % (90% CI =3.78 to 7.81) with an increase in median household income by ten thousand dollars. Studies in the past have also found strong correlation between socio-economic status and traffic safety outcome and suggest that people with lower socio-economic conditions are less likely to use seatbelts (Hunter et al, 1988; Preusser et al 1989; Wagenaar et al 1987; Shinar, 1993; Lerner et al, 2001).

Percentage of Fatalities with driver having BAC >0.08 g/dl (PBAC) – In most states, blood alcohol concentration levels above 0.08 are considered as intoxication for driving purposes. It is generally perceived that under the influence of alcohol, a driver is less likely to wear a seat belt and more likely to be involved in a crash. This is consistent with the model results, indicating higher unrestrained occupant fatalities with more intoxicated drivers. Unrestrained occupant fatalities increase by 0.46 % (90% CI = 0.19 to 0.73) for 1 % increase in intoxicated drivers. Previous studies have also found that greater alcohol consumption is related with higher number of traffic fatalities (Calkins, 2001). Moreover, non-users of seat belts are more likely to drink and drive (Lawson et al, 1982).

Percentage of Unemployed Labor Force (UNEMP) - Model predicts a decrease in unrestrained fatalities by 2.88 % (90 % CI = 1.23 to 4.54) with 1 % increase in unemployment. Economic conditions and personal income are directly correlated with total vehicle miles traveled. In a study of highway fatalities and unemployment, Leigh et al (1991) found that higher unemployment leads to higher number of traffic fatalities when adjusted for vehicle miles traveled. But, as travel decreases with unemployment, number of fatalities also decreases.

Seat Belt Law (LAW) –The UOF model estimates that changing from secondary to primary seat belt law would result in a reduction in unrestrained occupant fatalities by 10.34 % (90% CI = 7.57-13.11). This conforms to many previous studies that have found that number of fatalities decrease with increased seat belt use. According to one such study, changing from primary to secondary seat belt law reduced occupant fatalities by an estimated 7 % (Farmer et al, 2005). California changed from secondary to primary law in 1993, due to which fatalities reduced by 16% in the first five months compared to the corresponding months in previous years with secondary law (Ulmer and Preusser, 1994). In Kansas, as per Fatality Analysis Reporting System, a total of 477 occupants were fatally injured in crashes in 2002 and 60.7 % (290) of these occupants were unrestrained. If Kansas had primary seat belt law instead of secondary seat belt law, approximately 22-38 lives could have been saved in year 2002 alone, according to the predictions of this model.

Total Miles of Interstate Road (TI) – Seat belt usage rate model predicted that seat belt use is high on interstate, which is consistent with observational survey results on seat belt use. This would indirectly indicate a decrease in unrestrained occupant fatalities with increased interstate mileage. UOF model estimated a reduction in unrestrained occupant fatalities by 0.17 % (90% CI = 0.006 to 0.34) for a hundred-mile increase in interstate highway mileage. As per Fatality Analysis Reporting System in 2003, 12 percent of fatalities were on interstates, which is lesser as compared to approximately 21 percent on minor arterials and 19 percent on collectors even though exposure needs to be considered in making a true comparison.

Young Drivers (YD) – Young drivers in the age group of 16-24 years have low seat belt use and highest fatality rates compared to any other age group. Approximately 25% of fatally injured drivers in the United States were in the age group of 16-24 years in 2002 (FARS, 2002), for whom it is the leading cause of death. Results obtained by this model also estimated that unrestrained occupant fatalities increase with the increase in young driver population. One percent increase in young drivers is estimated to increase unrestrained occupant fatalities by 0.84 % (90% CI = 0.02 to 1.65). This could partly be due to inexperience and aggressive behaviors of young drivers. Moreover, the tendency of drinking and driving is also high in this age group. As per National Safety Council, about 30% of crashes killing young drivers involve alcohol. In 2002, 64 % of 16-20-year-old passenger vehicle occupants killed in crashes were not wearing seat belts (NHTSA, Traffic Safety Facts 2002, 2003). According to Insurance Institute of Michigan about 15 % of young drivers are involved in traffic crashes each year. In comparison, only 5 % of 55-64-year-olds are involved in roadway crashes annually. Similarly, National Safety Council estimates that young drivers represent only 6.6% of the nation's licensed drivers but they are involved in 14.8% of fatal crashes. These statistics show that younger drivers have a greater involvement in fatal crashes than other age groups.

4.3 FATALITY RATE AND MODIFIED FATALITY RATE MODELS

In unrestrained occupant fatality model, it was found that primary seat belt law decreases the percentage of unbelted fatalities. But along with unrestrained fatality percentage, it was thought to be useful to determine the effect of seat belt law and other factors on the total number of occupant fatalities. Number of fatalities in each state was divided by the population of that state in thousands to calculate the fatality rate, which is considered as the dependent variable for modeling. By using Multiple Linear Regression, a fatality rate model was developed by considering all the states except New Hampshire and District of Columbia. Since this model failed to satisfy basic assumptions of MLR modeling, another model to represent average states including Kansas was developed by removing the outlier states and is referred to as the modified fatality rate model. This section describes the results obtained through modeling and provides an explanation of the identified factors using the modified model.

4.3.1 Fatality Rate Model

Through MLR modeling, fatality rate model identified seven variables as significantly affecting the fatality rate in a given state, as summarized in Table 4.11.

Table 4.11: Fatality Rate Model

Variable Name	Variable Label	Parameter Estimate	Standard Error	t-value	Pr > t
Intercept	---	0.320	0.081	3.94	0.000
Seat Belt Law	LAW	-0.028	0.010	-2.79	0.007
Log of Hispanic and African American Population	LHAF	0.041	0.016	2.57	0.013
Median Household Income	MHI	-0.031	0.010	-3.18	0.002
Maximum speed limit law	MAXSPEED	0.036	0.011	3.28	0.002
Mean Travel Time to Commute to Work, in Minutes	TT	-0.003	0.001	-1.96	0.056
Percentage of Rural Population	RP	0.001	0.000	3.00	0.004
Fuel Tax in Dollars	FT	-0.001	0.001	-1.85	<0.07
R^2 =0.7763					

Equation 4.4 provides the relationship between the response variable, fatality rate and predictor variables shown in Table 4.11.

FRATE = 0.32 -0.02(LAW) + 0.04(LHAF) – 0.03(MHI) + 0.03(MAXSPEED) -

- 0.003 (TT) + 0.001 (RP) - 0.001 (FT) Equation 4.2

Where,

FRATE = Total number of vehicle occupant fatalities per 1000 population

LAW = Seat belt law, ("1" for primary law and "0" for secondary law)

LHAF = Log of percentage of Hispanic and African American population

MHI = Median household income, in ten thousand dollars

MAXSPEED = Speed limit law, ("1" for states if highest speed limit in the state is above 70 mph and "0" otherwise)

TT = Mean travel time for commuting to work, in minutes

RP = Rural population, in percentage

FT = Fuel tax charged per gallon of gas, in cents

Similar to previous models, assumptions of constant variance and normality of errors were verified first by examining the plot of observed versus predicted values and

Standardized Residual plot shown in Figures 4.12 and 4.13 respectively. The standardized residual plot does not suggest any particular trend to confirm the existence of non-constant variance. Some extreme observations, which have standardized residual values greater than ± 2 were observed and are highlighted in Figure 4.12. Normal probability plot shown in Figure 4.14 and Histogram given in Figure 4.15 suggest non-normality of the error term. This is evident from quantitative values of Kurtosis (5.39) and Skewness (1.65) statistics, which are farther away from zero. From these statistics and plots, it was found that the model fails to satisfy the basic assumption of normality of errors in MLR models, most likely due to few outliers in the dataset. These outliers were identified as Maryland, Montana, North Dakota, and Wyoming based on various statistics like standardized residuals greater than ± 2 and influential statistics i.e. DEFITS statistics and by visual observations of plot of observed versus predicted values (Figure 4.12) as well as residual plot (Figure 4.13).

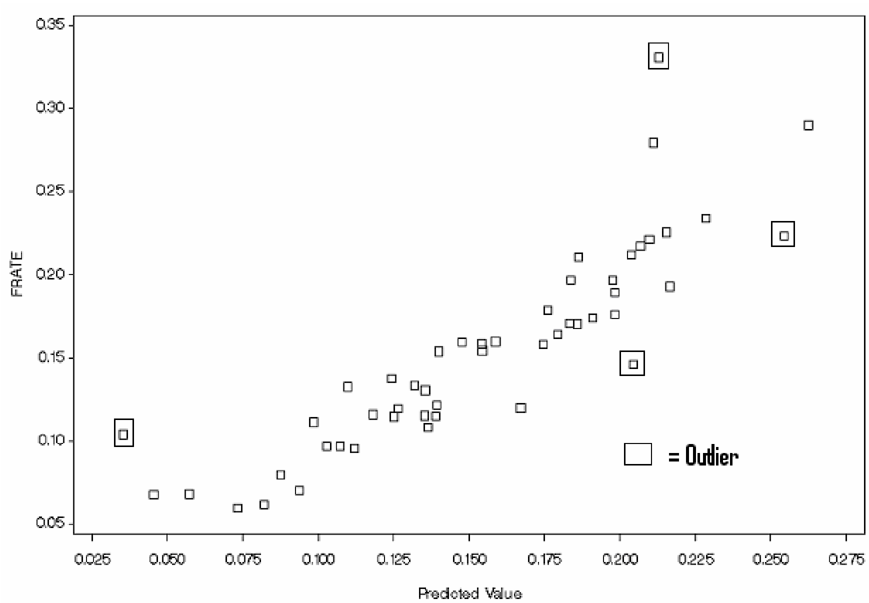


Figure 4.12: Observed Vs Predicted Values for Fatality Rate Model

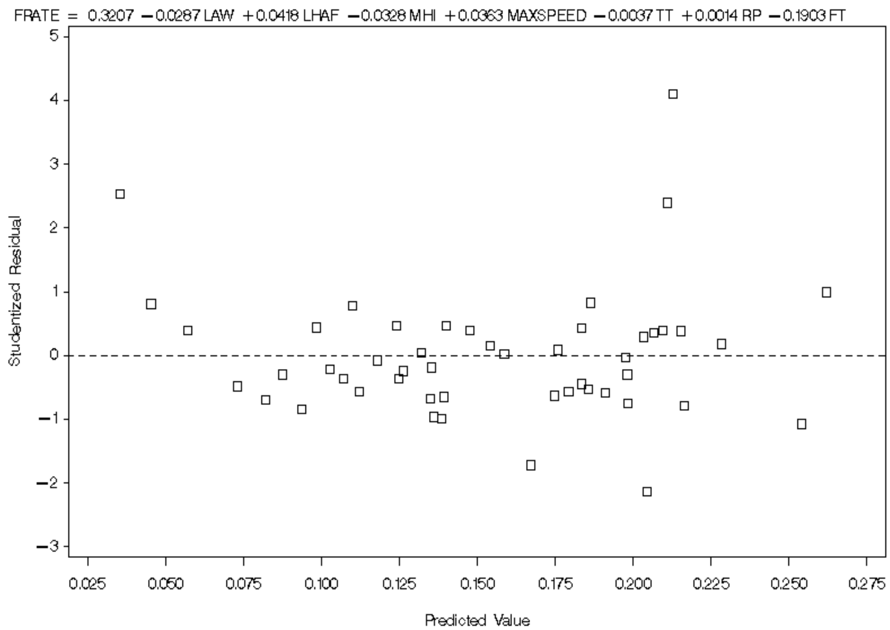


Figure 4.13: Standardized Residual Plot for Fatality Rate Model

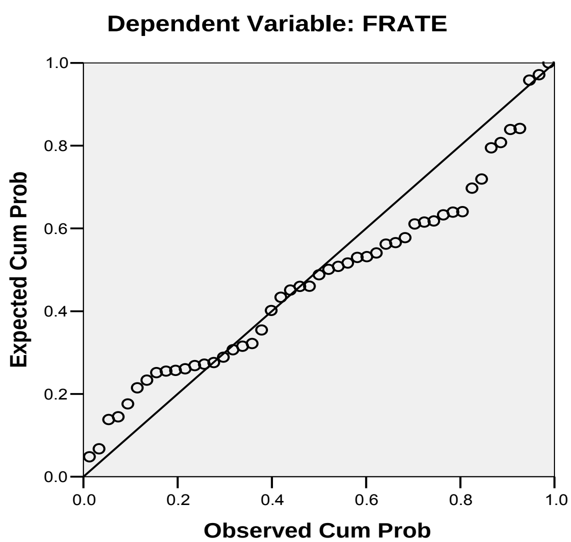


Figure 4.14: Normal Probability Plot for Fatality Rate Model

As mentioned previously observations that were isolated based on the criteria of standardized residual greater than $\pm$ 2 and/or DEFITS > 0.75, ($2\sqrt{p/n}$, where p = no.

of parameters in the model, n = no. of observations) are summarized in Table 4.12. These outliers are most likely due to extreme values of the independent variables in the model. These variables can be identified based on DFBETAS criteria as mentioned earlier in the seat belt usage rate model. Cut-off values for DFBETAS criteria = $2/\sqrt{n}$ = 0.29. (n=total number of observations).

Table 4.12: Outliers Based on Influential Statistics for Fatality Rate Model

State	Standardized Residual	DEFITS
Maryland	2.53	1.56
Montana	2.39	1.12
North Dakota	-2.12	-1.19
Wyoming	4.10	4.10

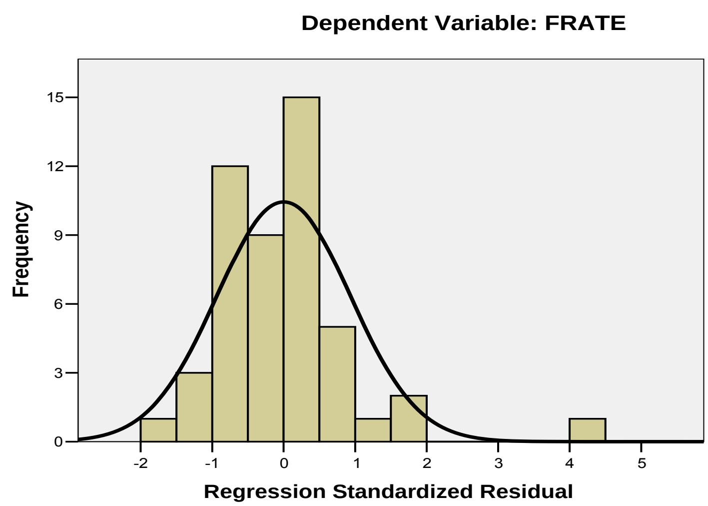


Figure 4.15: Residual Histogram for Fatality Rate Model

Table 4.13: DFBETA Statistics for Outlier Observations in Fatality Rate Model

States	LAW	LHAF	MHI	MAXSPEED	TT	RP	FT
Maryland	**0.42**	0.09	**0.87**	0.05	**0.68**	**0.65**	**0.70**
Montana	0.02	**-0.52**	**-0.37**	0.17	-0.03	-0.20	**0.35**
North Dakota	-0.03	**0.78**	**-0.30**	-0.22	0.15	**0.40**	0.22

Table 4.14: Comparisons of Variables of Outlier States with Average US Values for Fatality Rate Model

Wyoming	**-0.40**	**-0.41**	**-0.32**	0.28		**-0.95**	**-0.68**	**-1.52**
States	FRATE	LAW	LHAF	MHI	MAXSPEED	TT	RP	FT
Maryland	38.4	1	27	5.5	0	31.2	13.93	23.5
Montana	71	0	2	3.2	0	17.7	45.89	27
North Dakota	73.6	0	1	3.5	1	15.8	44.08	21
Wyoming	65.7	0	5	4.0	1	17.8	34.88	14
USA Average	*56.41*	NA	*17.79*	*4.25*	NA	*23.51*	*28.05*	*20.19*

Comparing Tables 4.13 and 4.14, it was observed that those variables, which are considerably higher or lower than average US values, do not satisfy the DFBETA criteria. For example, Log of Hispanic and African American Population have very low values for Montana, North Dakota and Wyoming. Due to this, DFBETA for this variable is higher than the cut-off value of 0.29 for those states.

4.3.2 Modified Fatality Rate Model

Modified Fatality Rate model was developed by removing the outliers detected in the fatality rate model. All those observations with standardized residual values above $\pm$ 2 and influence statistics above the cut-off criteria were removed from the original dataset considered in developing the fatality rate model. Accordingly, the new data set used for modeling excluded Maryland, Montana, North Dakota, and Wyoming.

The results obtained by the modified fatality rate model are summarized in Table 4.15. Variables identified by the modified model were the same as for the fatality rate model, even though differences were observed in the parameters estimates.

Table 4.15: Modified Fatality Rate Model

Variable Name	Label	Parameter Estimate	Standard Error	t-value	Pr > t
Intercept	--	0.323	0.057	5.60	<0.000
Seat Belt Law	LAW	-0.029	0.006	-4.77	<0.000
Log of Hispanic and African American Population	LHAF	0.044	0.010	4.21	0.000
Median Household Income	MHI	-0.035	0.006	-5.41	<0.000
Maximum Speed Limit Law	MAXSPEED	0.033	0.006	5.17	<0.000
Mean Travel Time to Commute to Work, in Minutes	TT	-0.003	0.001	-3.02	0.004
Percentage of Rural Population	RP	0.001	0.000	4.58	<0.000
Fuel Tax in Cents	FT	-0.180	0.066	-2.73	0.009
R^2 = 90.47 %					

Modified model can be expressed in the form of an equation as follows:

FRATE = 0.323 -0.029 (LAW) + 0.044 (LHAF) – 0.035 (MHI) + 0.033 (MAXSPEED)

- 0.003 (TT) + 0.001 (RP) - 0.001 (FT) Equation 4.3

Where,

FRATE = Total number of vehicle occupant fatalities per 1000 population

LAW = Seat belt law, “1” for primary law and “0” for secondary law

LHAF = Log of percentage of Hispanic and African American population

MHI = Median household income, in ten thousand dollars

MAXSPEED = Speed limit law, equal to “1” when highest speed limit on any road is above 70 mph and “0” otherwise

TT = Mean travel time for commuting to work, in minutes

RP = Rural population, in percentage

FT = Fuel tax charged per gallon of gas, in cents

Comparing plots of observed versus predicted values for both models (Figure 4.12 and 4.16) indicated that the modified model shows a more linear trend without any extreme observations. From the Normal Probability Plot (Figure 4.17) and Histogram (Figure 4.18), there is no evidence of non-normality or errors. The normal probability plot is reasonably linear, as compared to that of the original model and the histogram is more symmetrical about the central axis. Value of Kurtosis statistic is -0.51, for the modified model as compared to 5.39 in the fatality rate model and corresponding figures for skewness statistics are –0.09 and 1.65 respectively indicating more reliable results. Overall fit of the model is better with a higher R^2 value of 90.47%. So, the assumption of non-normality of errors could be considered as satisfied for the modified model.

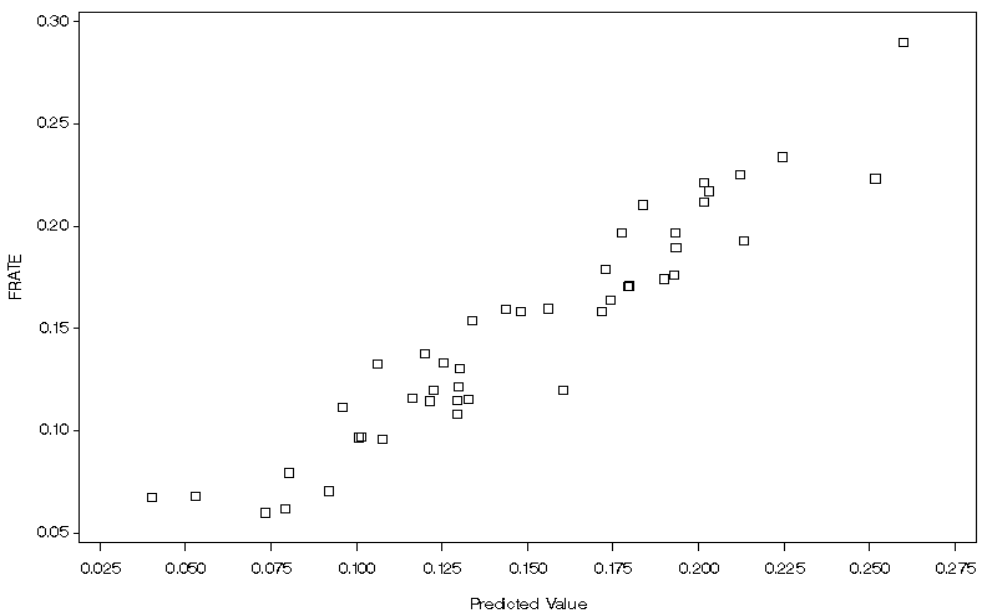


Figure 4.16: Observed Vs Predicted Values for Modified Fatality Rate Model

Standard errors of the variables in the modified model decreased and some variables became highly significant (p-value < 0.001). This improved the confidence intervals for the parameters and the accuracy of predictions. Confidence intervals and the individual effects of variables on fatality rate are summarized in Table 4.16.

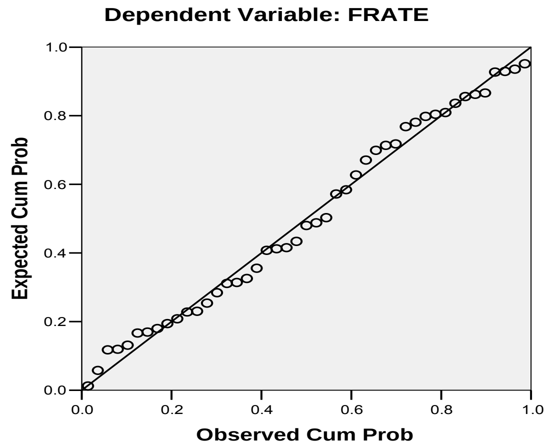


Figure 4.17: Normal Probability Plot for Modified Fatality Rate Model

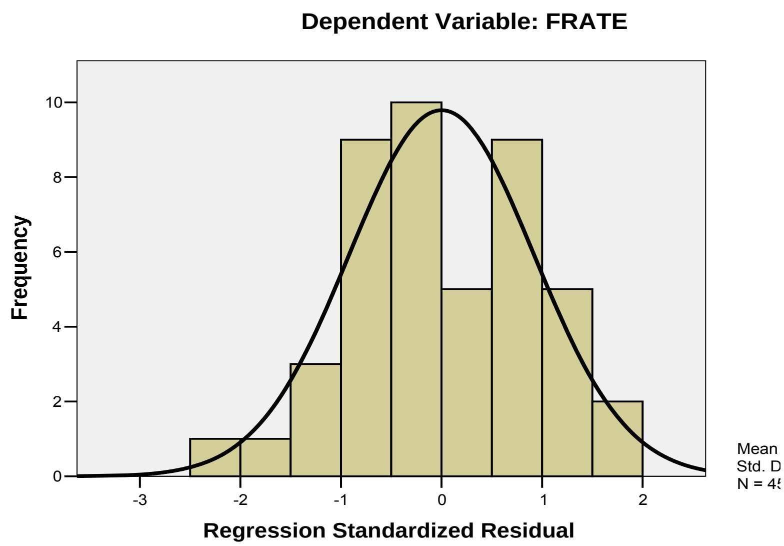


Figure 4.18: Residual Histogram for Modified Fatality Rate Model

<u>4.3.3 Description of the Results</u>

This section describes the results and practical applications of the modified fatality rate model, which identified seven factors as significantly affecting the fatality rate in a given state. Results obtained by this model are compared with previous research findings and the effects of these variables on fatality rate are explained.

Table 4.16: Individual Effects of Variables in Modified Fatality Rate Model

			90% Confidence Limit	
Response Variable	Increase in Response Variable by	Increase/Decrease in Fatality Rate	Lower Bound	Upper Bound
LAW	1 (primary law)	-0.029	-0.039	-0.018
LHAF	1 percent	0.044	0.026	0.062
FT	1 cent	-0.001	-0.002	-0.000
MAXSPEED	1 (max speed limit >70)	0.033	0.226	0.446
TT	1 minute	-0.003	-0.005	-0.001
MHI	10,000 dollars	-0.035	-0.047	-0.024
RP	1 percent	0.001	0.000	0.001

Seat Belt Law (LAW) – In compliance with the previous two models, this variable was identified as a significant factor affecting the fatality rate in a given state. Modified fatality rate model estimated a decrease in fatality rate by 0.029 (90% CI = 0.018 to 0.039) by enacting primary seat belt law. Many studies in the past found that mandatory seat belt law is effective in reducing traffic fatalities. Primary seat belt law is the most important element of mandatory seat belt law in reducing traffic fatalities (Cohen, 2003). It is widely agreed from various studies that seat belt law is effective in reducing vehicle occupant fatalities (Garbacz 1991; Loeb 1995; Wagenaar; 1988). Two research studies by NHTSA (1984) and Evans (1986) found effectiveness of seat belts in preventing fatalities as 45% and (41 ± 3)% respectively. But, they considered effectiveness of seat belts instead of the seat belt law, which is considered as a measure of preventing unrestrained occupant fatalities in this study. If Kansas had primary seat belt law, vehicle occupant fatalities could have been reduced by anywhere from 48 to 104 for the year 2002. This calculation is based on conversion from secondary law to primary law, with all other variables remaining constant.

Log of Hispanic and African American Population (LHAF) – Consistent with previous research findings that suggest lower seat belt use and higher fatality rate for Hispanic and African American populations, the model estimated that if Hispanic and African American population increases by one percent, fatality rate is estimated to increase by 0.044 percent (90% CI = 0.026 to 0.062). A study by Baker et al (1998) found that African American and Hispanic male teenagers are twice as more likely to be involved in fatal crashes. Overall motor vehicle crash related death was found to be higher for Hispanics compared to Non-Hispanics (Harper et al, 2000). Hispanics and African Americans have low seat belt use and high involvement in drinking and driving (Voas et al 1998; Lee P 1996), which confirms the correlation that suggests lower seat belt use results in higher fatalities.

Fuel Tax (FT) –Results obtained by the fatality rate model indicate decrease in fatality rate by 0.001 percent (90 % CI = 0.0006 to 0.002) for an increase in fuel tax by one cent. As mentioned earlier in section 4.1.3, a portion of fuel tax is used in funding safety programs and highway developments, repair, and maintenance projects, which could result in better quality and safer highways. Previous research also found that fuel tax decreases occupant fatalities (Cohen, 2003). Moreover, findings of the seat belt model suggested that seat belt use increases with an increase in fuel tax. Additionally increase in seat belt use decreases fatalities.

Maximum Speed Limit Law (MAXSPEED) – Fatality rate model predicts an increase in fatality rate by 0.033 (90 % CI = 0.022 to 0.044) for states having maximum speed limit above 70 mph i.e. when MAXSPEED variable takes value "1". It has been found in the past that higher speed limits result in higher fatalities (Cohen, 2003). Higher speed limit results in driving at higher speeds, which in turn might result in more severe crashes or more fatalities.

Travel Time for Commuting to Work (TT) – In case travel time to work increases due to congestion, it results in driving at lower speeds due to which traffic fatalities or more severe crashes may decrease. If travel time increases due to longer driving distance, divers are most likely to wear seat belt (Waller et al, 1969). It has also been found that seat belt use increases when drivers travel longer distances like intercity trips compared to short urban trips (Council, 1969). Model predicts similar results and estimates a decrease in fatality rate by 0.003 (90% CI 0.001 to 0.005) for an increase in one minute of average travel time for commuting to work.

Median Household Income (MHI) - Seat belt usage rate model identified that with higher socio-economic standards, seat belt usage increases. Moreover, higher socio-economic standard is also correlated with higher education level. So considering these facts it was expected that fatality rate would decrease with increased median household income. Model predicted results consistent with this understanding. As per this model, fatality rate would decrease by 0.035 (95 % CI = 0.047 to 0.024) with a ten thousand dollar increase in median household income.

Rural Population – Fatalities in rural areas are more frequent compared to urban areas as studied by various researchers. Lower seat belt use, higher rate of driving under influence, and longer emergency response times are some of the critical factors affecting increased severities of crashes in rural areas. As per this model, one percent increase in rural population increases fatality rate by 0.001. As per data obtained from FARS, about 33.7 % rural drivers involved in fatal crashes had BAC > 0.10 as compared to 9.9 % urban drivers. This could be one of the contributory factors for higher fatality rate on rural highways. Moreover according to seat belt usage rate model, on rural highways seat belt usage rate is low. Non seat belt use is one of the most important factors contributing to increased number of fatal crashes on rural highways (Dissanayake, 2004).

4.4 RESULTS OF THE SURVEY

This section describes the results of the road user surveys conducted in Kansas in relation to seat belt usage. The basic analysis shows the characteristics of the sample population, who were randomly selected to fill out the surveys. Based on the identified characteristics, relationships among seat belt use, awareness of seat belt law, and other factors influencing the use of seat belts is presented in the form of charts.

4.4.1 Characteristics of Sample Population

Characteristics of the sample population are presented in the form of charts showing distribution of sample population by categories such as age group, gender, median household income, employment status, type of employment, educational background, frequency and amount of driving, type of vehicle driven etc. For example, Figure 4.19 shows that 43% of the respondents are in the 16-24 year old age group.

Even though surveys were conducted in several different cities throughout Kansas, highest number of responses was obtained in and around Manhattan, which led to over representation of the 16-24 year age group, which was also observed to be the most cooperative group.

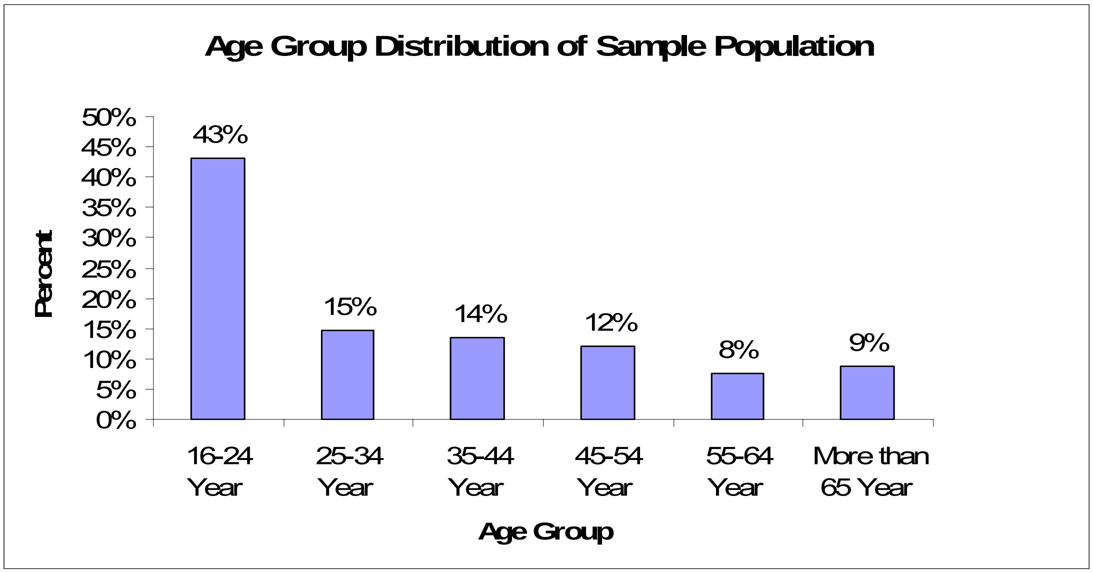


Figure 4.19: Age Groups of Survey Respondents

As seen from Figure 4.20, gender distribution for the sample is 52% and 48% for males and females respectively.

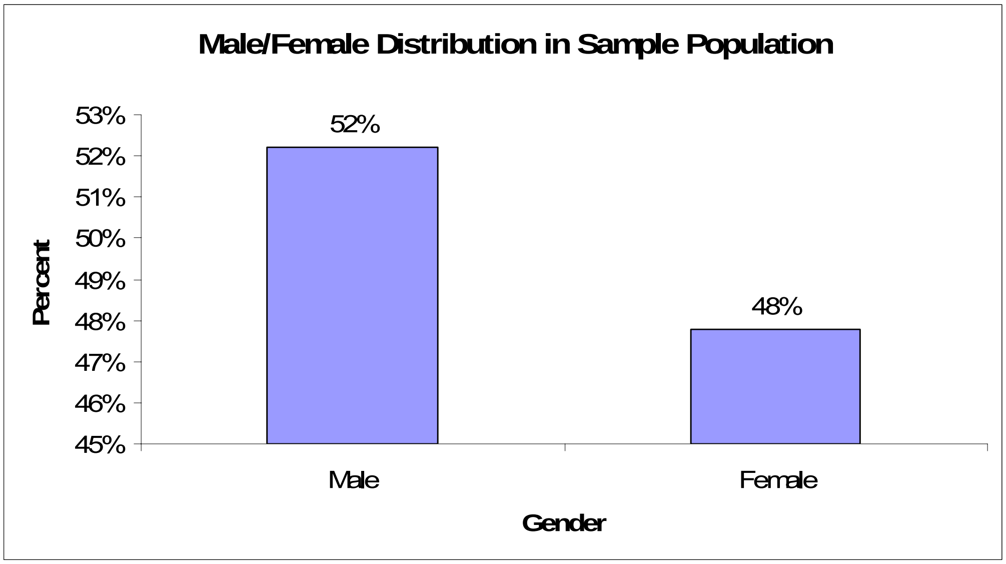


Figure 4.20: Gender Distribution of Survey Respondents

Another category of classification of the surveyed sample is by median household income. Survey questionnaire had six options for the median household income level, which ranged from $4,999 or less to $ 70,000 or above to accommodate respondents from various income levels. From 753 completed surveys, highest numbers of respondents i.e. 20% belong to the $5,000 -$19,999 category followed by 19% in the $50,000-$69,999. The bar chart shows that the sample population is more or less evenly distributed in terms of income groups.

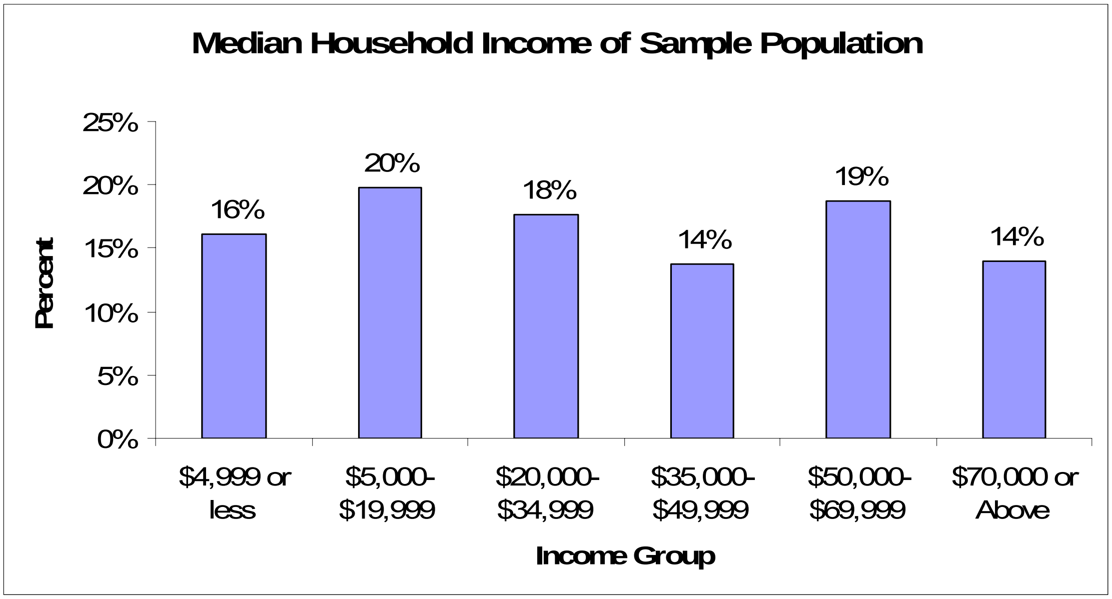


Figure 4.21: Percentage of Survey Respondents in Each Income Group

Statistical models developed in this study identify median household income, unemployment etc as important factors influencing seat belt use and vehicle occupant fatalities. To verify this result from survey analysis, even distribution of respondents in these categories is required. Figure 4.22 shows the employment status of the respondents. About 39 % responded as being employed full time and 5 % responded as being unemployed. Figure 4.23 describes the type of employment among the sample population. As mentioned earlier, more responses were obtained around Manhattan campus of the Kansas State University, due to which employment distribution shows a significant number of 'Students' compared to other categories.

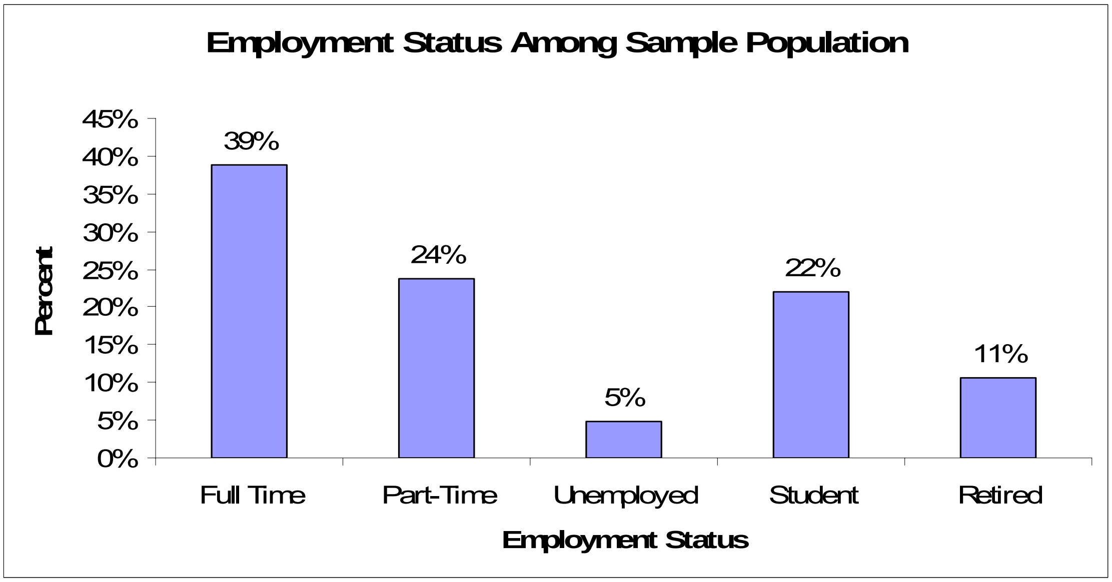


Figure 4.22: Employment Status of Survey Respondents

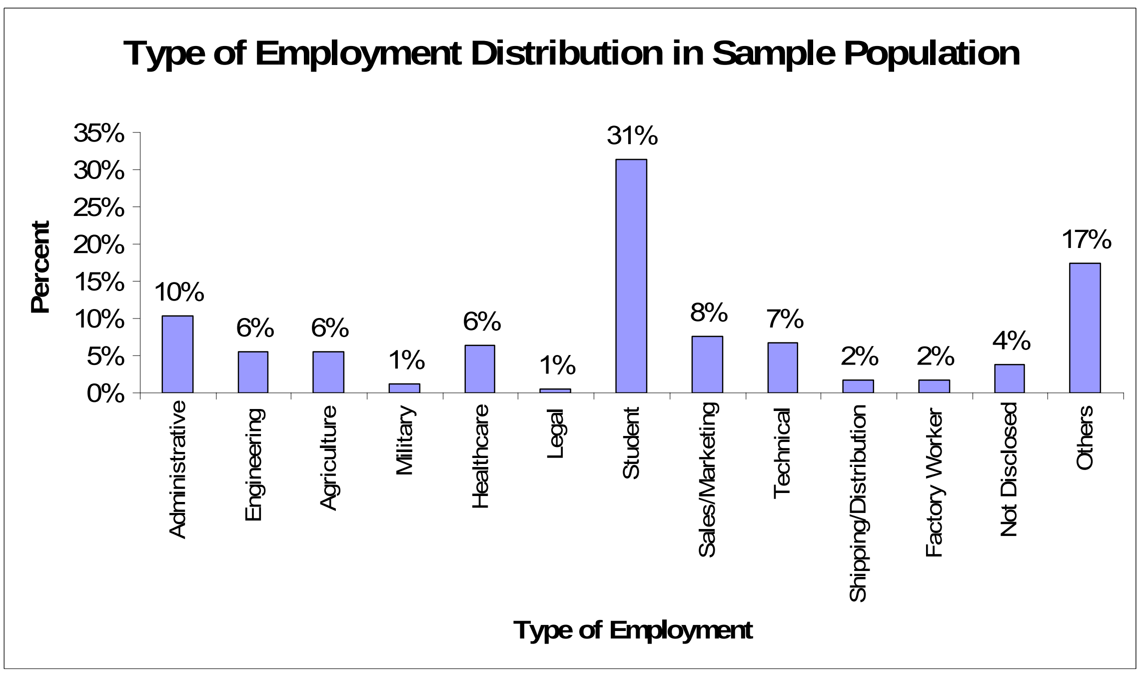


Figure 4.23: Type of Employment of Survey Respondents

Through the statistical modeling approach, it has been found that the seat belt use is directly proportional to the educational level of a person. Accordingly, the survey questionnaire was designed to capture the educational level of the respondents to verify this finding for Kansans. Fifty-one percent of the respondents said they attended some college and just 1 % said that they had no formal schooling.

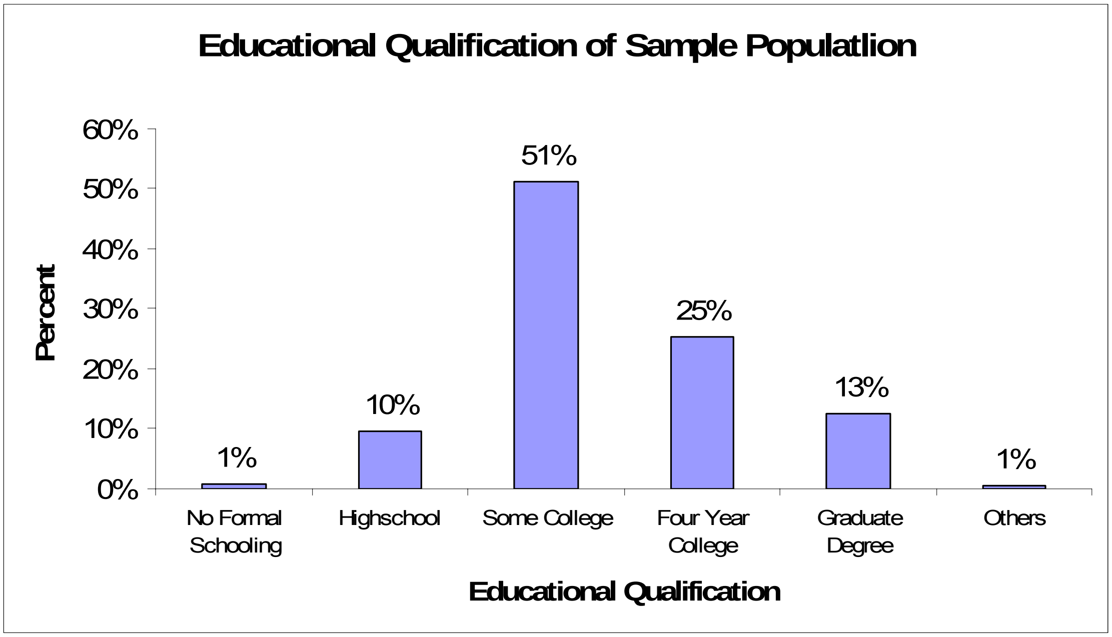


Figure 4.24: Educational Background of Survey Respondents

Although mixed results have been found among literature regarding seat belt use and ethnicity, it is a common perception that seat belt use is lower among African-Americans and Hispanics. Moreover, statistical models developed in this study also identified percentage of African American and Hispanic populations as significant factors affecting average seat belt usage rate in a state. Figure 4.25 shows the ethnic distribution of the sample population, where only 6 % of respondents were found to be of African American origin and 4 % of Hispanic origin.

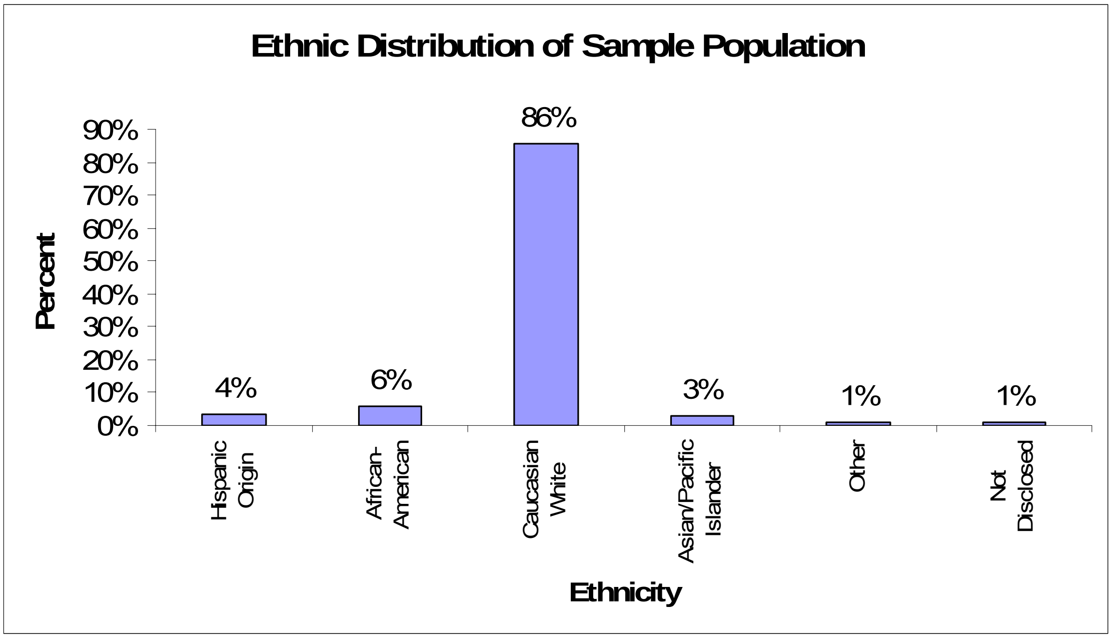


Figure 4.25: Ethnic Distribution of Survey Respondents

Frequency and amount of driving are another important characteristics to identify characteristics of individuals with higher or lower seat belt use. Respondents are categorized by frequency of driving by using days driven per week and amount of driving by using miles driven per month as shown in Figures 4.26 and 4.27 respectively. About 64 % of the sample population responded that they drove everyday of the week as compared to 2 % who said they drove only once a week. Similarly, based on miles driven per month, 43 % responded that they drove between 0-500 miles per month as compared to 3 % who said they drove more than 2000 miles per month. Main purpose of analyzing the characteristics of the surveyed sample is to have certain degree of uniformity in terms of various characteristics of the surveyed sample in order to obtain statistically dependable results. For example, if the number of responses from females is very low compared to number of males, the sample is not a true representation of average population in Kansas and the results could be misleading.

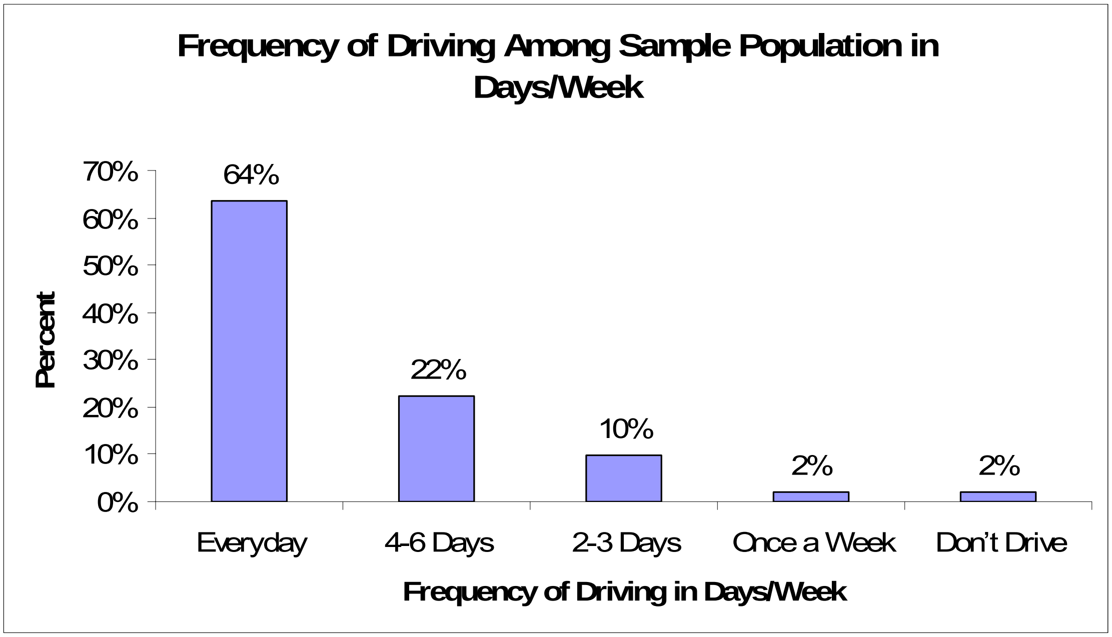


Figure 4.26: Frequency of Driving by Survey Respondents

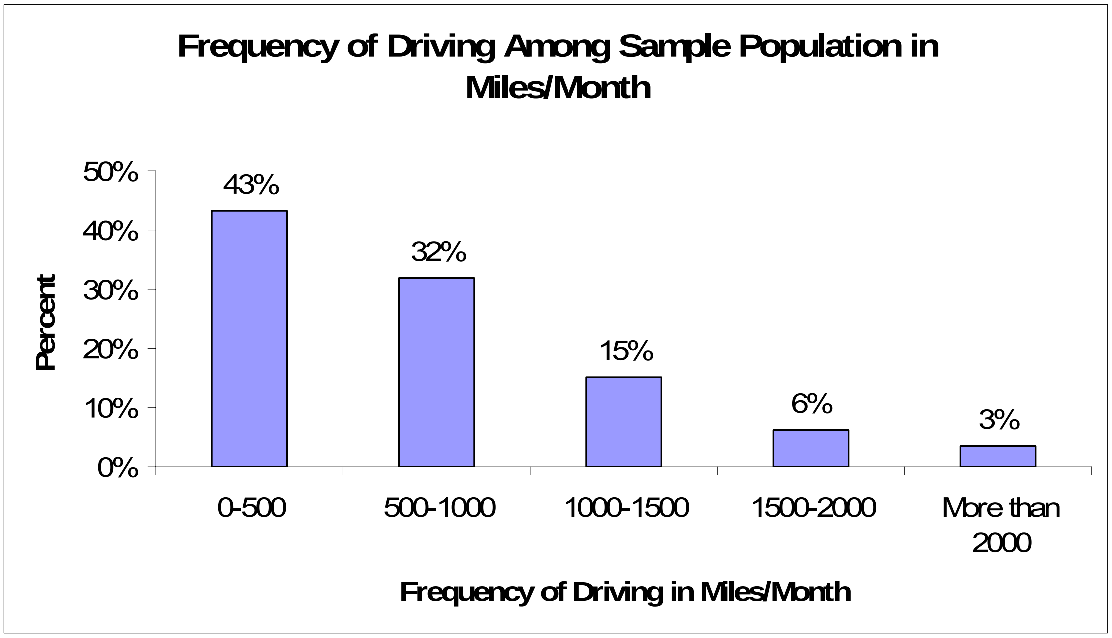


Figure 4.27: Amount of Driving by Survey Respondents

4.4.2 Seat Belt Law Awareness

Of the total number of respondents, fifty percent answered that seat belt law in Kansas is primary, which implies that half of the population is unaware that the seat belt law in Kansas is secondary. Only 43 % of respondents answered the question correctly saying Kansas has a secondary seat belt law and 6 percent people said they were unaware of the type of seat belt law. These results are presented in Figure 4.28. Hereafter, those who responded that seat belt law in Kansas is primary or they were unaware of seat belt law are referred as "Unaware" about seat belt law and those who answered seat belt law is secondary are referred as "Aware".

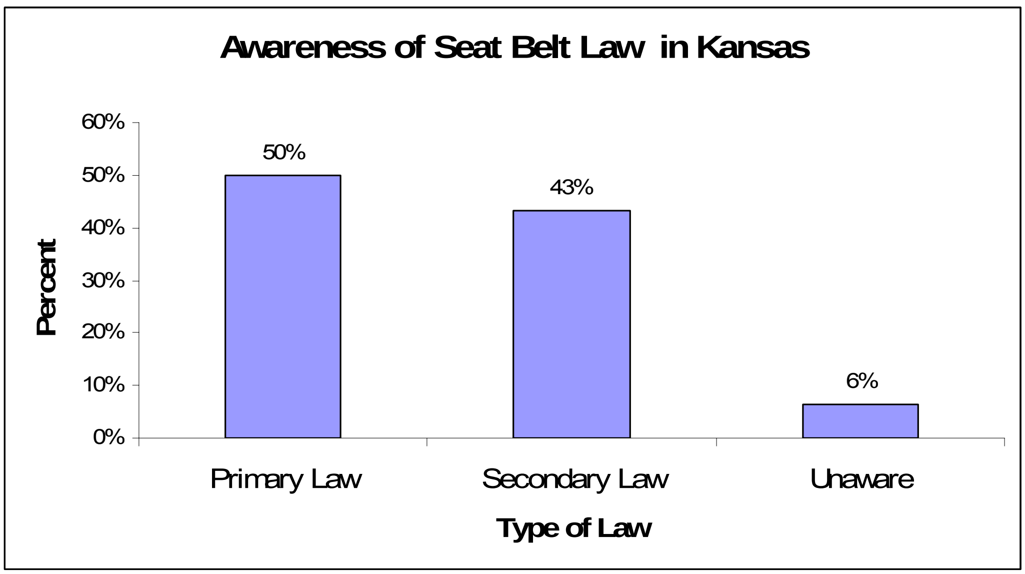


Figure 4.28: Awareness of the Type of Seat Belt Law in Kansas

The survey questionnaire also included a question on penalty in Kansas for violating seat belt law. The responses for this question are presented in Figure 4.29, which indicates that only 15 percent of the sample population was aware of the amount of penalty for violating the seat belt law.

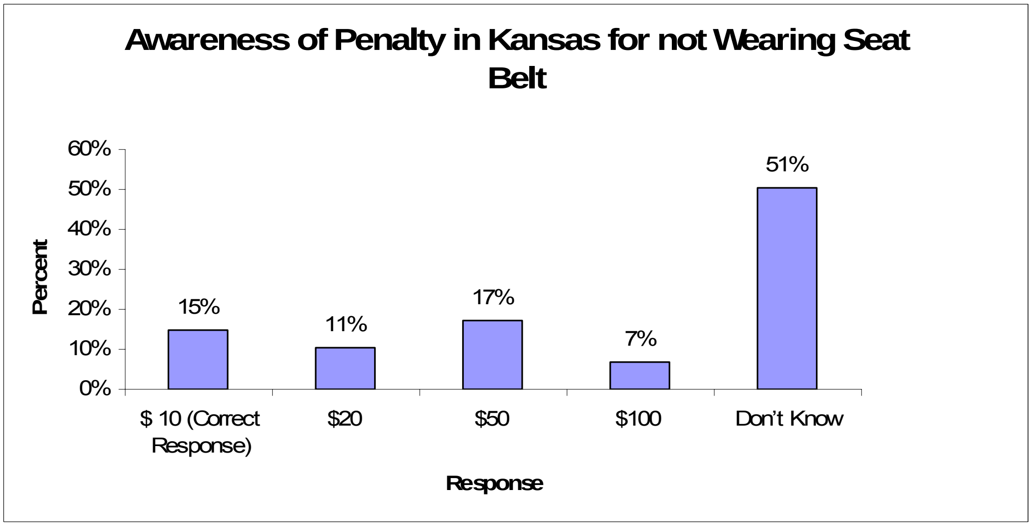


Figure 4.29: Awareness of Penalty for Seat Belt Violation

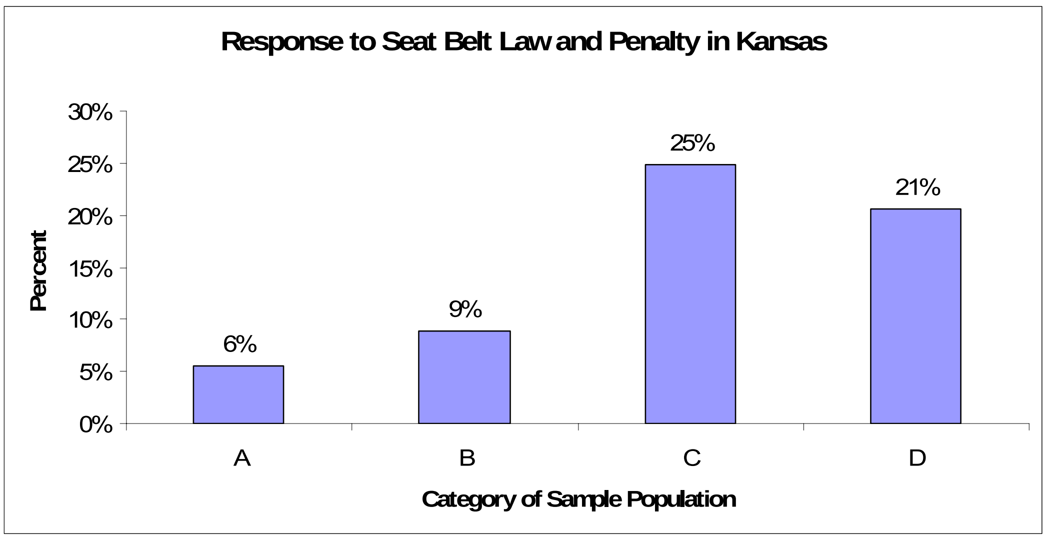


Figure 4.30: Awareness of Seat Belt Law and Penalty in Kansas

Combining the results on awareness of seat belt law and penalty indicated that only 9 percent (category B) of the respondents were aware of both the law and the penalty as presented in Figure 4.30.

A = Percentage of people who answered Kansas has primary seat belt law and penalty for not wearing seat belt is $10.

B = Percentage of people who answered Kansas has secondary seat belt law and penalty for not wearing seat belt is $10.

C = Percentage of people who answered Kansas has primary seat belt law but don't know about the penalty for not wearing seat belt.

D = Percentage of people who answered Kansas has secondary seat belt law but don't know about the penalty for not wearing seat belt.

Also, by considering the responses of 15 percent of the sample population that was aware of the penalty for not wearing seat belts, reasonability of penalty was analyzed, where 49 % answered that the penalty is reasonable, 34 % answered that this penalty should be increased, 6 % answered that it should be decreased and 11 % said that they did not know or care about the penalty. These results are presented in Figure 4.31.

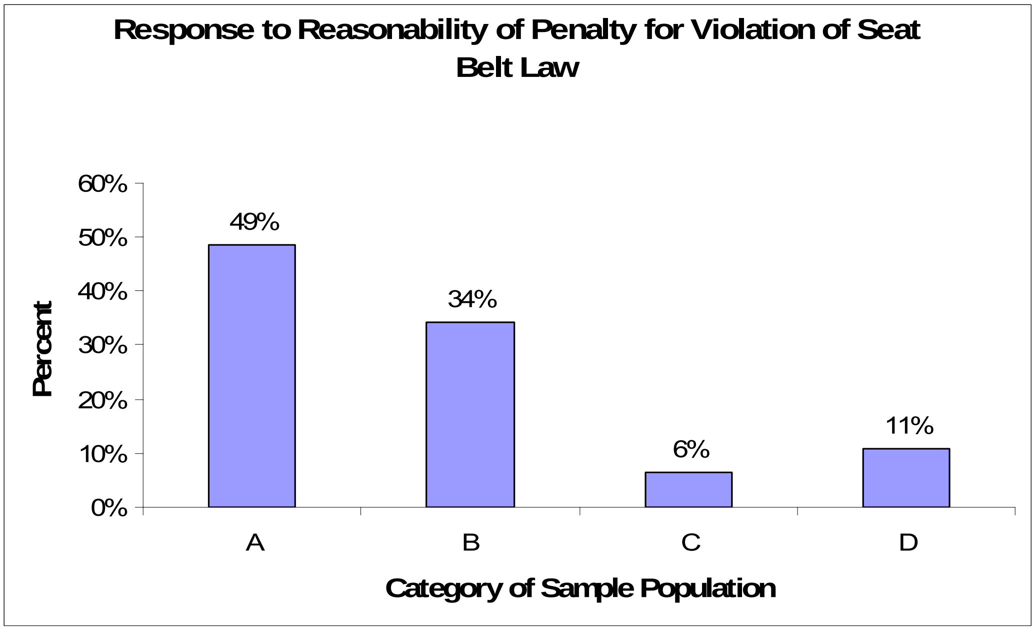


Figure 4.31: Reasonability of Penalty for Violation of Seat Belt Law

A = Sample population aware of penalty for not wearing seat belts and answered that penalty is reasonable.

B = Sample population aware of penalty for not wearing seat belts and answered that penalty should be increased.

C = Sample population aware of penalty for not wearing seat belts and answered that penalty should be decreased.

D = Sample population aware of penalty for not wearing seat belts and answered that they don't know/care about the penalty.

Based on the characteristics of the respondents, it was attempted to identify factors related to awareness of seat belt law. For example, relationships between gender, educational background, age group, median household income etc and awareness of law is developed. Figure 4.32 shows the relationship between gender and the awareness of the seat belt law, which does not show any clear differences.

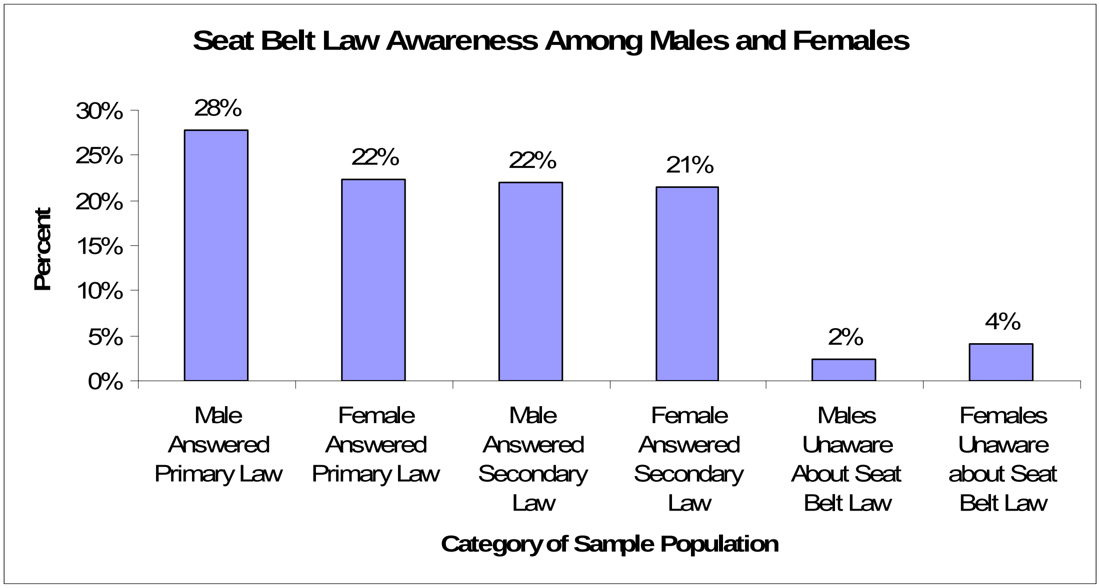


Figure 4.32: Awareness of Seat Belt Law by Gender

Even though it is generally perceived that lower education level would lead to lower awareness of the existing seat belt law, no clear differences could be seen among respondents as shown in Figure 4.33. Fifty percent of those with no formal schooling were aware of seat belt law compared to 49 % with a graduate degree or 37 % with a four-year college degree. Even if 58 % of those with a four-year college degree answered that the law is primary (incorrect response) as compared to only 17 % of those with no formal schooling not much weight could be put on this due to very small frequencies in the 'no formal schooling' and 'graduate degree' categories.

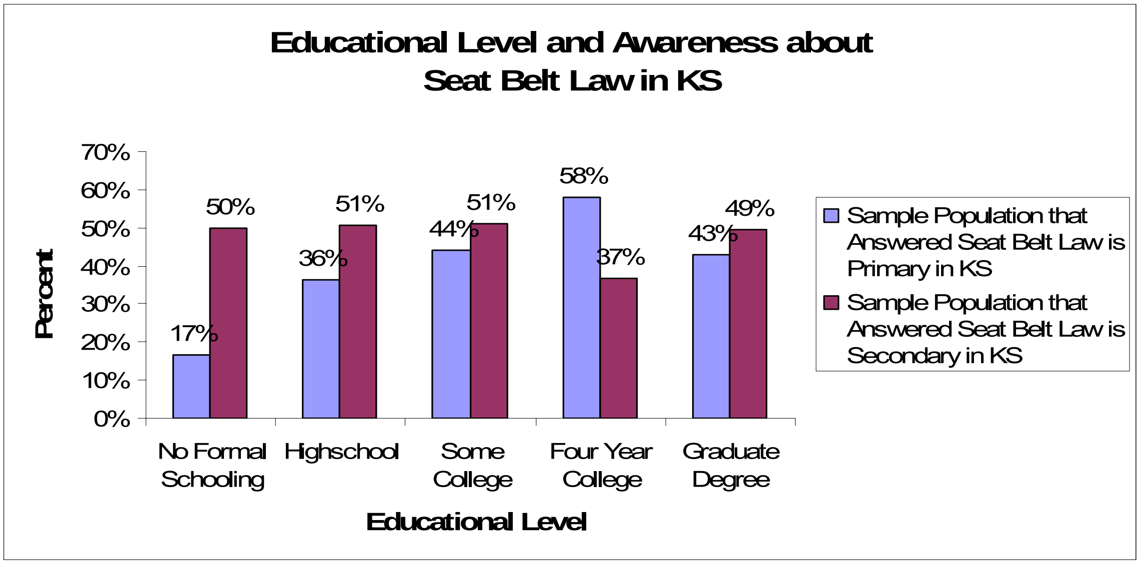


Figure4.33: Awareness of Seat Belt Law by Educational Level

As suggested by seat belt usage rate model developed in this study, it was found that seat belt usage is higher for higher income group. So the probability of awareness about law among higher income group could be more. Figure 4.34 indicates that awareness is highest among the median household income group of $50,000-$69,999, where 50 % respondents were aware of the type of law and lowest among the income group of $4,999 or less, where only 38 % were aware of the law. Among the highest income group of $70,000 or more, 48 % respondents were aware of the type of law and 52 % either answered incorrectly or did not respond. In general it could be said that the higher the income and education levels, people are more knowledgeable of the seat belt law, which conforms to the statistical modeling results.

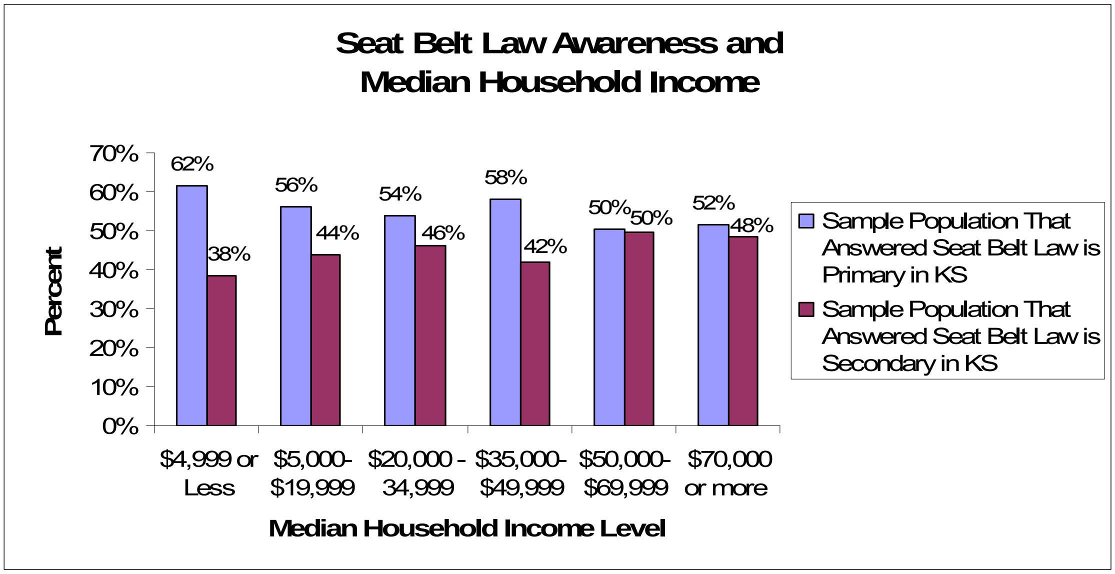


Figure 4.34: Awareness of Seat Belt Law by Median Household Income

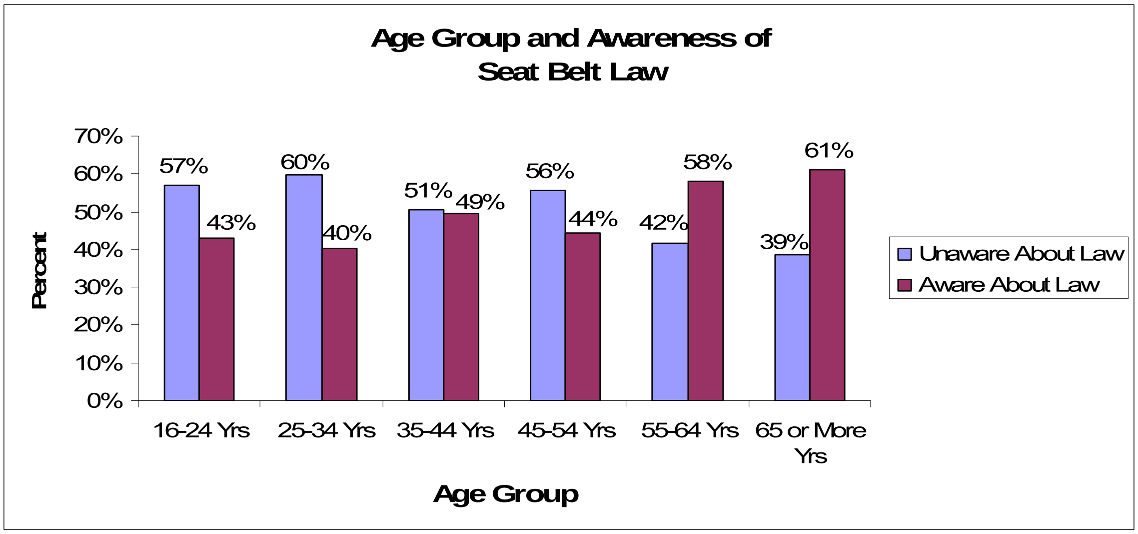


Figure 4.35: Awareness of Seat Belt Law by Age Group

Figure 4.35 indicates the awareness of seat belt law by age group. As expected, awareness is higher among the older age group of 55-64 yr and 65 yr or more age group. Awareness was found to be the lowest among the 25-34 yr age group followed by 16-24 year old age group. This confirms the fact that younger drivers form a critical group in regard to seat belt use.

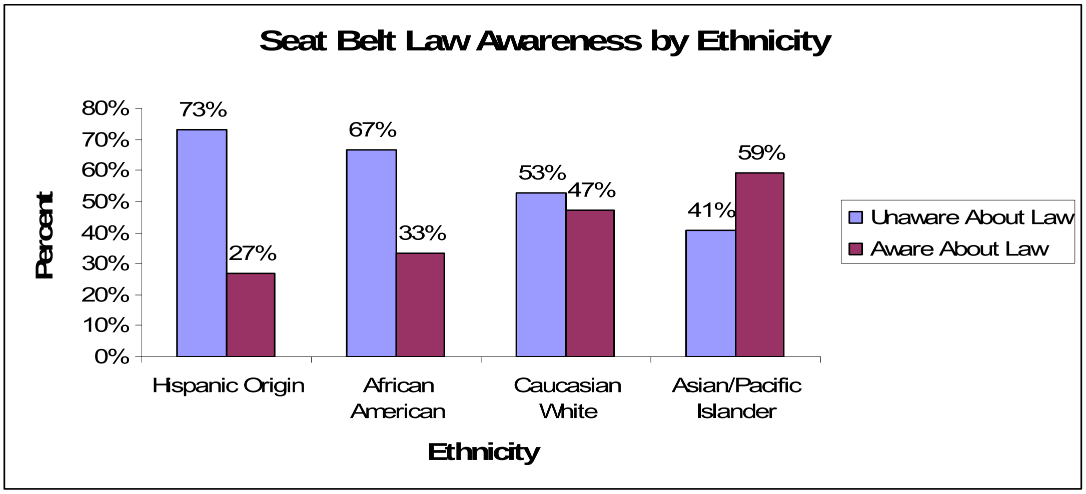


Figure 4.36: Awareness of Seat Belt Law by Ethnicity

When considering awareness of seat belt law by ethnicity, clear differences exists between groups as shown in Figure 4.36. Hispanics were found to have the lowest awareness, where only 27 % were familiar with the type of law, followed by African-Americans (33 %) and then Caucasian Whites (47%). More than 59 % of Asian/Pacific islanders are aware of the law, but as the number of responses from this ethnic group was only 22 out of total of 683 completed responses on this question, the results may not be statistically reliable.

4.4.3 Seat Belt Use by Characteristics of Sample Population

From the above charts, relationships between different characteristics and awareness of seat belt law can be deduced. But along with this, it is also important to identify if a relationship exists between awareness of law and seat belt usage. Figure 4.37 shows the response to use of seat belts by the surveyed population and Figure 4.38 shows seat belt use by awareness of seat belt law.

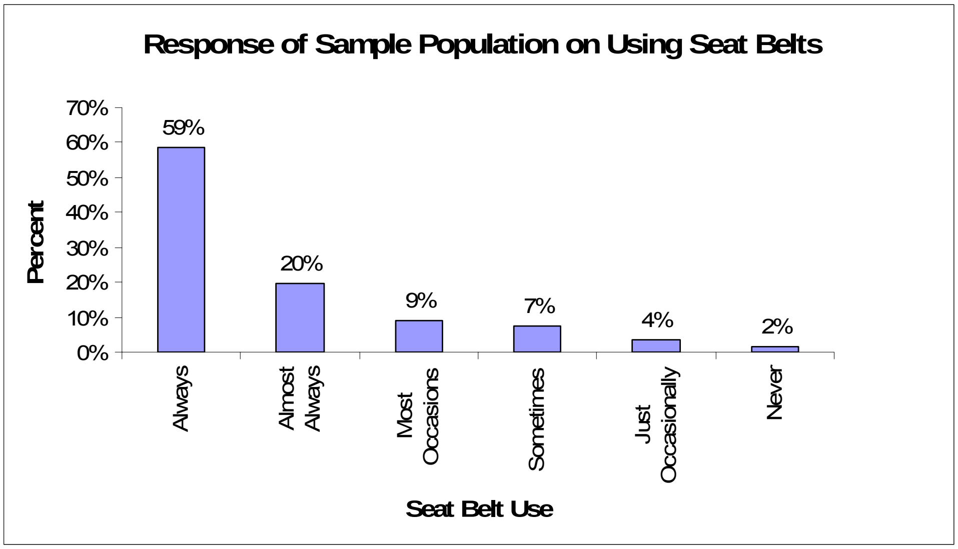


Figure 4.37: Stated Seat Belt Use among Sample Population

Figure 4.37 indicates that 59% people say that they ‘always’ use seat belts and about 2% say they ‘never’ use seat belts. Comparing stated behavior of seat belt use with the awareness of seat belt law as shown in Figure 4.38, it was found that only 25% of people who are aware of seat belt law ‘always’ wear seat belts whereas 29% of those who are unaware of the seat belt law (this includes those who answered seat belt law is primary in Kansas and those who answered they did not know about seat belt law) ‘always’ use seat belt. There is a possibility of discrepancy in the response of people who are not aware of seat belt law and still answered that they always use seat belts. On the other hand, those who are unaware of the actual type of law assume that the law is stricter than it really is, and thereby tend to use the seat belts more frequently. Accordingly, It appears as if Kansans who think that the law is primary are more likely to wear seatbelts.

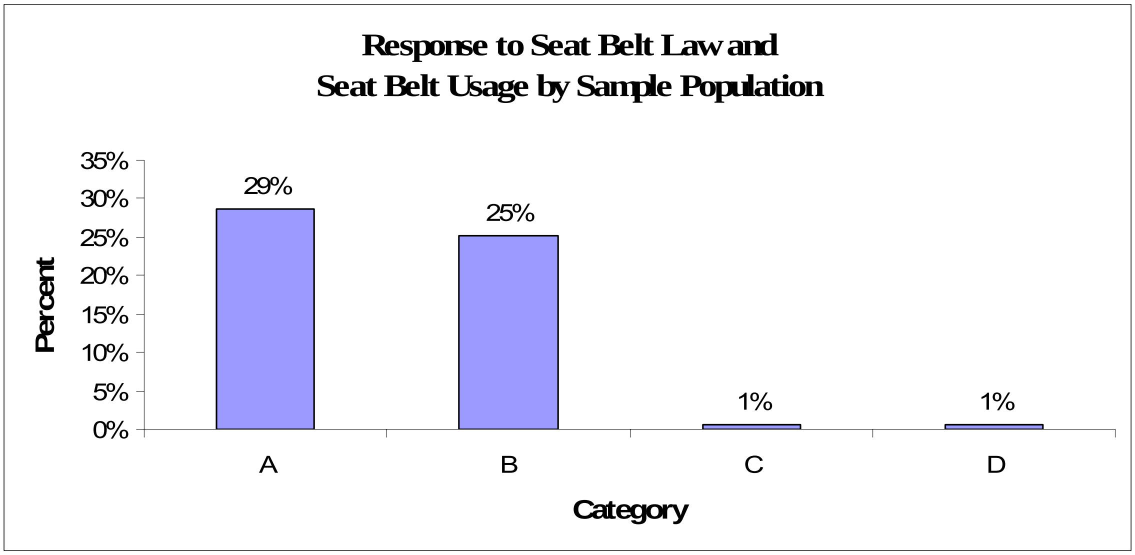


Figure 4.38: Stated Seat Belt Use and Awareness of Seat Belt Law

A = Category representing sample population that answered seat belt law in Kansas is primary and said they always use seat belts.

B = Category representing sample population that answered seat belt law in Kansas is secondary and said they always use seat belts.

C = Category representing sample population that answered seat belt law in Kansas is primary and said they never use seat belts.

D = Category representing sample population that answered seat belt law in Kansas is secondary and said they never use seat belts.

Seat belt use has also been categorized by various characteristics of the surveyed sample as done previously in the section on awareness about seat belt law. Figure 4.39 represents seat belt usage by gender.

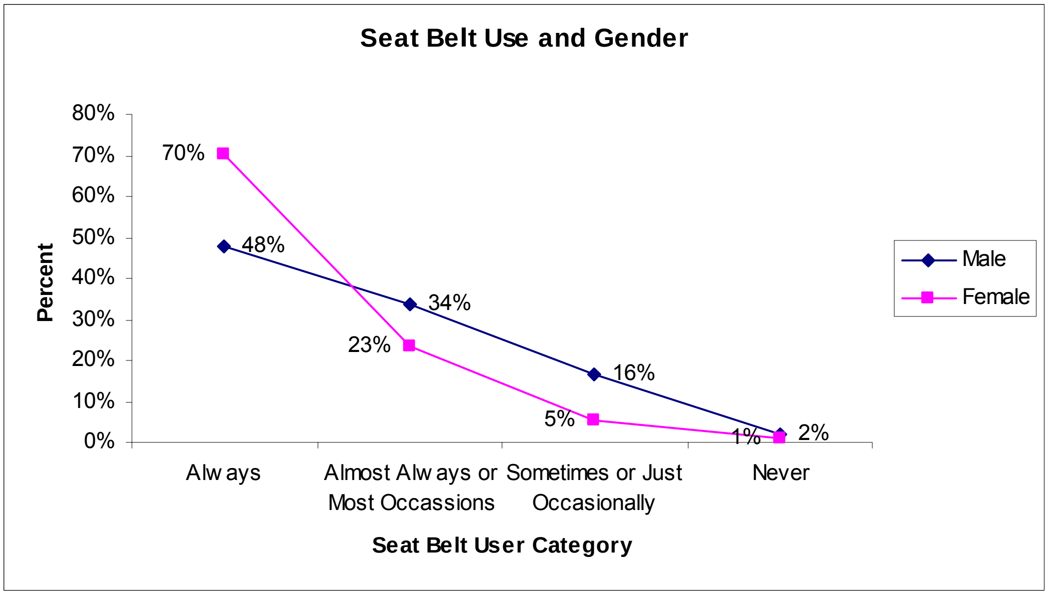


Figure 4.39: Stated Seat Belt Use by Gender

Figure 4.39 indicates that 70 % of female respondents belong to the 'always use seat belt' category as compared to 48 % of males. Similarly, only 1 % of females belong to the 'never use seat belts' category as compared to 2 % males. This states that the self reported seat belt usage is low among males than females by a huge margin.

Another general perception is that older adults have higher usage compared to teens and younger age groups. From Figure 4.40, it can be seen that percentage of people belonging to the 'always use seat belt' category increases with increased age. For example, 48 % of 16-24 year olds, 69 % of 45-54 year olds, and 78 % of older than 65 years belong to 'always use seat belt' category. Similarly, respondents in the 'Never use seat belts' category decrease as the age increases. This confirms the fact that seat belt use is lower among younger age groups, which is also consistent with the statistical modeling results observed in this study. Therefore, young drivers could be identified as one of the critical groups that need focused attention to increase usage rates.

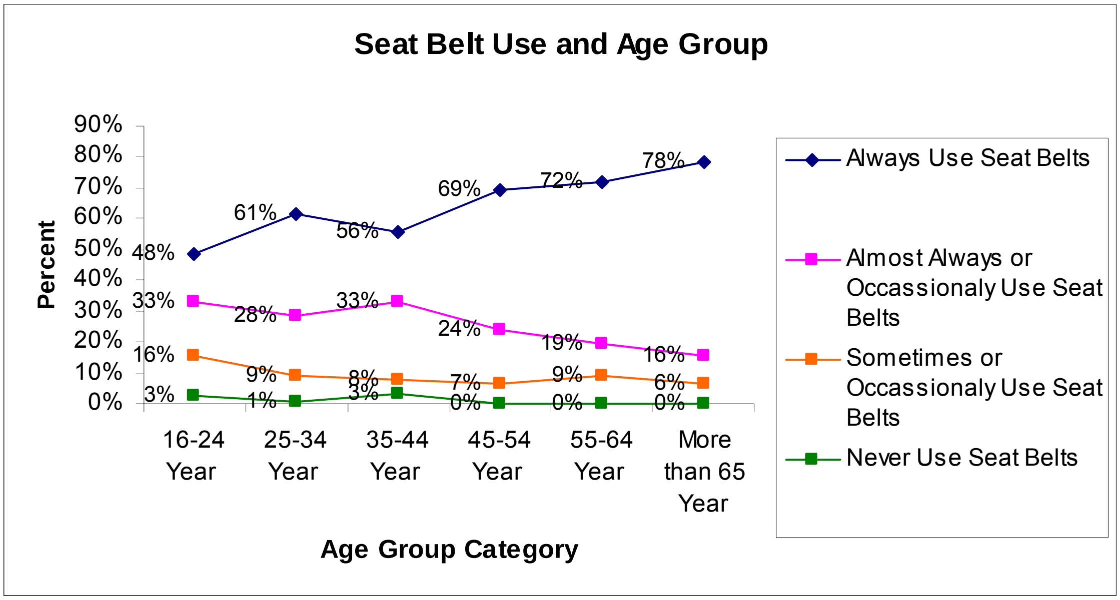


Figure 4.40: Stated Seat Belt Use by Age Group

Seat belt use has been found to be higher among people with higher income groups as mentioned previously. Figure 4.41 shows that highest percentage (24 percent) of people in the 'Always use seat belts' category belong to the higher income group of $50,000-$69,000. Similarly $70,000 or more income group has the lowest percentage (4 percent) of people that belong to the 'Never use seat belts' category. Moreover, as the income level increases, percentage of people in the "Always use seat belts" category also increases except for the $70,000 or more income group category. The reason for the $70,000 or more income group having a lower percentage of people in the 'Always use seat belts' category could not be identified based on the available data.

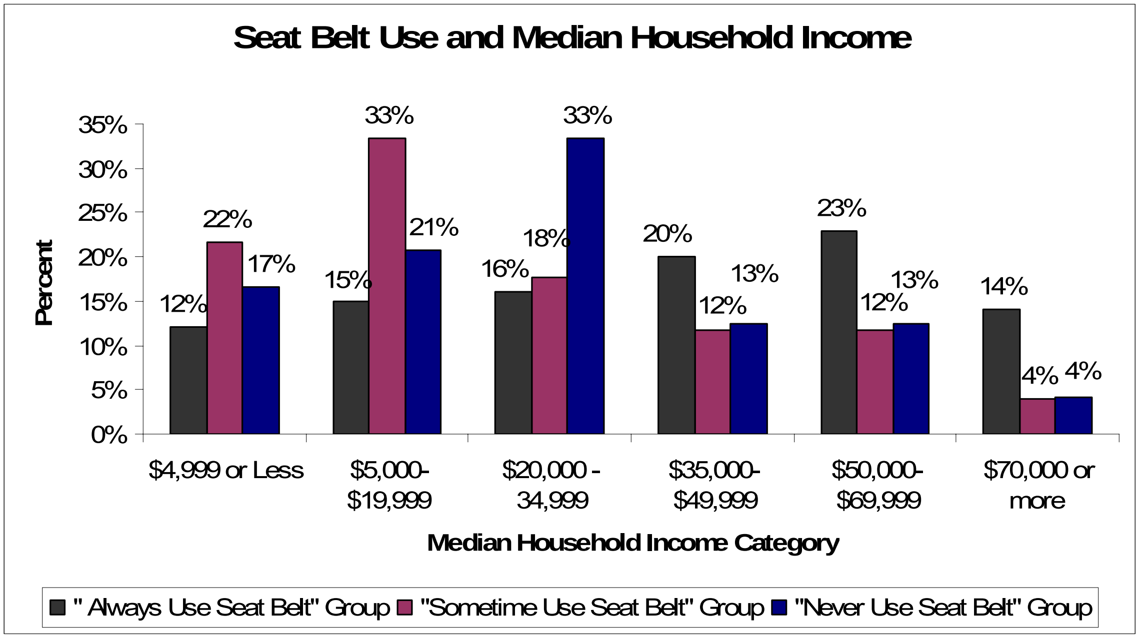


Figure 4.41: Stated Seat Belt Use by Median Household Income Level

It is generally believed that seat belt use is low among some ethnic groups compared to others even though previous research has indicated mixed results. Some studies have found lower seat belt usage among African Americans and Hispanics as compared to Caucasian whites, whereas some other studies have found no difference in usage among ethnic groups. Results of this analysis, as shown by Figure 4.42 suggest that respondents in the ‘Always use seat belt’ category are highest among Asians and Pacific islanders at 76 % and lowest among Hispanics at 52 %. However, the percentage of African Americans who stated that they always use the seat belts is unusually high at 64 % as compared to 58 % for Caucasian Whites, which is contradictory with the statistical modeling results. Similarly, the corresponding figures in the ‘Almost always or most occasions’ category are 32 % and 24 % for Hispanics and Asian/Pacific islanders respectively. Results for the Asians/Pacific islander group may not however be statistically valid, as the numbers of responses were low in that category.

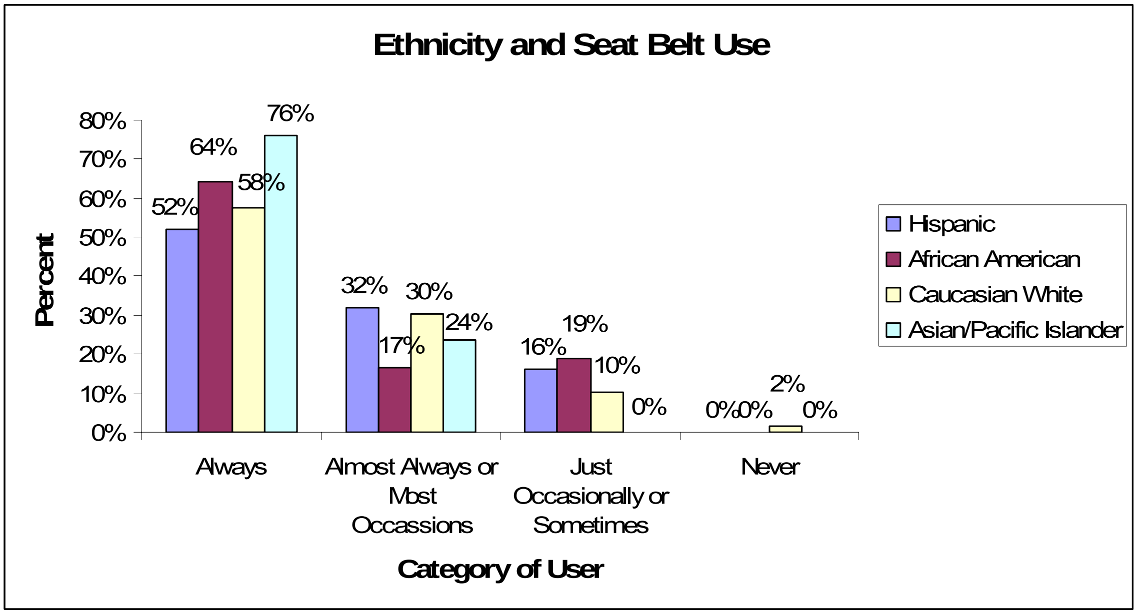


Figure 4.42: Stated Seat Belt Use by Ethnicity

Additionally, type of vehicle being driven has a connection to the seat belt usage behavior of drivers as shown in Figure 4.43. 63% of car drivers, 54% of SUV drivers, 68% of van drivers, and 41% of truck drivers said that they always use the seat belts. A significant 27% of pick-up truck drivers stated they ‘Sometimes or just occasionally’ use belts and almost 3% said they never use seat belts. Accordingly, stated seat belt use is highest among van users and lowest among pick-up users, which could represent the characteristics of people more likely to use different types of vehicles. Typically, women and mothers are more likely to use vans and pick-up trucks could be more popular among farming communities and/or in rural areas. So, there could be inter-relationships among these factors.

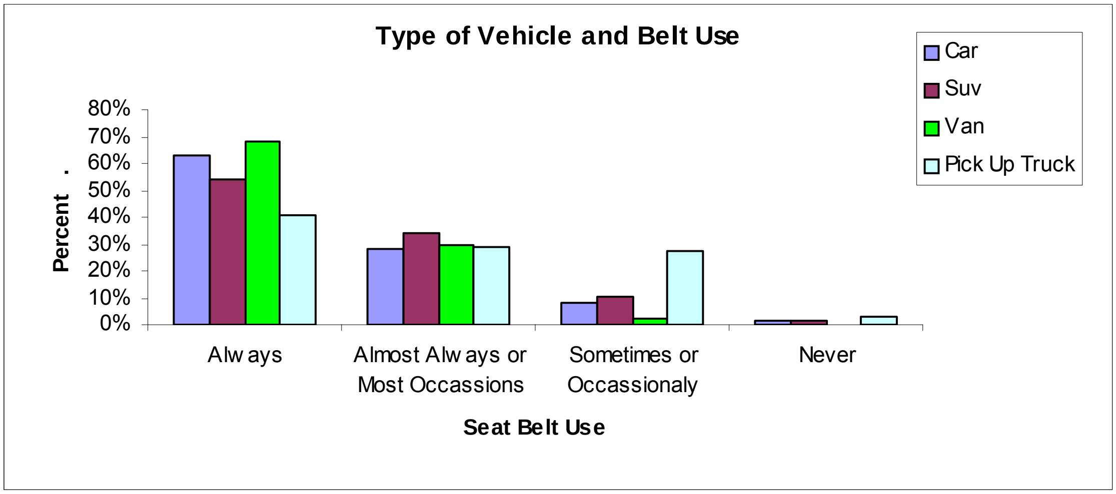


Figure 4.43: Stated Seat Belt Use by the Type of Vehicle

4.4.4 Factors Influencing Seat Belt Usage

Along with the characteristics of surveyed sample there were many other factors that influenced the use of seat belts either positively or negatively. Figure 4.44 presents the reasons given by the surveyed sample for not wearing seat belts. Highest number of respondents said that they were less likely to use seat belts while driving short distance. Moreover, about 25 % said that they forget to put it on and about 19 % said that they use it less often when they are in a hurry. Reasons for not wearing seat belts are labeled as follows:

A = Do not wear seat belts when in a hurry

B = Do not wear seat belts when driving a short distance

C = Do not wear seat belts often as they forget to put it on

D = Do not wear seat belts when driving in light traffic

E = Do not wear seat belts since it is uncomfortable

F = Do not wear seat belts when they assume that chances of crashes are low

G = Do not wear seat belts when people traveling with them don't wear seat belts

H = Do not wear seat belts when they are driving in rural areas

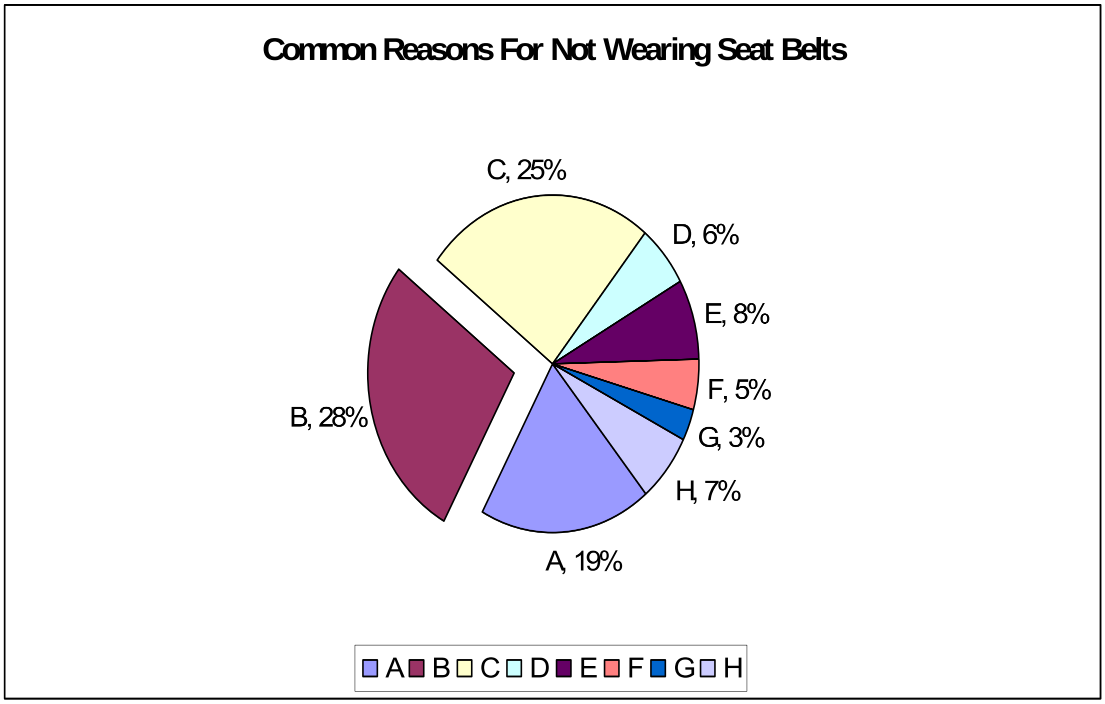


Figure 4.44: Stated Reasons for not Wearing Seat Belts

Along with these reasons that discourage use of seat belts, there also are some factors that affect seat belt usage positively as shown in Figure 4.45. For example, it was found that 22 % of respondents were more likely to use seat belts while driving in bad weather conditions. 17 % said they were more likely to use seat belts while driving with a child and another 17 % responded that they are more likely to use seat belts while driving at night. Possibility of using seat belts more frequently while driving at night was a surprising result, as it is perceived that seat belt usage is generally low at nighttime compared to daytime. This is because of the difficulty the police officer faces to judge if the motorist is wearing a seat belt or not, leading to lesser chances of being stopped and penalized.

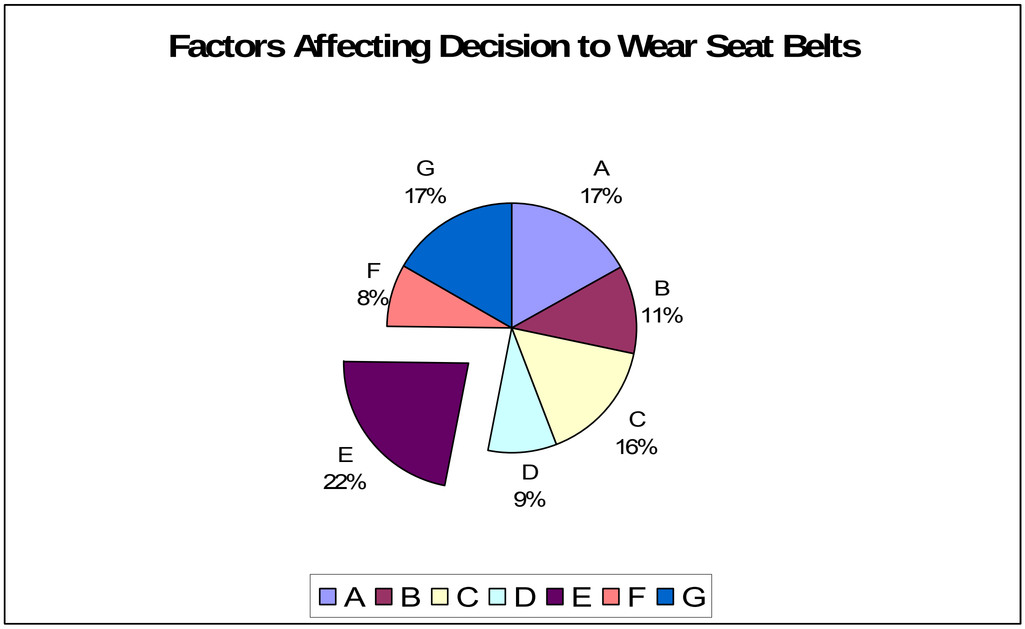


Figure 4.45: Factors Positively Affecting Decision to Wear Seat Belts

Factors positively affecting the decision to wear seat belts among the respondents are labeled as follows:

A = Driving at night

B = After being involved in a crash

C = Strict law enforcement

D = When driving under influence of alcohol

E = Bad weather

F = When passengers are under the influence of alcohol

G = While driving with a child

Some other factors that affect seat belt use behavior are type and characteristics of trips and roads. As shown in Figure 4.46, based on the question on the type of trips where the respondents are more likely to wear seat belts, 38 % replied that they are more likely to wear seat belts for work/school related trips as compared to 27 % saying the same for personal trips/running errands. These results may be useful in identifying locations where seat belt usage is likely to be low and increasing enforcement accordingly in those locations would be more effective.

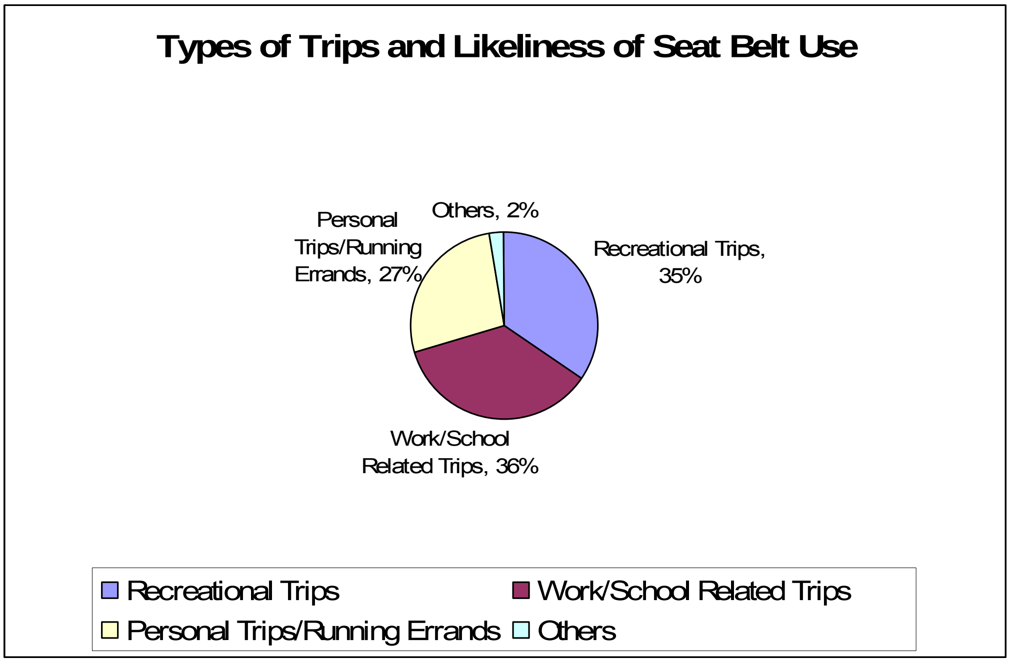


Figure 4.46:Types of Trips Seat Belt Use is More Likely

Similarly when considering type of road and seat belt use, statistical models developed in this study indicated that seat belt usage is higher on interstate roads and lower on rural highways. The results obtained from analysis of surveys as shown in Figure 4.47 are consistent with this finding, where 51 % of respondents answered that they are more likely to use seat belts on interstate roads compared to 14% on two lane roads without a median. City roads and two lane roads without a median fall in between these two categories.

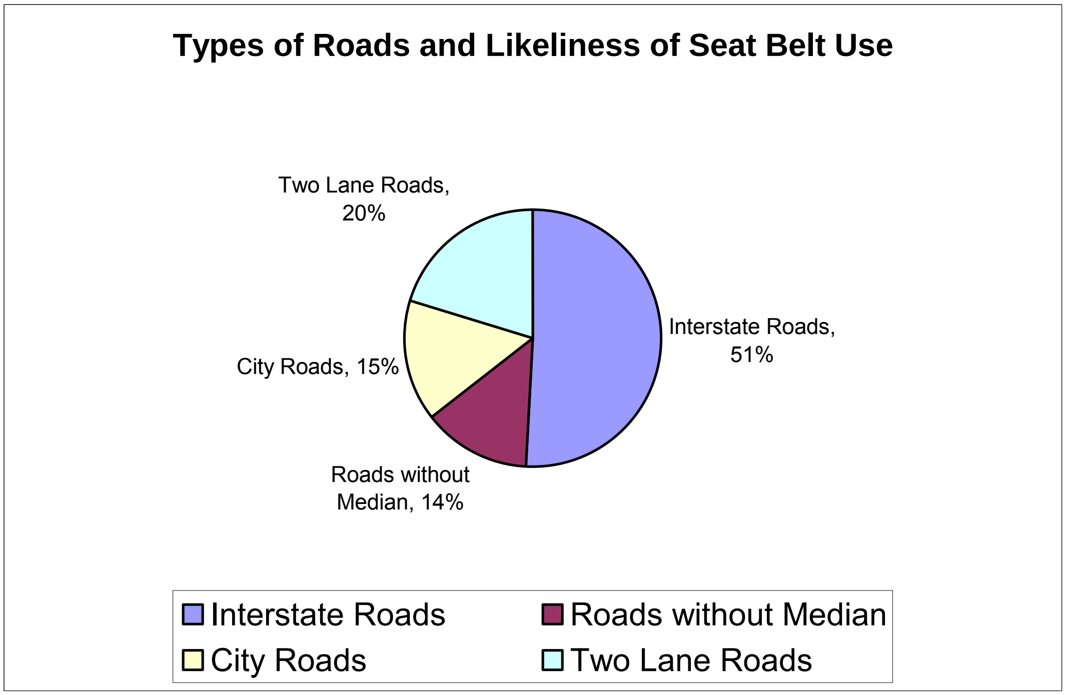


Figure 4.47: Types of Roads Seat Belt Use is More Likely

To identify countermeasures for increasing seat belt usage rates in Kansas, respondents were asked what would motivate them to use seat belts more often. These results are presented in Figure 4.48, which indicates that one fifth of the surveyed sample identified stricter enforcement as a factor that would motivate them to wear seat belts. Similarly ‘Reminder from someone’, ‘Increase in insurance if ticketed for not wearing seat belts’, ‘Higher fine’ and ‘Stricter seat belt laws’ were factors supported by 18, 17, 15 and 14 percentage of the surveyed sample that would motivate them to use seat belts more often. Education/Training program was the least supported factor where only 4 percent respondents said that it would motivate higher seat belt use. These findings indicate that drivers themselves like stricter laws and other punishments to improve their own safety, perhaps because they are not able to maintain high level of self-discipline.

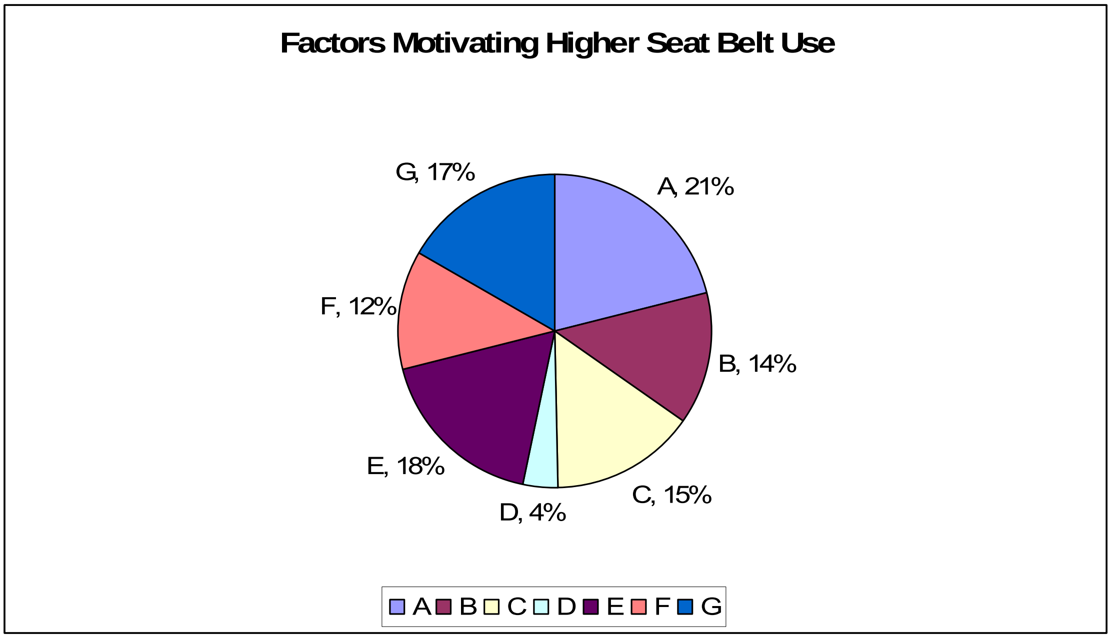


Figure 4.48: Factors Motivating Increased Use of Seat Belts

In Figure 4.48, factors motivating higher seat belt use are labeled as follows:

A = Strict law enforcement

B = Stricter seat belt law

C = Higher fine

D = Education/Training program

E = Reminder from someone

F = Automatic reminder system in car

G = Increase in insurance, if ticketed for not wearing seat belts.

4.4.5 Summary and Conclusions of Survey Results

From the results obtained by this analysis, some important conclusions can be made, which are summarized as follows.

Awareness of Seat Belt Law - General awareness of seat belt law among Kansans is quite low. It was found that awareness is lower among females, lower income groups, and younger age groups and among Hispanics and African Americans compared to Caucasian whites.

Seat Belt Use –About 59 % of the surveyed sample said they always use seat belts. State usage was found to be lower among males, younger drivers, and lower income groups. Hispanics were found to have the lowest seat belt usage and Asian/Pacific islanders were found to have the highest usage.

Reasons for not using seat belts more often – Some of the more frequent reasons identified by the respondents for not using seat belts are when driving a short distance, because they forget to put it on, and when they are in a hurry. About two-third of the sample gave one or more of these reasons for not wearing seat belts. Moreover, by category of trips, seat belt usage is more likely to be high for work/school related trips and less likely for personal trips/running errands. By type of facility, stated usage is higher on interstate roads and lower on rural roads.

Factors Motivating Seat Belt Usage – Some of the factors that were found to positively affect the decision to wear seat belts include bad weather conditions, driving with a child, driving at night, strict law enforcement, reminder from someone for using seat belts, higher fines, increase in insurance if ticketed for not wearing seat belts. Even though some of these factors are uncontrollable, other findings indicate that drivers like stricter laws and other punishments to improve their own safety, perhaps because they are not able to maintain high level of self-discipline by themselves.

CHAPTER FIVE - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY & CONCLUSIONS

Even though seat belt usage has increased steadily over the last decade, still it has not reached a level, where maximum benefits can be obtained. The challenge now is to increase restraint usage among groups and individuals who have not yet accepted the educational or enforcement messages related to the safety benefits of wearing the seat belt. This study focused mainly on identifying these critical groups, as well as other factors like locations, policies and regulations etc that influence seat belt usage rates and the associated safety outcomes.

In order to achieve these objectives, several statistical models were developed where one model was for identifying the factors affecting the state seat belt usage rate. Two critical factors, African-American population and rural highway mileage were identified as inversely related to seat belt usage rates, i.e. higher the African American population or rural highway mileage is lower the average usage rate in a state is. Along with this, six factors were identified as positively affecting seat belt usage rates. Among these, type of seat belt law is the most significant factor that could increase the average usage rate in a state. Based on the estimates of this study, converting from secondary to primary law could be expected increase seat belt usage rate by approximately 11 percent in Kansas. This estimated increase was found to be consistent with examples of states like Michigan, New Jersey, Oklahoma, Washington, Alabama and Washington D.C, which showed an increase in seat belt usage rate by approximately 9-14 percent by converting from secondary to primary enforcement.

Another significant factor that would be helpful in increasing seat belt use is increasing the penalty for violating the seat belt law. It was found that increasing the penalty by ten dollars could be expected to increase seat belt use by approximately 4.8 percent. Similarly, factors like fuel tax, crime rate, median income and miles of interstate road were found to positively influence seat belt usage rates.

The effect of seat belt law and other associated factors on occupant fatalities was also studied in this research. Statistical model on unrestrained occupant fatality percentage identified four factors that are capable of reducing the amount of unrestrained occupant fatalities. Among them primary seat belt law was the most significant factor, where it was estimated that converting to primary law would reduce fatalities by approximately ten percent. Other factors identified as reducing fatalities are median household income level, miles of interstate road and unemployment rate. The results also suggested that higher percentage of African-American and Hispanic population, young drivers and alcohol involvement among drivers involved in fatal crashes leads to higher percentage of unrestrained occupant fatalities. Accordingly, they could be identified as critical areas that need focused attention.

Similarly, another statistical model developed in this study, fatality rate model, also identified seat belt law as the most critical factor in decreasing fatality rate in a given state. Based on the estimates of this model, converting to primary enforcement could have saved 48-104 lives in Kansas in year 2002 alone. Other factors that are identified as capable of reducing fatality rate were increased median household income, fuel tax and travel time. The factors that were found to increase fatality rate were African American and Hispanic population, maximum speed limit law, and rural population.

Road user surveys were conducted in Kansas indicated that in Kansas awareness about seat belt related law is lower among lower income groups, younger drivers, Hispanics and African Americans. Majority of Kansans seems to be not familiar with the specifics of the seat belt law. Results also indicate that seat belt usage is lower among males, younger drivers, lower income groups, pick-up truck drivers, and Hispanics. Some other factors affecting seat belt usage among the survey sample were driving short distance, driving at night, driving under bad weather etc.

From the results obtained by statistical models and surveys conducted in Kansas five categories of factors were identified to affect seat belt use and occupant fatalities as summarized below.

Demographic and Socio-economic Variables – Higher median household income was found to increase seat belt usage rate and decrease both unrestrained occupant fatalities and fatality rate whereas higher percentages of African American and Hispanic population, rural population, and young drivers were found to increase either unrestrained occupant fatality percentage or fatality rate. Additionally, crime rate increases seat belt use and percentage of unemployed labor force decreases unrestrained occupant fatalities, most likely due to lesser travel by unemployed individuals.

Policy and/or Regulations – Primary seat belt law was the most significant variable under this category to increase seat belt use and decreasing both unrestrained occupant fatalities and fatality rate. Fuel tax and penalty for not wearing seat belt were also found to increase seat belt usage rates while fuel tax also decreased fatality rate. Additionally maximum speed limit law affects fatality rate.

Roadway and Traffic Characteristics – Higher interstate road mileage was found to increase seat belt usage rate in a state and decrease unrestrained occupant fatalities. Rural highway mileage was found to decrease seat belt usage rates and travel time for commuting to work decreased unrestrained occupant fatalities, indicating higher seat belt use for longer commute or travel. It should be noted that these findings represent the characteristics of road users rather than direct effect of these variables. For example since people are more likely to buckle up on interstate roads, increased interstate mileage also increases the average usage rate.

5.2 RECOMMENDATIONS

Based on the findings of this study, critical groups and locations as well as policies and regulations that critically affect seat belt usage and vehicle occupant fatalities in Kansas could be identified. Recommendations suggested for each category of factors that were identified, are as follows.

- **Policy and Regulations** - The importance of stricter seat belt laws, not only for increasing the usage but also towards reducing fatalities is clearly identified in this study. In order to increase seat belt usage rate in Kansas, converting to primary seat belt law is identified as the single most effective factor. Additionally, increasing the penalty for violating the seat belt law is also identified as one of the most effective factors for increasing the usage. Surprisingly, importance of stricter laws and increased penalty were also identified by a significant percentage of Kansans as well. Additionally, limiting the maximum speed to 70 miles per hour could reduce fatality rate.

- **Focused Attention on Critical Demographic Characteristics** – This study found rural population, African Americans and Hispanics as at a higher risk of being involved in vehicle occupant fatalities and also are groups with lower seat belt usage. Also critical from this viewpoint are the young drivers and lower income groups. These groups are considered critical and more focused education programs directly targeted at these groups are required to create awareness on the importance of seat belts among them.
- **Intensified Enforcement based on Critical Roadway Characteristics** – Interstate roads have higher seat belt use whereas rural highways have lower seat belt usage and higher number of fatalities. Hence, strict enforcement is required particularly on rural highways. Increased penalty and points on driver's license for not wearing a seat belt could significantly increase usage rate and decrease fatalities on rural highways.

In general, since the level of knowledge among Kansans seems to be very low, it is necessary to maintain an aggressive awareness/education campaign on seat belts, while paying particular attention on safety benefits in terms of lives saved and economic impacts. Additionally, it is strongly suggested to change the law to primary seat belt law and increase the penalty for not wearing seat belts, which currently stands at mere $10. This will give higher authority to enforcement officers to punish seat belt law violators and at the same time general public would become more conscious about the seat belt law. This can lead to highly significant improvements in seat belt usage rates and reduce number of vehicle occupant fatalities.

REFERENCES

1. Baker, S.P.; Braver, E.R.; Chen, L.H., Motor Vehicle Occupant Deaths among Hispanic and Black Children and Teenagers. Arch Pediatrics Adolescent Medicine, 152; 1209-1212, 1998.

2. Baker, S.P.; O'Neill, B.; Ginsburg, M.J.; Li, G., 1992, The Injury Fact Book, 2nd Edition, Oxford University Press, New York.

3. Balci, R.; Alicia, V, Comfort and Usability of Seat Belts, SAE Technical Paper Series, SAE 2001 World Congress, 2001.

4. Belsley, D.A.; Kuh, E.; Welsch, R.E., *Regression Diagnostics*, New York: John Wiley & Sons, Inc. 1980.

5. Benjamin J.M.; Reinfurt D., Race and Safety Belts in North Carolina, Washington D.C: Technical Report, US Department of Transportation. 1994.

6. Bester J.C., Explaining National Road Fatalities, Accident Analysis and Prevention Journal, 33; 663-672, 2001.

7. Bhattacharyya, M.N.; Layton, A.P., Effectiveness of Seat Belt Legislation on the Queensland Road Toll-An Australian Case Study in Intervention Analysis, Journal of American Statistical Association 74(367); 596-603,1979.

8. Bohlin, N. A Statistical Analysis of 28,000 Accident Cases with Emphasis on Occupant Restraint Value. New York; Society of Automotive Engineers, Inc.

9. Braver, E.R.; Race, Hispanic Origin, and Socioeconomic Status in Relation to Motor Vehicle Occupant Death Rates and Risk Factors among Adults. Accident Analysis and Prevention, 35(3); 295–309, 2003.

10. Calkins, L.N.; Zlatoper, T.J.; The Effects of Mandatory Seat Belt Laws on Motor Vehicle Fatalities in the United States, Social Science Quarterly, Vol. 82, No 4, 2001.

11. Cammisa, M.X.; Williams, A.F.; Ferguson, S.A., Self-Reported Seat Belt Use in Four Countries: A Telephone Survey, Journal of Crash Prevention and Injury Control, 2, 103-110.

12. Cohen, A.; Eianv, L.; The effect of Mandatory Seat Belt Law on Driving Behavior and Traffic Fatalities, The Review of Economics and Statistics, 85(4); 828-843, 2003

13. Council, F.M., Seat Belts; A Follow Up Study of Their Use Under Normal Driving Conditions, Journal of Safety Research, 1(3); 127-136, 1969

14. Cubbin, C.;Leclere, F.B.; Smith, G.S., Socio-economic Status and the Occurrence of Fatal and Non-fatal Injury in the United States, American Journal of Public Health, 90; 70-77, 2000. Date Accessed 05/22/2005.

15. Derrig,A.R; Gomez, S.M; Abatahi, A., The Effect of Seat Belt Usage Rates on Number of Motor Vehicle Related Fatalities, Harvard School of Public Health, 2000.

16. Dinh-Zarr, T.B.; Shults, D.A.; Shults, R.A; Zaza, S.; Elder, R.W.; Nichols, J.L., et al, Task Force on Community Prevention Services, Reviews of Evidence Regarding Interventions to Increase Use of Safety Belts, American Journal of Preventive Medicine, 21(4S); 48-65, 2001

17. Dissanayake, S.; Ratnayake, I., An Investigation on Severity of Rural Highway Crashes in Kansas, Transportation Research Board Annual Meeting CD-ROM, 84th Annual Meeting, Washington D.C., 2004.

18. Eby, D.W.; Vivoda J.M.; Standard Enforcement in Michigan: A One Year Follow up and Review. The University of Michigan and Michigan Office of Highway Safety Planning, UMTRI-2001-22, May 2001.

19. Evans, L., The Effectiveness of Safety Belts in Preventing Fatalities; Accident Analysis and Prevention, 18(3);229-241,1986.

20. Farmer, M.C.; Williams, A.F.; Effect on Fatality Risk of Changing from Secondary to Primary Seat Belt Enforcement, Journal of Safety Research, 36; 189-194, 2005.

21. Fatality Analysis Reporting System (FARS), National Highway Traffic Safety Administration, US Department of Transportation, 2002.

22. Fhaner, G., Hane, M., Seat Belts: Factors Influencing their Use, Department of Psychology, University of Uppsala, Sweden, 1972.

23. Gantz, T.; Garza, J.D.; Ragland, D.; Cohen, L.; Traffic Safety and Community of Color, University of California, Berkeley, Traffic Safety Center, 2003.

24. Garbacz, C., Estimating Seat Belt Effectiveness with Seat Belt Usage Data from the Center for Disease Control, Economic Letters 34; 83-88, 1990a.

25. Glassbrenner, D., Research Note, Seat Belt Use in 2003-Use Rates in the States and Territories, Report No DOT HS 809 646. Washington DC; National Highway Traffic Administration, 2003.

26. Hallmark, S.; Mueller, K.; Veneziano, D., Evaluation of Racial Differences in Seat Belt Use and Child Restraint Use; Review of Existing Literature, Iowa Department of Transportation, CTRE 03-151, 2004.

27. Hamed M. M.; Easa, M. Said, Ordered Probability Modeling of Seat Belt Usage, Journal of Transportation Engineering, May/June1998.

28. Harper, J. S.; Marine, W.M.; Garrett, C.J.; Lezotte, D.; Lowenstein, S.R.; Motor Vehicle Crash Fatalities: A Comparison of Hispanic and Non-Hispanic Motorists in Colorado. Annals of Emergency Medicine, 36(6); 589–596, 2000.

29. Huang, B.; Pretson, J., Road User's Attitude and Behaviou; Compendium of Survey Contents, University of Oxford, Transport Studies Unit, 2004

30. Houston, D.J.;Lillliard, E.R.; Grant, W.N.; Legislation Traffic Safety; A Pooled Time Series Analysis, Social Science Quaterly, 76(2); 328-345, 1995.

31. Hunter, W.W.; Stutts, J.C; Stewart, R.R; Rodgman, E.A., Overrepresentation of Seat Belt Non-Users in Traffic Crashes, Report No HSRC-TR74. Chapel Hill, NC; University of North Carolina Highway Safety research Center; 1988.

32. Kweon, J, Y.; Kockleman., Driver Attitude and Choices; Speed Limit, Seat Belt Use, Alcohol Consumption and Crash Histories, Submitted to Journal of Safety Research, 2003

33. Lawson, J.J.; Arora, H.A; Jonah, B.A.; Krysewski, J.A; Stewart,D.E ; Hieatt, D.J. Nighttime Surveys of Drivers; Alcohol Use, Annual Proceedings of the 26th Annual Meeting of American Association of Automotive Medicine. Des Plaines, IL; AAAM; 375-388, 1982.

34. Lee, P; Drsay, E; Lumpkin J, et al. Analysis of Hispanic Motor Vehicle Trauma Victims in Illinois, Academic of Emergency Medicine, 3; 221-227, 1996.

35. Leigh, J.P.; Waldon H.M.; Unemployment and Highway Fatalities, Health Polit Policy Law, 16(1): 135-56, 1991.

36. Lerner E.B; Billittier A.J; Moscati R.M; Connery, C.M; Stiller, G., The Influence of Demographic Factors on Seatbelt Use by Adults Injured in Motor Vehicle Crashes. Accident Analysis and Prevention, 33: p. 659-662, 2001.

37. Loeb, P.D., The Effectiveness of Seat Belt Legislation in Reducing Injury Rates in Texas, American Economic Review, 85(2); 81-84, 1995.

38. Lund, A.K., Voluntary Seat Belt Use among US Drivers; Geographic, Socio-economic and Demographic Variation, Accident Analysis and Prevention, 18(1); 43-50, 1985.

39. Lund, A.K; Preusser, D.F; Williams, A.F., The effect of New York's Seat Belt Use Law on Teenage Drivers, Accident Analysis and Prevention Journal, 19; 73-80, 1987.

40. Mayrose J, J.D., An Analysis of Race And Demographic Factors Among Motor Vehicle Fatalities. The Journal of Trauma Injury, Infection, and Critical Care. 52; 752-755, 2002.

41. McCartt, A.T.; Northrup, V.S., Factors Related To Seat Belt Use Among Fatally Injured Teenage Drivers. Journal of Safety Research, 35; 29-38, 2004.

42. Motor Vehicle Traffic Crashes as a Leading Cause of Death in the U.S., 2002 – A Demographic Perspective, Technical Report**,** DOT HS 809 843, National Center for Statistics and Analysis, 2005.

43. Neil K. C.; Preusser, F.D; Lives Lost By States-Failure to Implement Primary Safety Belt Laws, A Report for National Safety Council's Air Bag and Seat Belt Safety Campaign, 2003.

44. Nelson, D. E.; Bolen, J.; Marcie-Jo Kresnow, Trends in Safety Belt Use by Demographics and by Type of State Safety Belt Law, 1987 through 1993. American Journal of Public Health, Vol. 88, No. 2, pp. 245–249, 1998.

45. New Letter, US Department of Transportation, 2001. www.dot.gov/affairs/nhtsa2901.htm

46. New York Department of Motor Vehicle, Division of Research and Development, A pilot Study of Drivers Attitudes Towards Seat Belts; Research Report No 4, 1963(a)

47. *NIST/SEMATECH e-Handbook of Statistical Methods*, http://www.itl.nist.gov/div898/handbook/, Date Accessed 04/04/2005

48. NHTSA, Annual Report File (ARF), National Highway Traffic Safety Administration, US Department of Transportation, Washington D.C. 2002.

49. NHTSA, Research Note, Safety Belt Use in 2002, Use Rates in States and Territories, Technical Report, DOT HS 809 587, May 2003a

50. NHTSA, Safety Belt Use in 2003, Technical Report, DOT HS 809 646, US Department of Transportation, September, 2003b.

51. NHTSA, Traffic Safety Facts on Occupant Protection, Technical Report, DOT HS 809 765, US Department of Transportation, 2004.

52. Peek, C.; Becker, T.M.; Wiggins, C.L., Pedestrian Fatalities- New Mexico, 1958-1987, Morb Mortal Weekly Report, 40; 312-314, 1991.

53. Philip, S.; Yamada,A.; Sael, C.; Moffat,J., Predicting Seat Belt Use In Fatal Motor Vehicle Crashes From Observation Surveys of Belt Use; Accident Analysis and Prevention, 34;139-148,2002.

54. Preusser, D.F.; Bloomberg, R.D.; Edwards, J.M. Increasing Safety Belt Use among High Risk Drivers. Interim Report. Washington D.C.; US Department of Transportation; 1989.

55. Preusser, D.F; William, A.F; Lund, A.K. The Effect of New York's Seat Belt Use Law on Teenage Drivers. Accident Analysis and Prevention. 19; 73-80; 1987.

56. Raeder, P.K., Kuziomoko, L., Attitudes Towards Seat Belts and Shoulder Restraints, New York State Department of Motor Vehicle; Research Report No 1, 1968.

57. Rana, B.; Shen, W., Comfort and Usability of Seat Belts, SAE 2001 World Congress, 2001

58. Reinfurt, D. A.; Wells, J.W.; Rogman, E., Characteristics of Drivers Not Using Seat Belts in a High Belt Use State. Journal of Safety Research, Vol. 27, No. 4; 209 –215, 1996.

59. Reinfurt, D. W.; Campbell, B.J.; Stewart, J.R.; Stutts, J.C., Evaluating the North Carolina Safety Belt Wearing Law. Accident Analysis and Prevention, 22; 197–210.1990.

60. Riviara, F.P.; Thompson, D.C.; Cummings, P., Effectiveness of Primary and Secondary Enforced Seat Belt Laws, American Journal of Preventive Medicine, 16; 30-39, 1999.

61. SAS Institute Inc., SAS for Windows, Release 8.1. Cary, NC. 1999.

62. Schichor, A; Berstein, B; Crabtree, B., Safety Belt use and stress in adolescents. J of Adolescence, 25: 773-779, 1990.

63. Seat Belt Use in 2002, Report No DOT HS 809 587, National Highway Traffic Safety Administration, Washington DC. 2003.

64. Sewell C.M.; Becker, T.M.; Wiggins, C.L., Injury Mortality in New Mexico's American Indians, Hispanics and Non-Hispanic Whites, 1958-1982. West J Med, 150; 708-713, 1989.

65. Shinar, D., Demographic and Socio-economic Correlates of Safety Belt Use, Accident Analysis and Prevention, 25(6); 745-755, 1993.

66. Shoulder Belt Use in Minnesota, Results from 2002 Controlled Intersection Study. www.dps.state.mn.us/OTS/crashdata/2002BeltSurvey.ppt

67. Shults, R.A.; Elder, R.W.; Sleet, D.A.; Thompson, R.S.; Nichols, J.L.; Primary Enforcement Laws are Effective Even in the Face of Rising Belt Use Rates, Accident Analysis and Prevention, (36); 491-493, 2004.

68. Snyder, E.E; Spreitzer, E., Social, Emotional and Physical Factors associated with Seat Belt Use, Washington D.C; AAA Foundation for Traffic Safety; October 1990.

69. Solomon M.G., An Evaluation of NHTSA's region IV Click it or Ticket campaign, May 2001, Report No DOT HS 809 404. Washington DC; National Highway Traffic Administration, 2002.

70. Solomon, M.G.; Nissen, W.J.; Preusser, D.F.; Occupant protection Special Traffic Enforcement Program evaluation. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1999. DOT HS 808 884.

71. Traffic safety Center (2004), Online Newsletter Volume 2, Number 2, Summer 2004. Date Accessed - 04/22/2005.

72. Traffic Safety Facts 2002- State Traffic Data, National Center for Statistics and Analysis www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2003/809773.pdf. Date Accessed 11/20/2005.

73. Ulmer, R.G.; Preusser C.W.; Preusser, D.F.;. Cosgrove, L.A., Evaluation of California's Safety Belt Law Change from Secondary to Primary Enforcement. Journal of Safety Research, 26(4); 213–220, 1995 US Dept. of Transportation: Washington, DC.

74. Voas, R.B.; Wells, J.; Lestina, D., Drinking and Driving in the United States; The 1996 National Roadside Survey, Accident Analysis and Prevention, 30; 267-275,1998.

75. Wagenaar, A. C.; Maybee, R.C.; Sullivan, K.P., Mandatory Seat Belt Use Law in Eight States; A Time-Series Evaluation. Journal of Safety Research, 19; 51-70, 1988.

76. Wagenar, A.C.; Streff, F.M.; Molnar, L.J; Businski, K.L.; Schultz, R.H. Factors related to nonuse of seat belts in Michigan DOT HS 807 217. Washington. DC; US Department of Transportation, 1987.

77. Waller, P.F.; Barry, P.Z., Seat Belts; A comparison of Observed and Reported Use. Chapel Hill, North Carolina; The University of North Carolina, Highway Safety Research Center, 1969.

78. Wells, J.K.;Williams, A.F.; Farmer, M.C., Seat Belt Use Among African Americans, Hispanics, and Whites. Accident Analysis and Prevention, 34; 4, 523–529, 2002.

79. Williams, A.F.; McCartt, A.T.; Geary, L.L., Seat Belt Use by High School Students, Injury Prevention, 9; 25-28, 2003.

DATA REFERENCE

1. **Blood Alcohol Concentration Level Law** – National Conference of State Legislature, Website address - http://www.ncsl.org/statefed/stalt08.htm. Accessed on 11/14/2004.

2. **Crime Rate** – Statistical Abstract of the United States for 2004-2005, Section 5 Law enforcement, courts and prison, Pg -188.

3. **Fatality Rate Per 100 Million Vehicle Miles Traveled**- Traffic Safety Facts, 2002- State Traffic Data, National Center for Statistics and Analysis. www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2003/809773.pdf. Accessed on - 11/27/2004.

4. **Fatality Rate –** Calculated by total number of occupant fatalities in each state (obtained from Traffic Fact 2002- State Traffic Data) divided by Population of each state (obtained from Statistical Abstract of United States, 2003)

5. **Fuel Tax -** Statistical Abstract of the United States for 2004-2005, Section 23, Transportation, Pg -689

6. **Highway Miles of Rural Roads** – Highway Statistics 2002, Section V, Roadway Extent, Characteristic and Performance, Federal Highway Administration. www.fhwa.dot.gov/policy/ohim/hs02/re.htm. Accessed on 11/18/2004***. Accessed on - 11/28/2004***

7. **Maximum Speed Limit Law**- States' Attitudes towards Speed Limits: Summary Chart. http://www.ibiblio.org/rdu/sl-attud/chart.html. Accessed on 11/18/2004.

8. **Median Household Income** - Statistical Abstract of United States 2004-2005, Section 13. Income, Expenditure and Wealth, Page 442.

9. **Penalty for Seat Belt Violation** - Traffic Safety Facts, 2002- State Traffic Data, National Center for Statistics and Analysis. www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2003/809773.pdf. Date Accessed – 11/27/2004.

10. **Percentage of African American Population**- Statistical Abstract of United States -2003, Section 1 Population, Page 25.

11. **Percentage of Fatalities with BAC>0.08 g/dl** - Traffic Safety Facts, 2002- State Traffic Data, National Center for Statistics and Analysis. www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2003/809773.pdf. Date Accessed – 11/27/2004.

12. **Percentage of High School Students** - Statistical Abstract of United States - 2003, Section 4 Education, Page 155.

13. **Percentage of Hispanic Population**- Statistical Abstract of United States -2003, Section 1 Population, Page 26.

14. **Percentage of Young Drivers** - Highway Statistics 2002, Section III, Driver Licensing, Federal Highway Administration. http://www.fhwa.dot.gov/policy/ohim/hs02/index.htm. Accessed on 11/28/2004

15. **Seat Belt Law** - Safety Belt use in 2003, Use Rate in States and Territories, Technical Report, DOT HS 809 713, 2004

16. **Total Miles of Interstate Road** - Highway Statistics 2002, Section V, Roadway Extent, Characteristic and Performance, Federal Highway Administration. http://www.fhwa.dot.gov/policy/ohim/hs02/index.htm. Date Accessed 11/20/2004 Accessed on 11/28/2004.

17. **Unrestrained Occupant Fatalities** - Traffic Safety Facts, 2002- State Traffic Data, National Center for Statistics and Analysis. www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2003/809773.pdf. Date Accessed – 11/29/2004

18. **Seat Belt Usage Rate** – Safety Belt use in 2003, Use Rate in States and Territories, Technical Report, DOT HS 809 713, 2004

19. **Vehicle Miles Traveled on Rural Roads -** Highway Statistics 2002, Roadway Extent, Characteristic and Performance, Federal Highway Administration. www.fhwa.dot.gov/policy/ohim/hs02/re.htm. Accessed on 11/18/2004. Accessed on 11/27/2004.

APPENDIX A - SEAT BELT USAGE- SURVEY FORM

We are conducting a survey on seat belt usage in Kansas with the intention of increasing safety. Please show your support by answering the following questions. Information collected will be used for research purposes only.

Please check the appropriate response.

1. Do you have a valid driver's license?
   O Yes　　O No

2. Select the appropriate statement that describes the existing seat belt law in Kansas
   O Police can stop you and issue a ticket for not wearing seat belt.
   O Police can ticket you for not wearing seat belt only if you are involved in some other violation as well.
   O Don't know

3. Currently in Kansas, how much is the fine for not wearing a seat belt?
   O $ 10　　O $ 20
   O $ 50　　O $ 100
   O Don't care

4. Do you think that existing amount of fine is reasonable?
   O It is reasonable　　O Should be increased
   O Should be decreased　　O Don't know
   O Don't care

5. How long have you been driving?
   O 0 -5 years　　O 5-10 years
   O 10 -20 years　　O 20 years or more.
   O Don't drive

6. What kind of vehicle do you drive?
   O Car　　O SUV
   O Van　　O Pick up Truck
   O Other _____________

7. How old is the vehicle you drive?
   O 0 -5 years　　O 5- 10 years
   O 10 -15 years　　O 15-20 years
   O More than 20 yrs　　O Don't know

8. How many days do you drive in a week?
   O Everyday　　O 4-6 days
   O 2-3 days　　O Once a week

9. Approximately how many miles do you travel each month?
   O 0 -500　　O 500 -1000
   O 1000 -1500　　O 1500 -2000
   O More than 2000　　O Not applicable

10 What kind of seatbelt system do you have in your car?
   O Automatic　　O Manual　　O Don't know

11. If you answered automatic seat belt system, do you ever disengage/disconnect it?
O Yes   O No   O Not applicable

12. Does your vehicle have any kind of reminder system (like chime/beep) to remind you that your seat belt is not fastened?
O Yes   O No   O Don't know

13. How often do you wear a seat belt while driving?
O Always   O Almost always
O Most occasions   O Sometimes
O Just occasionally   O Never

(If you selected " Always" go to question-20)

14. You may not wear a seat belt if ….(check all that apply)
O You are in hurry   O You are driving short distance
O You forget to put it on   O You are driving in light traffic
O You feel uncomfortable   O You think chances of crashes are low
O People riding with you don't wear seat belts.
O Other (explain)____

15. Does any reason stated below affect your decision to wear a seat belt? (check all that apply)
O Driving at night.   O After being involved in a crash.
O Strict law enforcement   O You are under influence of alcohol
O Bad weather   O Passenger/s are under influence of Alcohol.
O Driving with a child.
O Other (explain)____

16. On what kind of trips are you more likely to wear a seat belt?
O Recreational trips   O Work related trips
O Personal trips/Running errands   O Other(explain)____________

17. When are you more likely to wear seat belts?
O As a driver   O As a front seat passenger
O As a rear seat passenger   O Same for all cases.

18. On what types of road are you more likely to wear seat belts? (check all that applies)
O On interstate   O On roads without median
O On city roads   O On two lane roads.
O Road doesn't matter   O Other (specify)___________________

19. What would motivate you to wear your seat belt most often? (Check all that apply)
O Strict law enforcement   O Stricter seat belt laws
O Higher fine   O Education/training programme
O Reminder from someone   O Automatic reminder in car (like chime/beep/flashing light)
O Increase in insurance if ticketed for not wearing seat belt   O Other ____________________
____

20. Have you ever been involved in a crash?
O Yes   O No
O If yes, how many times __________

21 Were you wearing a seat belt at the time of crash?

- O Yes　　O No
- O Not applicable　　O Don't remember

22 Have you ever been cited for any kind of traffic violation?

- O Yes　　O No
- O If yes, type of violation__________

23. Has seat belt usage increased/decreased for you in past one year?

- O Increased　　O Decreased
- O Almost the same　　O Don't know

24 Can you think of any reason for this increase/decrease in usage?

____

____

25. How many people are there in your household?

- O 1-2 people　　O 3 people
- O 4 people　　O 5 or more

26. How many of them are below 16yrs of age?

- O None　　O 1-2 people
- O 3-4 people　　O 5 or more

27. How many vehicles are there in your household?

- O None　　O 1-2
- O 3　　O 4 or more

28. Your age group?

- O 16-24 yrs　　O 25-34 yrs
- O 35-44 yrs　　O 45-54 yrs
- O 55-64 yrs　　O 65 and above

29. Sex?

- O Male　　O Female

30. Your marital status?

- O Single　　O Married
- O Divorced　　O Widowed
- O Separated　　O Not disclosed

31. Your ethnic background?

- O Hispanic origin　　O African American
- O Caucasian white　　O Asian/Pacific Islander
- O Other_____________　　O Not disclosed

32. Your educational qualification?

- O No formal schooling　　O Some high school
- O Some college　　O Four year college
- O Graduate degree　　O Other(specify)____________

33. Your current employment status?

O Full Time	O Part-time
O Unemployed	O Student
O Retired	O Other ___________

34. How would you describe your occupation?

O Administrative	O Engineering
O Agriculture	O Military
O Healthcare	O Legal
O Government job	O Sales/Marketing
O Technician	O Shipping/Distribution
O Factory worker	O Not disclosed
O Other (specify)______________________	

35. How much is your annual household income?

O Less then $ 4,999	O $5,000 - $19,999
O $20,000 -$34,999	O $35,000 -$49,999
O $50,000 -69,999	O $70,000 and above

36. Please select appropriate option regarding your primary residence?

O Own house
O Rental

37. Please enter the zip code of your primary residence _____________

K - TRAN

KANSAS TRANSPORTATION RESEARCH
AND
NEW - DEVELOPMENTS PROGRAM

A COOPERATIVE TRANSPORTATION RESEARCH PROGRAM BETWEEN:

KANSAS DEPARTMENT OF TRANSPORTATION

THE UNIVERSITY OF KANSAS

KANSAS STATE UNIVERSITY