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## SOCIO-ECONOMIC ANALYSIS OF FATAL CRASH TRENDS
### (Final Report)

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# SOCIO-ECONOMIC ANALYSIS OF
# FATAL CRASH TRENDS

(Final Report)

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16. Abstract

    This report describes the analysis of fatal crash patterns and explores the impact of socioeconomic factors and safety regulations on statewide crash rates.  This analysis separated statewide crash rates between 2002 and 2004 into two samples, 1) those with crash rates 25 percent greater than the average national rate and 2) those with crash rates lower than this threshold.  Safety regulations and socioeconomic factors were identified as having a significant effect on crash rates, with socioeconomic factors showing a higher potential to explain differences in crash rates between the two samples.

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# Executive Summary

This report describes the analysis of fatal crash patterns and explores the impact of socioeconomic factors and safety regulations on statewide crash rates. This analysis separated statewide crash rates between 2002 and 2004 into two samples, 1) those with crash rates 25 percent greater than the average national rate and 2) those with crash rates lower than this threshold. Safety regulations and socioeconomic factors were identified as having a significant effect on crash rates, with socioeconomic factors showing a higher potential to explain differences in crash rates between the two samples.

Based upon the analysis presented above the following conclusions are made concerning contributing factors and conditions surrounding fatal crash rates in the United States.

1. Statistical analysis of national crash data indicates that socioeconomic factors including income, poverty levels and education levels have a high correlation with fatal crash rates. Kentucky specific analysis indicated that high school education attainment levels was the most significant indicator of high crash rates when examined on a county level.

2. Statistical analysis indicated that traffic safety laws can decrease the fatal crash rate with the most significant impacts associated with:

   a. Administrative License Revocation
   b. Graduated Licensing Program
   c. Primary Seat Belt Enforcement Law
   d. Mandatory Helmet Law

   Overall, the impact of laws and regulations was significantly less than socioeconomic factors examined in the study.

3. Crash type experience for both the southeastern high crash states and western high crash states is very similar and follow the same trends.

4. States with average crash rates were shown to have a higher percentage of single vehicle crashes than those in the high crash states. Conversely, rear end and angle crashes were shown to have higher distributions in high crash states. One possible explanation for this could be related to driver experience in which more rural states, such as the high crash states, provide drivers with more experience on rural roadways but less experience in urban settings. This experience would then lead to improved driving on rural roadways, where the potential for a single vehicle crash is higher, but could also lead to a greater potential for crashes when faced with an urban setting.

5. When examining environmental conditions, the general trend in all categories is similar for both the high crash states and other states. However, southeastern states are shown to have a percentage of fatal crashes occurring during the

morning period (7 a.m. - 9 a.m.) than other states.  A slightly higher distribution is also present during the evening period, between 7 p.m. and 10 p.m., for both the southeastern and western high crash states.  These patterns are also similar to the findings for light conditions, in which the high crash states were shown to have an higher percentage of fatal crashes during partially lit conditions such as dawn and dusk conditions.

# 1. Introduction

Fatal highway crashes in the United States continue to result in alarming numbers of fatalities each year. As compiled and reported by the National Highway Traffic Safety Administration (NHTSA) in their "Traffic Safety Facts 2003 Overview," motor vehicle crashes are the leading cause of death for persons from 2 through 22 years of age (based on 2000 data). In addition, it was reported that 42,643 people were killed and 2,889,000 injured in 2003. However, the national crash rate in terms of fatalities per 100 million vehicle miles (F/100MVM) of travel has decreased in recent years to a historic low of 1.48. This decreasing trend nationally has been in place since the mid 1980's. Even with this overall decreasing trend, the 2002 statistics showed there were 12 states with fatal crash rates that exceeded the national crash rate by 25 percent or more. The states with highest crash rates included Arizona, Arkansas, Kentucky, Louisiana, Mississippi, Montana, Nevada, New Mexico, South Carolina, South Dakota, West Virginia, and Wyoming.

In Kentucky, the fatality crash rate has increased from 1.71 F/100MVM in 1999 to 2.07 in 2004. In addition, the number of fatalities in Kentucky has reached the highest level in many years with 978 deaths in 2004.

The objectives of this research study were to analyze fatal traffic crash characteristics in the 12 states with highest rates. Analyses were performed to evaluate the relationship between crash rates and contributing factors. Among those to be considered are the following variables: types of roads, geographic location, socio-economic characteristics of drivers, and characteristics of vehicles being driven. The effectiveness of various laws and regulations aimed at improving roadway safety were also examined with respect to fatal crashes.

Fatal crash characteristics in Kentucky were then examined with respect to the same variables evaluated for the national data. Kentucky data were disaggregated to the county level to determine if fatal crashes in Kentucky follow the same trends as the national fatalities.

Fatal crash types were examined to identify higher involvements of certain crash types for those states with higher a rate of fatal crashes.

# 2. Methodology

Fatal crash analysis was conducted in two phases to identify contributing factors to increased fatal crash rates on the national level. First, national crash data were analyzed with respect to socio-economic and geographic factors to identify potential contributing factors. Based upon the findings of this research, Kentucky fatal crash data were analyzed to identify differences between national and state crash trends.

Analysis of national fatal crash trends was conducted using data provided by the Fatality Analysis Reporting System (FARS). These data were supplemented with socio-

economic data from the US Census Bureau and the Bureau of Transportation Statistics. National analysis was conducted in two parts. First, regression analysis was performed using general state-level data form the US Census and Bureau of Transportation Statistics to identify potential factors which influence increased fatal crash rates. Statistical analysis was then performed on the individual FARS records comparing various attributes of crashes between those states having crash rates in the top quartile of the nation to the remaining states. It should be noted that this study was conducted over a two-year time period and every effort was made to use the most recently available data. Due to new releases of the FARS database this study examined 2001-2003 data as well as 2002-2004 data.

Kentucky specific analysis aimed to reproduce the national statistical analysis on a county level. This analysis utilized the FARS database and census data used in the national analysis.

Procedures for these analyses are presented below.

## 2.1    National Fatal Crash Rate Regression Analysis

Regression analysis was performed on state level data with the fatal crash rate serving as the dependent variable. Crash rates for each state in the United States were obtained from the Fatality Analysis Reporting System (FARS) for the years 2001, 2002 and 2003, providing 150 observations. Independent variables were then obtained to characterize socio-economic, transportation infrastructure and road-user factors for each state. **Table 1** summarizes the independent variables evaluated in the analysis and the source of the data.

Table 1:  Regression Analysis Independent Variables

| Independent Variable | Data Source |
|---|---|
| *Median Income* | US Census Bureau (2000) |
| *Percent of Population Below Poverty Level* | US Census Bureau (2000) |
| *Percent of Population with High School Degree or Equivalent* | US Census Bureau (2000) |
| *Percent of Population with College Degree* | US Census Bureau (2000) |
| *Mean Age of Registered Drivers* | Bureau of Transportation Statistics |
| *State Population* | US Census Bureau (2000) |
| *Statewide Population Density (ppl/sq. mi.)* | Calculated |
| *Percent of Registered Vehicles that are Trucks (Light or Heavy)* | Bureau of Transportation Statistics |
| *Total Vehicle Miles of Travel* | Bureau of Transportation Statistics |
| *Percent of VMT on Rural Roads* | Bureau of Transportation Statistics |
| *Percent of VMT on Local Rural Roads* | Bureau of Transportation Statistics |
| *Average Travel Time to Work* | Bureau of Transportation Statistics |
| *Average Annual Precipitation* | National Oceanic and Atmospheric Administration (NOAA) |
| *Primary Seat Belt Law* | National Highway Transportation Safety Administration |

Derivations of each of the variables listed above were also developed for use in the initial analysis including the square and $Log_{10}$ of each variable to determine if crash rates followed a linear, polynomial or logarithmic distribution based on each of the independent variables. Binary variables were developed based on each of the independent variables indicating whether the observed value was in the bottom, middle or top third of all observations.

A linear regression model was then developed using a stepwise approach to identify those variables with the most significant impact on statewide fatal crash rates. A P-value of 0.05 was used as the threshold for determining significance of variables in the model.

Additional analysis was also conducted to determine the effectiveness of laws and regulations, aimed at improving traffic safety, on reducing fatal crash rates. The laws examined are those that are connected with the FHWA Section 410 Grant Incentive Program and include:

- Administrative License Revocation
- 0.08 BAC per se law
- Graduated Licensing Program (as recommended by NHTSA)
- Primary Seat Belt Enforcement
- Mandatory Helmet Law

State specific data was collected from the National Highway Traffic Safety Administration (NHTSA) State Traffic Safety Information System for each of the three study years (2002, 2003 and 2004).

The results of this analysis are presented and discussed in **Section 3.1**.

## 2.2   Statistical Analysis of Fatal Crashes (National)

Crash data provided by the FARS database for the years 2002, 2003 and 2004 were analyzed to identify significant differences in the characteristics of fatal crashes between those states having high fatal crash rates and those states with fatal crash rates at or below the national average. This analysis examined vehicular and passenger characteristics of fatal crashes including:

- Vehicle Age
- Vehicle Type
- Rollover Crashes
- Driver Age
- Driver Sex
- Restraint Use
- Airbag Availability
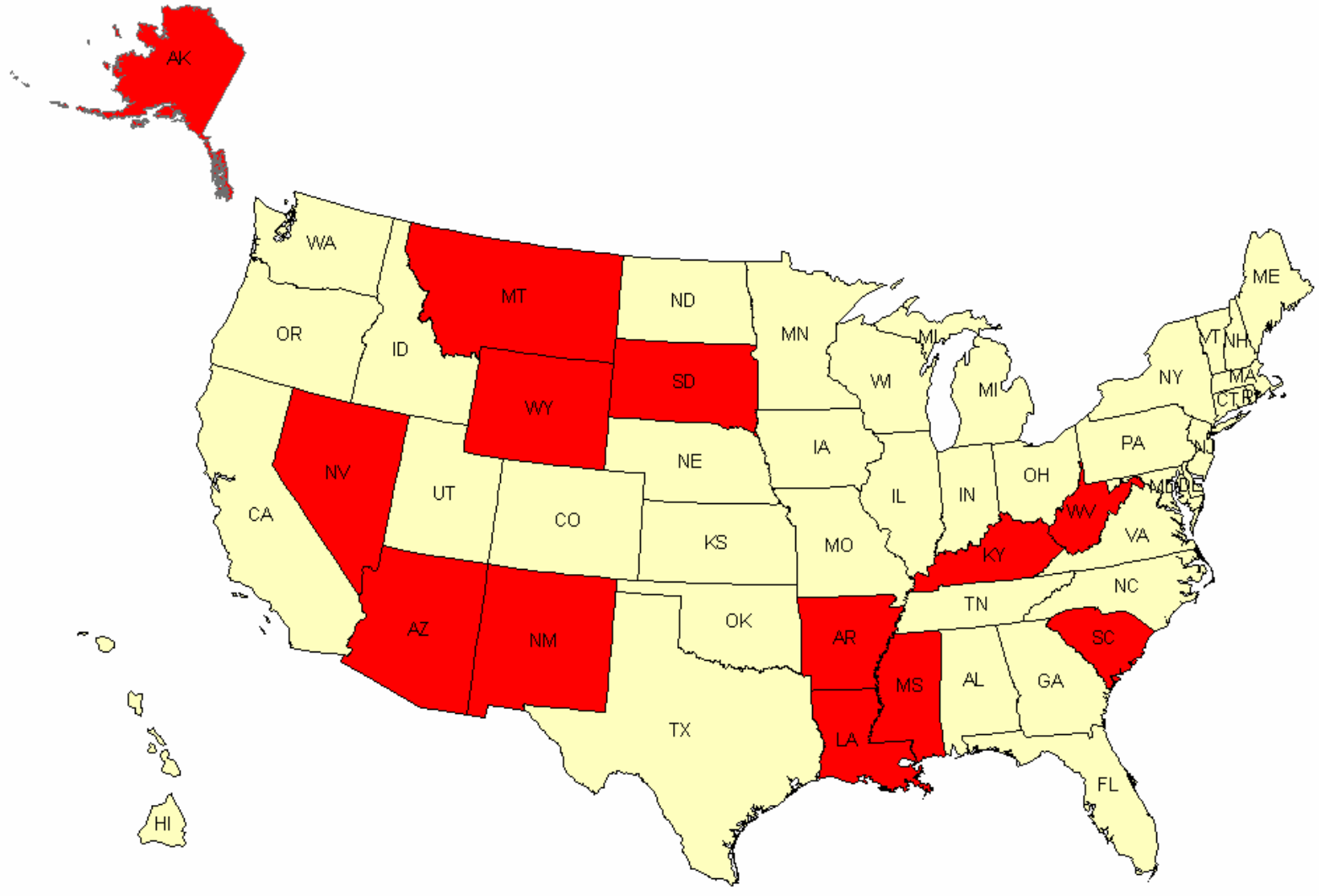- Identified Contributing Factors
    - Roadway

- Vehicle
- Driver

FARS data was separated into two sample groups, Sample A which had an average fatal crash rate greater than 25 percent above the national average and Sample B which included all remaining states. **Figure 1** provides a map identifying those states in Sample A. The mean value and standard error of the mean for the two samples was determined, and a Z-test was conducted to determine if there are statistically significant differences between the mean values of the two samples. A 95 percent confidence interval was used to determine statistical significance, which corresponds to a Z-value of 1.96.

The results of the analysis are summarized and discussed in **Section 3.2**.

Figure 1: High Crash States
Crash Rate > 1.25 x Average

## 2.3 Kentucky Fatal Crash Analysis

Statistical analysis was also performed for Kentucky fatal crashes on a county level to determine if the contributing socioeconomic factors identified in the national analysis also apply to Kentucky crash experience. US Census data was collected for all 120 Kentucky counties including age, median income, poverty levels, educational attainment and population density. An average fatal crash rate for each county was determined using three years (2002-2004) of fatal crash data from the FARS database and VMT estimated from the HPMS ADT data.

The results of this analysis are presented in **Section 3.3**.

## 2.4 Fatal Crash Type Analysis

Based upon crash information recorded in the FARS database, crash types were determined for all fatal crashes in the study period. The distribution of different crash types was compared for those states having a fatal crash rate 25 percent higher than the national average (Sample A, above) and the remaining states (Sample B). As seen in Figure 1, high fatal crash states are either located in the southeast or in the western states. Crash types were also examined by disaggregating the high fatal crash states into the southeast and western states to determine if they experience different crash patterns due to the local geography.

The results of this analysis are presented in **Section 3.4**.

# 3. Results

## 3.1 National Fatal Crash Rate Regression Analysis Results

As discussed above a linear regression model was developed to identify relationships between socio-economic and transportation infrastructure factors to the statewide fatal crash rates. Only those independent variables which had a P-value of 0.05 or less, indicating a 95 percent confidence in the relationship, were included in the final model. Based upon this analysis, four factors were identified as having a statistically significant impact on fatal crash rates.

- Mean Income (I)
- Percent of Population below the Poverty Line (P)
- Population Density (Pd)
- Percent of Population with High School Degree or Equivalent (HS)

The following equation relates these variables to the statewide crash rate.

EQ 1. $CrashRate = 8.137 - 1.299 Log(I) + 0.001\ P^2 - 0.350 Log(Pd) - 0.002\ HS^a$
a: HS factor only applied to those observations in the top third of observations.

The model identified above has an $R^2$ value of 0.595 and an adjusted $R^2$ value of 0.584, indicating that almost 60 percent of the variation in statewide fatal crash rates can be explained by these four variables.

**Table 2** lists the standardized coefficients and the estimated P-Value for each variable. The standardized coefficients are developed based on a normalization of the variables where each normalized variable has a standard deviation of 1. The standardized coefficients allow for direct comparison of the magnitude of impact for each variable on the crash rate.

Table 2:  Standardized Coefficients

| Variable | Standardized Coefficient | P-Value |
|---|---|---|
| Log (Income) | -0.1993 | 0.035 |
| (Poverty Level)$^2$ | 0.2649 | 0.007 |
| Log (Pop. Dens.) | -0.4984 | 0.000 |
| High School | -0.2437 | 0.002 |

As can be seen from the table, all values examined had a P-value less than 0.05 indicating greater than a 95 percent confidence level of the significance of the variable in determining fatal crash rates. All coefficients are negative except for poverty level indicating that crash rate decreases with increasing income, population density and high school graduation levels. Crash rates are shown to increase with increasing percentages of populations below the poverty level.

Population density is shown to have the largest impact on crash rate with a standardized coefficient of 0.4984 indicating a significantly higher crash rate in less dense, more rural states. The magnitude of the impact of poverty levels and high school education are similar around 0.25.

A separate regression model was also developed to identify the effectiveness of traffic safety laws which are applied by many states. This analysis examined laws that are connected with the FHWA Section 410 Grant Incentive Program which include:

- Administrative License Revocation (Revoke)
- 0.08 BAC per se law (BAC)
- Graduated Licensing Program (as recommended by NHTSA) (Grad)
- Primary Seat Belt Enforcement (Belt)
- Mandatory Helmet Law (Helmet)

The following equation relates these variables to the statewide crash rate.

EQ 2.  *CrashRate= 1.865 – 0.223 (Revoke) + 0.085 (BAC) - 0.146 (Grad) -0.136 (Belt) – 0.105 (Helmet)*

The model identified above has an $R^2$ value of 0.146 and an adjusted $R^2$ value of 0.116, indicating that approximately 10 percent of the variation in statewide fatal crash rates can be explained by the presence (or absence) of these laws. It is noted that the socioeconomic model presented above provides a significantly higher $R^2$ value indicating that extraneous factors have a much higher influence on fatal crash trends than state regulations.

**Table 3** lists the standardized coefficients and the estimated P-Value for each variable. The standardized coefficients are developed based on a normalization of the variables where each normalized variable has a standard deviation of 1. The standardized coefficients allow for direct comparison of the magnitude of impact for each variable on the crash rate.

Table 3: Standardized Coefficients

| Variable | Standardized Coefficient | P-Value |
|---|---|---|
| Revoke | -0.234 | 0.004 |
| BAC | 0.093 | 0.249 |
| Grad | -0.157 | 0.064 |
| Belt | -0.158 | 0.050 |
| Helmet | -0.124 | 0.147 |

All laws examined demonstrated a negative impact on the fatal crash rate except for the 0.08 BAC threshold, which also had a P-value of 0.249 indicating a low confidence level in the effect of the 0.08 threshold. This could largely be influenced by the fact that those states not enforcing a 0.08 threshold may utilize a BAC only slightly higher than 0.08 such as 0.10 and the overall difference between the two thresholds is negligible.

In addition, the mandatory helmet law, while demonstrating a negative influence on the fatal crash rate, had a P-value of 0.147, indicating an 85 percent confidence level in the findings. However, this lower confidence interval is likely attributed to the relatively small percentage of motorcycles in relation to automobiles which are involved in fatal crashes. Mandatory helmet laws should therefore be assumed to have a positive impact on improving fatal crash rates.

All other factors demonstrate a significant impact on reducing fatal crash rates with administrative license revocation having the largest impact. While administrative license revocation may be a deterrent from reckless driving and keep poor drivers off the roadway it may also be indicative of the commitment from the state to improving the safety of the state transportation system.

## 3.2 Statistical Analysis of Fatal Crashes Results

The results of the statistical analysis of fatal crashes are presented in **Table 4**. Statistical significance was found between the mean value of the two samples for all variables examined, except for driver gender, which showed the same distribution of male and

female drivers in both samples. The difference across all characteristics examined suggests that the reason certain states have significantly higher crash rates compared to others is due to a number of factors acting in concert and cannot be attributed to a single factor.

Table 4: Fatal Crash Characteristic Statistical Analysis Results

| Variable | Mean Value | | Z-Value |
| --- | --- | --- | --- |
| | Other State | High Crash State | |
| **Crash Location** | | | |
| Intersection Related | 0.247 | 0.183 | 27.64 |
| Divided Highway | 0.304 | 0.314 | 3.39 |
| **Vehicle Characteristics** | | | |
| Vehicle Age | 8.548 | 8.780 | 6.61 |
| Vehicle Type (% Auto) | 0.555 | 0.507 | 16.71 |
| Airbag Availability | 0.558 | 0.478 | 29.32 |
| **Occupant Characteristics** | | | |
| Driver Age | 40.394 | 39.669 | 6.62 |
| Driver Gender (1 Female; 2 Male) | 1.314 | 1.316 | 0.70 |
| Restraint Use (Fatalities Only) | 0.356 | 0.278 | 25.47 |
| **Contributing Factors** | | | |
| Roadway | 0.007 | 0.006 | 2.70 |
| Vehicle | 0.934 | 0.958 | 22.57 |
| Driver | 0.373 | 0.361 | 4.61 |
| **Rollover** | **0.205** | **0.249** | **17.69** |

As can be seen from Table 4, the average vehicle age is shown to be higher in states with higher fatal crash rates, by approximately 0.25 years. This higher vehicular age, may be responsible for the lower availability of airbags and the higher number of vehicle related factors contributing to the crash being reporting for these states. The older vehicle age for high crash states may be the result of the reported lower median incomes for these states.

A higher percentage of sport utility vehicles and trucks is also shown to be involved in fatal crashes in these states when compared to other states. This may also be a contributing factor to the higher percentage of rollover crashes present in high crash states.

Drivers involved in fatal crashes in high crash states were shown to have a lower average age than the other states. This is especially significant considering that there is no appreciable difference in the average age of all registered drivers between the two samples. However, contrary to what would be expected with a lower driver age and lower driver education, reported driver related factors contributing to the crash were actually lower in states with high crash rates than in other states.

Proper restraint belt use of fatalities is shown to be significantly lower in the high fatal crash states than it is in other states. When the use of both a shoulder and a lap belt is examined, use decreases in both samples decrease with a significantly lower reported use (22 percent) in high crash states compared to the other states (28 percent). This may be indicative of both driver education as well as vehicle age, similar to the availability of air bags.

As discussed, the lower income and subsequent older average vehicle age in high crash states may contribute to the lower availability of air bags and shoulder and lap belt restraints in vehicles. However, as safety equipment improves and is deployed in more vehicles, it is possible that older vehicles will soon have similar safety systems as newer vehicles, which may aid in reducing the fatal crash rate among these states.

## 3.3 Kentucky Fatal Crash Analysis Results

As discussed above, a linear regression model was developed to identify relationships between socio-economic factors and fatal crash rates within Kentucky counties. Only those independent variables which had a P-value of 0.05 or less, indicating a 95 percent confidence in the relationship were included in the final model. Based upon this analysis, high school graduation rate was identified as having a statistically significant impact on fatal crash rates.

The following equation relates these variables to the county crash rate.

EQ 1. *CrashRate= 9.087 – 13.658 (HS)*

The model identified above has an $R^2$ value of 0.307 and an adjusted $R^2$ value of 0.301, indicating that over 30 percent of the variation in Kentucky's fatal crash rates can be explained by this single variable. High school education levels were determined to have a P-value of 0.000 indicating a confidence interval greater than 99.999 percent that high school education is a significant factor influencing crash rates within the model.

All other factors examined within the national analysis were initially included within the Kentucky specific analysis, however, none produced statistically significant findings greater than the 0.05 threshold and did not significantly increase the $R^2$ value for the model.

## 3.4 Fatal Crash Type Analysis Results

Fatal crashes were evaluated for the distribution of crash type based upon the manner of collision data provided in FARS database. Six specific crash types were examined. These are:

1. Single Vehicle Crashes
2. Rear End Crashes
3. Head On Crashes
4. Angle Crashes

5. Sideswipe Crashes (Same Direction)
6. Sideswipe Crashes (Opposite Direction)

**Figure 2** compares the distribution of these fatal crash types for those states with a high fatal crash rates (Sample A) and those states with average or below average fatal crash rates (Sample B). Additionally, distributions are provided for high fatal crash states in the southeast and for those states in the western states.

Figure 2: Fatal Crash Type Analysis
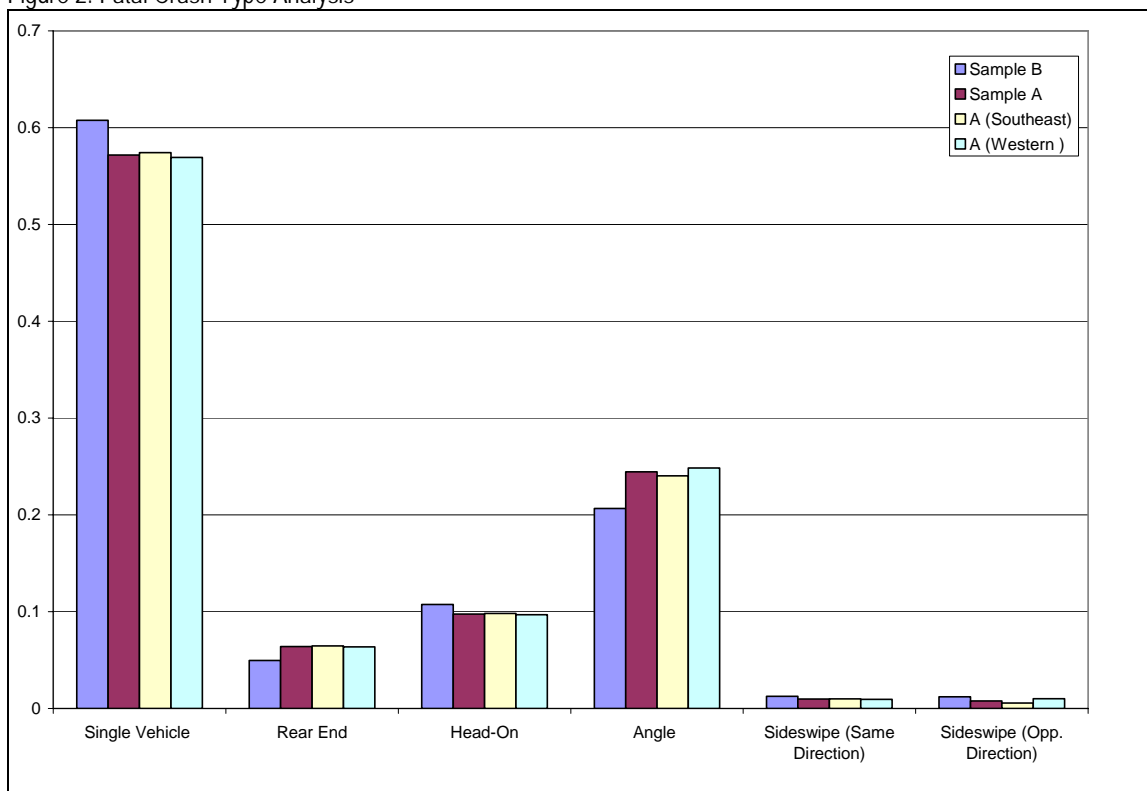


Crash rates for both groups of states show the same general trend, however, upon closer examination, several distinct differences are present. When examining single vehicle crashes, states with average crash rates are shown to have a higher percentage than those in the high crash states. Conversely, when examining rear end and angle crashes, states with high crash rates are shown to have a higher representation of these crash types than other states. This analysis is surprising in the fact that high crash states are shown to have a lower population density and a higher percentage of rural roadways in which the potential for a single vehicle crash is greater, which is in direct conflict with the findings. Likewise, those states with lower fatal crash rates tend to have higher population densities and therefore increase the chance for more "urban" crash types such as rear end and angle crashes.

One possible explanation for this occurrence could be related to driver experience. In more rural states, drivers will generally have more experience with rural roadway conditions and therefore while having less experience in urban settings. This experience

would then lead to improved driving on rural roadways, where the potential for a single vehicle crash is higher, but could also lead to a greater potential for crashes when faced with an urban setting. The converse could also be true for more urban areas in which drivers have greater experience with urban situations and therefore have a lower propensity for urban crashes and a higher propensity for rural crashes.
It should also be noted that the crash type experience for both the southeastern and western high crash states is very similar and follow the same trends.

Crash records were also analyzed for environmental factors that may contribute to the increased fatal crash rate in high crash states. Analysis examined crashes by time of day, lighting conditions and weather conditions. **Figures 3, 4 and 5** show the results of this analysis.

The general trend in all categories is similar for both the high crash states and other states. However, southeastern states are shown to have a higher percentage of fatal crashes occurring during the morning period (7 a.m. - 9 a.m.) than other states. A slightly higher distribution is also present during the evening period, between 7 p.m. and 10 p.m., for both the southeastern and western high crash states. These patterns are also similar to the findings of light conditions, in which the high crash states are shown to have a higher percentage of fatal crashes during partially lit conditions such as dawn and dusk conditions.

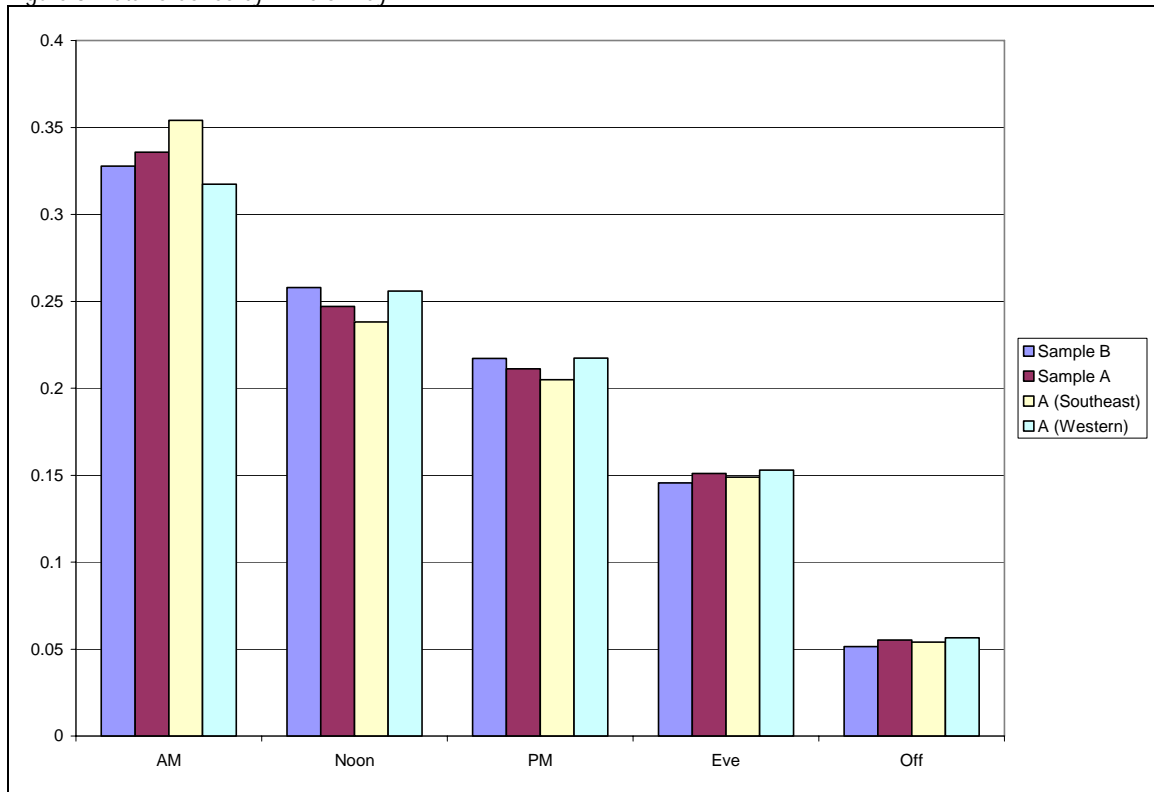Figure 3: Fatal Crashes by Time of Day
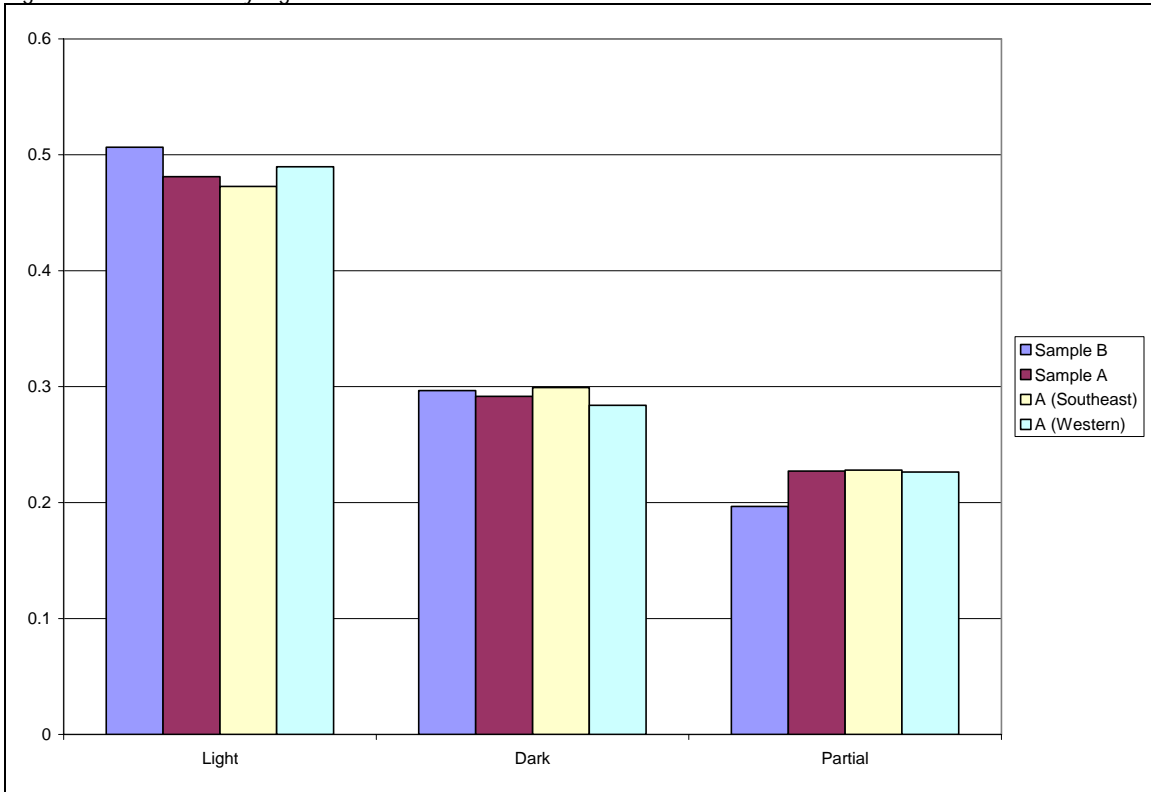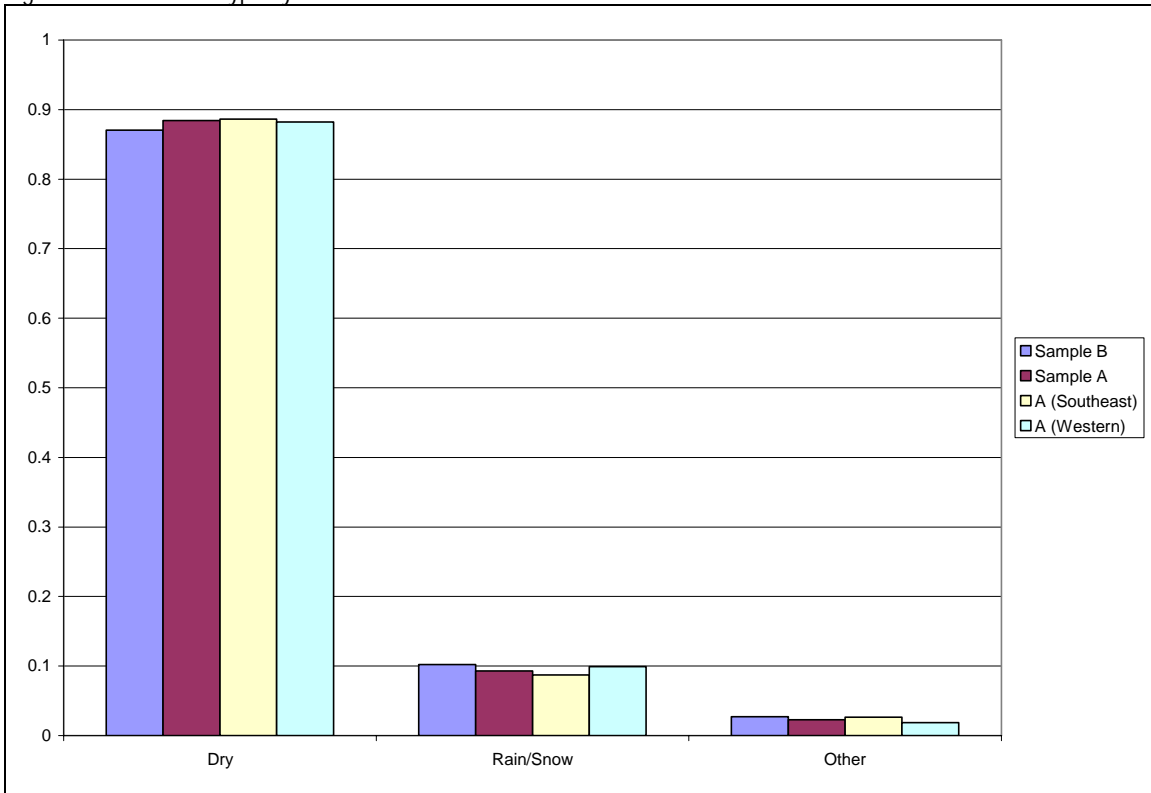
Figure 4 Fatal Crashes by Light Conditions



Figure 5: Fatal Crash Type by Weather Conditions

# 4.0  Summary and Conclusions

Based upon the analysis presented above the following conclusions are made concerning contributing factors and conditions surrounding fatal crash rates in the United States.

6.  Statistical analysis of national crash data indicates that socioeconomic factors including income, poverty levels and education levels have a high correlation with fatal crash rates.  Kentucky specific analysis indicated that high school education attainment levels was the most significant indicator of high crash rates when examined on a county level.

7.  Statistical analysis indicated that traffic safety laws can decrease the fatal crash rate with the most significant impacts associated with:

    a.  Administrative License Revocation
    b.  Graduated Licensing Program
    c.  Primary Seat Belt Enforcement Law
    d.  Mandatory Helmet Law

    Overall, the impact of laws and regulations was significantly less than socioeconomic factors examined in the study.

8.  Crash type experience for both the southeastern high crash states and western high crash states is very similar and follow the same trends.

9.  States with average crash rates were shown to have a higher percentage of single vehicle crashes than those in the high crash states.  Conversely, rear end and angle crashes were shown to have higher distributions in high crash states.  One possible explanation for this could be related to driver experience in which more rural states, such as the high crash states, provide drivers with more experience on rural roadways but less experience in urban settings.  This experience would then lead to improved driving on rural roadways, where the potential for a single vehicle crash is higher, but could also lead to a greater potential for crashes when faced with an urban setting.

10. When examining environmental conditions, the general trend in all categories is similar for both the high crash states and other states.  However, southeastern states are shown to have a percentage of fatal crashes occurring during the morning period (7 a.m. - 9 a.m.) than other states.  A slightly higher distribution is also present during the evening period, between 7 p.m. and 10 p.m., for both the southeastern and western high crash states.  These patterns are also similar to the findings for light conditions, in which the high crash states were shown to have an higher percentage of fatal crashes during partially lit conditions such as dawn and dusk conditions.