Fatal Vehicle Crash Rates in the Southeast United States: Why are they higher?

FATAL VEHICLE CRASH RATES IN THE SOUTHEAST UNITED STATES: WHY ARE THEY HIGHER?

FINAL REPORT

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EXECUTIVE SUMMARY

The southeastern region of the United States has been experiencing consistently higher fatal vehicle crashes and fatality rates compared to other regions of the country. The region has also a number of different socioeconomic characteristics compared to the nation including low median household incomes, high percentages of population below poverty levels and classified as rural, and lower percentages in high school completion and university attainment than the national average. It is then possible that these types of socioeconomic characteristics could influence highway safety by affecting the age and type of vehicles owned, the condition of these vehicles, and the attitudes of the drivers towards safety and risk taking behaviors.

The objectives of this study were to identify potential socioeconomic factors that could affect and contribute to the higher accident rates in the Southeast and to develop preliminary relationships between socioeconomic characteristics and accident trends that could explain these higher numbers and rates. Driver and vehicle characteristics from accident databases were related to socioeconomic and demographic variables based on the zip code of the drivers' residence. Accident rates were obtained using the induced exposure methodology for single- and multi-vehicle accidents.

The results showed that driver age and gender is not significantly different in the Southeast than any other parts of the country. However, vehicle age and type were factors that seem to contribute more on single-vehicle accidents in the area. Morever, the data presented here showed that there are indeed relationships between the socioeconomic variables examined and fatal accident rates in the Southeast. In general, according to the accident propensity analysis, drivers at fault who belong to areas with low socioeconomic characteristics were found more likely to be involved in single-vehicle accidents. These relationships were more obvious when more than two variables combined in the multivariable analysis. However, the classification of the data in a large number of cells when combining three or more variables did not allow for an adequate number of accidents and thus, some of the trends observed could not be statistically substantiated.

The findings of this study suggest two possible directions for future research: 1. expansion of the data base to more than three years and the development of a more detailed multivariable analysis to allow

for a better understanding of the three way interrelations among the variables and provide additional information regarding the impact of the socioeconomic variables on fatal accidents in the Southeast; and 2. development of a micro-model to define relationships between accidents and the specific socioeconomic characteristics of the drivers involved in the accident by collecting median household income and driver education level, since the use of these variables based on the drivers' residence zip code may have introduced some bias in the current analysis due to unknown variability.

The findings of this study have pointed out the relationship between the age of the vehicle and fatal accidents and the higher ratios of younger drivers for single-vehicle accidents. Obviously, older vehicles are less safe than newer vehicles and the age of the vehicle is closely tied to a variety of social factors. Vehicle inspection programs may then be used as a countermeasure aiming to identify vehicles with safety related deficiencies. Finally, to address the young driver related problems, driver education seems to be the reasonable countermeasure for improving their safety. Specific programs that would present to young drivers the problems of rural roads, since this is the area where most accidents occur, and their potential for single-vehicle accidents are required to increase their awareness. The lack of vehicle inspection and driver education in several of the southeast states may also be contributing factors and the reinstatement of such programs may be a necessity.

It is believed that these two countermeasures, driver education and vehicle inspection, are an important first step towards improving the safety of all drivers in the Southeast and impacting the fatality, and in general, accident rates in the region. The proposed continuation of this study could only enhance the knowledge gained so far, provide additional information regarding the factors that may contribute to the increased fatal accident rates of the region, and allow for the development of countermeasures aiming to reduce the fatal rates in the Southeast.

1. INTRODUCTION

The southeastern region of the United States, comprised of the eight states of the Federal Highway Administration's Region 4, has been experiencing consistently higher fatal vehicle crashes compared to other regions of the country. When comparing fatalities per 100 million vehicle miles (MVM), nearly all of the eight states of the southeastern region have fatality rates grater than the national average. In 1996 none of the eight states in Region 4 had rates less than the national average of 1.7 fatalities per 100 MVM (U.S. Department of Transportation, 1997).

A number of socioeconomic characteristics could influence accident behavior directly and indirectly. Household income, for example, could affect the type and age of vehicles owned, which in turn can influence the potential for accident involvement. Therefore, by investigating the demographic and socioeconomic characteristics of the southeastern states, the relationships between these characteristics and vehicle crashes can be identified and their impact on fatal accidents could be determined. Having determined the demographic factors that may contribute to the increased accident occurrence, further research can be initiated to develop counter-measures aiming to reduce accident rates in the southeastern states.

The objectives of this study were: 1) to identify potential socioeconomic factors that could affect and contribute to the higher accident rates in the Southeast; and 2) to develop preliminary relationships between socioeconomic characteristics and accident trends that could explain these higher numbers and rates. To achieve these objectives, this study related socioeconomic variables considered potential accident indicators to driver and vehicle characteristics obtained from accident records. The demographic characteristics of the zip code area of the drivers involved in a fatal accident were considered as representative indicators of the area where the driver resides. Accident rates were obtained using the induced exposure methodology for single- and multi-vehicle accidents and relationships were developed that could identify contributing demographic factors to accident occurrence.

This report presents the findings of this study. Following this introduction, the literature review results are presented followed by the methodology applied and the results of the study. The last section of the report discusses the findings and presents the conclusions the study.

2. BACKGROUND INFORMATION

Regional trends in monthly fatalities for 1996 show that there were 10,783 fatalities in Region 4 for the one-year period, which is 26 percent of the total fatalities in the United States. The trends in numbers of fatalities for 1975 through 1996 in Region 4 indicate that all states and the region have consistently higher fatality rates than the nation average. A summary of motor vehicle fatality rates in the southeast compared to the U.S. average is presented in Table 1 (U.S. Department of Transportation, 1997).

Table 1. Motor vehicle fatality rates in the southeast compared to the U.S. average (Fatalities per 100 million vehicle miles)

STATE	1975	1980	1985	1990	1996
Alabama	3.6	3.2	2.5	2.6	2.2
Florida	3.2	3.6	3.2	2.6	2.1
Georgia	3.5	3.5	2.5	2.2	1.8
Kentucky	3.5	3.3	2.5	2.5	2.0
Mississippi	3.8	4.2	3.5	3.1	2.7
N. Carolina	4.1	3.6	3.0	2.2	1.9
S. Carolina	4.0	3.8	3.6	2.8	2.3
Tennessee	3.4	3.4	3.0	2.5	2.1
REGION 4	3.6	3.6	3.0	2.5	2.1
United States	3.4	3.3	2.5	2.1	1.7

During the same period, various safety improvement programs have been undertaken in all parts of the United States aiming to improve safety. The reduction in the nationwide fatality rates indicates that these programs have a significant impact. However, it appears that fewer benefits have been gained as a result of those programs in the Southeast. Moreover, it is reasonable to believe that design standards are similar among the various states and one should not expect lower standards for the southeastern states. Therefore, other factors should influence these trends.

Past research on motor vehicle crashes has documented that approximately 85 percent of the contributing factors are associated with the driver, 10 percent involve the highway, and 5 percent involve the vehicle. Therefore, it is obvious that most problems causing motor vehicle crashes are linked to the driver. A number of factors have had an influence on accident rates and safety levels with various degrees of success. Implementation of alcohol enforcement programs and campaigns to increase safety belt usage have had major impacts on highway safety. Young and old drivers are significantly overrepresented in the number and rate of fatalities. Even though a relatively small percentage of the motor vehicle crashes are caused by highway design flaws, safely designed highways lessen the severity of injuries when crashes occur. The vehicle is not a contributing factor in many crashes; however, more safely designed vehicles have had beneficial effects in the reduction of injuries resulting from crashes.

A plausible explanation for the increased accident rates, especially fatal rates, in the Southeast is the differences in a variety of socioeconomic characteristics in this region compared to other regions. Based on statistics from the Bureau of the Census, all states in Region 4 have lower percentages in high school completion and university attainment than the national average (U.S. Department of Commerce, 1996). With respect to income characteristics, most of the states in the region have a median family income 35 percent lower than the national median income; they are at the bottom of the national rankings with respect to both income and disposable income per capita; and they have the largest percentages among the states of persons below poverty level. These types of socioeconomic characteristics could definitely influence highway safety by affecting the age of vehicles owned (older, less safe vehicles), the type of vehicles driven (more pickup trucks than automobiles, smaller and possibly less safe vehicles), the condition of these vehicles (not properly maintained), and the attitudes of the drivers towards safety and risk taking behaviors.

At the same time, the fact that most areas in the region are considered rural areas may also contribute to these increased rates. Approximately 40 percent of the area of the southeastern states is classified as rural, compared to national average of 29 percent, and most of the states have a larger percentage of their population classified as rural than the national average of 30 percent. Historical data indicate that the fatality rates are twice as large in rural areas than in

urban areas (U.S. Department of Transportation, 1995). Thus, the combination of the higher fatality rates in rural areas and the rurality of the Southeast may also explain these higher accident rates throughout the southeastern states.

Despite the fact that no specific source was found referring to the Southeast, the remaining of this section discuss modeling methodologies in order to establish the context and approach for conducting this study. An important role of the social economy activity in accidents was generally determined utilizing macro-models. However, due to their limitations, this study suggests a different approach based on micro-models.

The use of different macro-models to explain the fluctuations in the annual number of fatalities for several countries has been utilized in past research and has determined an important impact of economic activity on fatality trends. The most clear example happened after the oil crisis in the mid 1970's, when many countries experienced decreases in fatalities. In some countries, such as Japan, Germany, and Israel, the total number of fatalities was reduced by one-half (Hakim et al., 1991). Some of the macro-models used to determine the number of fatalities based on number of vehicles and population needed to be reevaluated. Due to this unforeseen change, it is apparent that such macro models are not accurate and require additional data to forecast accident trends. To account for variables that could influence travel behavior, the concept of travel exposure was introduced.

Past research showed that economic variables--of which unemployment seems to be used the most--are negatively related to accidents with injuries. Some authors attribute this relationship to larger sensitivity of the higher-risk groups to the economy. For example, in periods of economic recession, the number of young driver fatality rates is significantly lower than in other periods. A likely explanation is that young drivers make fewer trips on rural roads and fewer trips at night, which may reduce the fatality rates, while barely reducing the miles they travel (Hoxie, Skinner, & Wang, 1984). On the other hand, Peltzman (1975) suggested a demand-oriented explanation for the negative relationship between economic variables and accident rates. As income rises, the demand for safer cars increases; public investment in transport-related infrastructure increases as well. Similarly, as economy grows, more is spent in road safety features and better road

maintenance. Thus, holding constant the number of miles driving, rising income is negatively linked to accidents. Inclusion of income and vehicle miles traveled in an economic model may lead to biased estimates because of the "double counting" of the same phenomenon; income explains demand for travel. It is important to point out that even though there were different explanations of the impact of the economic variables analyzed in such studies, the relationship found between the economic conditions and the accidents were statistically significant (Hakim et al., 1991).

Macro-models are very limited for forecasting accidents due to the under-estimation of the benefits of road safety measures implemented. The model of Partyka (1984) represents a good example of this limitation. The study, using a 22 year time series accident forecasting model, related the number of road fatalities to the number of unemployed workers, employed workers, and people not available in the labor force. With the introduction of a dummy variable for the oil crisis in 1975, the model fits extremely well, achieving a coefficient of 0.98. However, for the fast economic expansion period of 1982 – 1988, the model presented discrepancies of forecasting values close to 35 percent. The presence of several extraneous variables can influence accident rates, and consecutively changes in safety policies, and make the prediction of long term accident rates based on linear regression models very difficult.

From the literature review, it seems that the state of explaining and predicting accidents based on macro-models that relate the economy with accidents is still deficient. It should also be stated that these models, although in some cases achieve a good fitting, do not allow to clearly identify the influence of socioeconomic variables on accidents. Controversial opinions of the same results emphasize this concern. A promising direction for future developments seems to build these macro-models from microanalysis that helps to understand better the impact of economic variables on accidents. An example of this is a specific bicycle study conducted to compare the demographic and economic characteristics of bicyclists involved in bicycle-motor vehicle accidents in the urban area of Dade County in Florida (Epperson, 1995). The methodology used tabulated accident rates by census tract and then related them to economic characteristics for each census tract, using linear regression technique. The study concluded that bicycle planners should give greater attention to neighborhoods where extreme poverty exists and where transit

availability is inferior. Even though the study examined few factors, the correlation achieved for some explanatory variables after performing statistical tests represents a clear influence of each of them on the number of accidents.

Given the status and ability of prediction models, it was deemed more appropriate to use an alternative method to proceed with the statistical analysis for this study. To identify the socioeconomic conditions that directly affect accident rates in the Southeast, the driver at fault is examined and accident rates are obtained with the use of the quasi-induced exposure methodology presented in the next section.

3. METHODOLOGY

3.1. Introduction

Frequency distributions for the selected variables were performed in order to determine the ranges of groups for each variable. These general trends allow for comparing regional findings for each variable with the national average. The fatal accident database was separated in single-vehicle accidents and multi-vehicle accidents and with or without pedestrian involvement.

The set of independent variables to be analyzed include the following:

1. Variables from the accident reports:
   - driver age
   - driver gender
   - vehicle age
   - vehicle type
   - roadway classification
   - number of lanes

   These variables are used to identify directly characteristics of those individuals at fault in fatal accidents for the Southeast. Vehicle age may be studied as an indirect economic variable (older vehicles are less safe vehicles), while vehicle type seeks to identify the potential driving behavior due to vehicles that normally are associated for the Southeast (pickups). On the other hand, roadway type and number of lanes determine the relationship between geometric features and rural zones to fatal accidents. Most of these variables are traditionally used in accident analysis and thus, are included here.
2. Socioeconomic variables:
   - median household income
   - per capita income
   - population below poverty status
   - unemployment
   - educational attainment
   - rural population

In general, these variables describe specific socioeconomic conditions for the population. Even though the first four variables evaluate economic conditions, every one might have different influences in fatal accidents because they represent different scenarios. Median household income represents better the economy of an individual when interacts in society, while per capita income is more significant when comparing the economy of an entire region. On the other hand, the third economic variable--population below poverty status--was selected to identify how poverty influences fatal accidents. Unemployment rate is not a direct economic variable, but it can describe non-quantified effects such as the psychological state of individuals. Finally, the rurality and the education are two social aspects to be studied, since they have an important relation to fatal accidents.

3.2. Quasi-induced Exposure Method

The quasi-induced exposure allows for determining relative accident involvement for specific characteristics of the driving population, such as driver age and gender, as well as vehicle characteristics, such as vehicle age and type. These groups of interest can then be linked to other parameters of interest, such as time of day of accident occurrence, socioeconomic characteristics of the driver, and so forth, to identify factors contributing to accident occurrence. Accident rates disaggregated into such categories would be useful metrics for establishing the relative safety among groups and would provide invaluable direction for policy development aimed at improving highway safety. Although computerized databases now yield sufficiently accurate estimates of the frequencies of accidents sub-divided by many of these characteristics, correspondingly accurate estimates of accident exposure are often difficult or impossible to make. Moreover, investigators sometimes disagree about which exposure measure is most appropriate for each specific application. The traditional methods are based on estimating the amount of vehicle-miles traveled (VMT) by simply multiplying the ADT with the length of the roadway. However, the use of VMT's calculated in this manner prohibit the development of exposure metrics for other variables of interest such as specific times of day, driver and vehicle characteristics, as well as the other variables of interest, i.e. demographic characteristics.

To overcome some of the problems and limitations in estimating exposure by driver and vehicle type from exogenous values such as travel distance, drivers licensed, and vehicles registered,

methods have been developed that derive exposure estimates from the accident database itself. These techniques are coming into more widespread use and have been recently validated against more conventional techniques (Stamatiadis & Deacon, 1997).

An additional interactive effect which has not received adequate prior attention is the differences over time among the types of drivers and vehicles that use different elements of the roadway system (Mengert, 1982). For example, it is reasonable to assume that younger drivers are more likely to comprise a larger proportion of the driving population on local streets during weekend nights than on Interstates during rush periods. These kind of differences are not *accurately* represented by traditional aggregate exposure metrics such as total VMT's because of the difficulty in collecting the large amount and variety of needed data. The use of induced exposure can thus provide an alternative means to achieve this stratification of data over the variables of interest and, as a result, can reflect the differences in driver/vehicle characteristics for each such combination.

3.3. Relative Accident Rates

To proceed with the accident analysis, accident propensities for different driver and vehicle characteristics are required. The measure of the accident propensity used in the quasi-induced exposure methodology is the relative accident involvement ratio (RAIR) defined as the ratio of the percentage of at-fault drivers/vehicles for a given set of characteristics to the percentage of not-at-fault drivers/vehicles for the same set of conditions. Therefore, to determine both the accident proneness and the accident exposure, the driver/vehicle for each accident should be categorized into one of the following three basic groups: 1. drivers/vehicles of single-vehicle accidents, 2. drivers/vehicles at-fault in two-vehicle accidents, and 3. drivers/vehicles not-at-fault in two-vehicle accidents. Accidents involving two at-fault drivers, no at-fault drivers or three or more vehicles are disregarded in this type of data analysis, since they could introduce a bias and they constitute a relatively small number of accidents/drivers (approximately 13 percent).

Given this basic categorization, two accident rates are computed--single- and multi-vehicle rates. For single-vehicle accidents, the accident rate is defined as the ratio of drivers/vehicles in single-vehicle accidents for a given set of conditions to drivers/vehicles of the same set of conditions of

the not-responsible drivers/vehicles in two-vehicle accidents. This ratio will be denoted as RAIRs in the following. For two-vehicle accidents, the ratio is defined as described in above (ratio of driver/vehicle at-fault to the driver/vehicle not-at-fault) and will be noted as RAIRm. These ratios are used as a measure of relative accident propensity for different groups of drivers and vehicles where values greater than 1.0 indicate a higher likelihood of accident involvement for that group.

As stated above, the quasi-induced exposure method allows for developing an accurate means for identifying risk factors most likely to be associated with fatal accidents. These factors may include driver age and gender groups, vehicle type and age groups, and socioeconomic characteristics related to driver locality. Moreover, using the risk factors identified, countermeasures could be developed aiming to reduce the large number of accidents occurring on secondary roadways. Such countermeasures may include education of certain driving populations, enforcement of traffic laws, and vehicle safety inspection.

3.4. Data Compilation

A database was developed using the information from two sources. Using the Fatality Analysis Reporting System (FARS), maintained by the National Highway Traffic Safety Administration, fatal accident information was collected for accidents occurred in the southeastern states for a three-year period, 1994 to 1996. Table 2 summarizes the accident information for the southeastern states obtained from the FARS database. Similarly, demographic variables were extracted from the 1990 Census database and were related to the FARS variables using the drivers' residence zip code as the common link. Even though within each zip code there may exist a range of socioeconomic values, it was assumed that the average values presented in the Census data are reasonable proxies of the overall values of the zip code. Moreover, the lack of availability of the data in smaller geographical sections than the zip code necessitated this assumption.

A complete match between the two databases was not possible due to the lower number of zip codes in the Census data most likely because of time difference (additional zip codes may have been introduced later than 1990). It is also important to notice that the variables selected from the FARS database (driver age, driver gender, vehicle type, vehicle age, roadway classification, and

number of lanes) represent direct characteristics for the drivers or vehicles involved, while the variables selected from the Census data (median household income, per capita income, rural population, educational level, unemployment, and population below poverty status) represent local conditions for the drivers. This is important since the local variables will not be the exact ones for the drivers involved in the accidents, but they would generally represent the drivers' local socioeconomic environment. As a result of the data compilation, a new database with the selected socioeconomic variables was created for the fatal accidents in Region 4 for the 1994 to 1996 time period.

Table 2. Fatal accident data for Region 4 (1994-1996)

ACCIDENT DATA	1994	1995	1996	TOTAL
TOTAL NUMBER OF FATAL ACCIDENTS	9,151	9,557	9,617	28,325
TOTAL NUMBER OF FATALITIES	10,256	10,712	10,783	31,751
ACCIDENT LOCATION				
Rural accidents	5,980	6,525	6,543	19,048
Urban accidents	3,171	3,032	3,074	9,277
NUMBER OF LANES				
2 Lane roads	6,994	7,256	7,268	21,518
4 lane roads	1,310	1,457	1,460	4,227
Other lane roads	847	844	889	2,580
VEHICLES INVOLVED				
Total number of vehicles involved	14,033	14,771	14,828	43,632
Accidents with no motorists involved	1,517	1,565	1,487	4,569
Accidents with 1 vehicle involved	4,987	5,261	5,272	15,520
Accidents with 2 vehicles involved	3,585	3,635	3,691	10,911
Accidents with 3 vehicles involved	476	524	522	1,522
Accidents with more than 3 vehicles involved	103	137	132	372
PEOPLE INVOLVED				
Number of people involved	24,876	26,070	26,163	77,109
Number of non motorists involved	1,661	1,722	1,595	4,978
Number of drinking drivers	2,984	2,959	3,065	9,008

In order to accomplish the accident propensity analysis utilizing the methodology described previously, it was essential to categorize the driver participation into two groups: drivers at fault and drivers not-at fault. Since the driver participation varies due to the number of vehicles

involved in the accident, accidents should be separated into single-vehicle accidents and multi-vehicle accidents. For this study, accidents involving pedestrians or three or more vehicles were disregarded. This was considered necessarily to obtain the higher representation of fatal accidents, as well as to warranty the correct selection of the drivers at fault. The selection of the driver's responsibility was done according to the related driver factors. For the multi-vehicle accidents, accidents with both drivers at fault or unidentified drivers at fault were not considered because they could introduce a bias in the analysis. Table 3 summarizes the selected accidents for the analyses. As this table indicates, the selected accidents represent 73 percent of the total fatal accidents and 87 percent of the total fatal accidents without pedestrians. For the linked census variables, these percentages are slightly lower.

Table 3. Selected accidents for the analyses

Number of vehicles	Total fatal accidents			Selected accidents	
	Non pedest.	With Pedest.	Total	FARS variables	Census variables
Single-vehicle	11,283	4,237	15,520	11,283	10,715
Two vehicles	10,639	272	10,911	9,351	8,872
Three(+) vehicles	1,834	60	1,894		
Totals	**23,756**	**4,569**	**28,325**	**20,634**	**19,587**

4. RESULTS

Utilizing the constructed database, relationships for the twelve selected independent variables were analyzed for the total number of drivers at fault and for the relative accident ratio between each variable. The driver frequency distribution for drivers at fault allows to identify the contribution of each group in the total number of accidents. Determining the relative accident involvement ratio for each group helps to define the effect of one particular group and its tendency to cause more accidents than been involved in. The results for each independent variable as well as their relationships are presented in the following sections of this report. Statistical analyses were performed using logistic regression with a confidence interval of 95 percent.

4.1. Accident Variables

4.1.1. Driver Age

Driver age is a demographic variable of great concern, since it identifies groups of drivers with higher accident propensity. Drivers were grouped in six age groups using ten-year intervals, and to produce an adequate sample size, drivers younger than 24 were grouped in a category as well those over 65. Figure 1 shows the age of the driver at fault for single- and multi-vehicle accidents. The youngest drivers (under 25 years) have the highest number of crashes for both single- and multi-vehicle accidents, among drivers involved in fatal accidents. It is also important to notice that older drivers (over 65) have a significantly high number of multi-vehicle accident involvement.

Considering exposure to fatal accidents, ratios are developed for single and multi-vehicle accidents. Figure 2 confirms the finding that younger drivers in single-vehicle accidents and older in multi-vehicle accidents are the most likely groups to cause fatal accidents. However, it could be concluded that older drivers in multi-vehicle accidents have a greater propensity to cause fatal accidents. While younger driver cause more single-vehicle accidents these findings are similar to other nationwide trends and do not show any significant deviation for the Southeast.

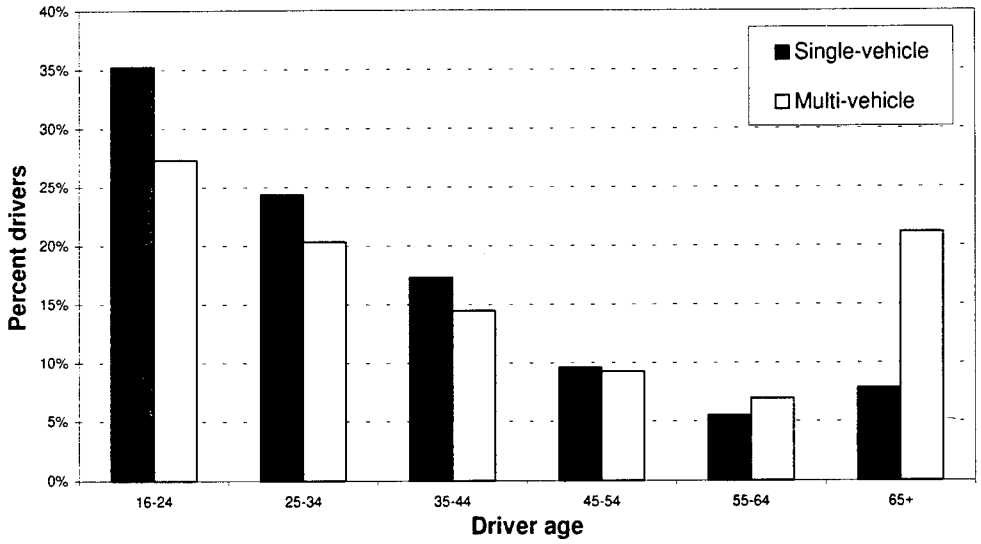

Figure 1. Fatal accident percentages for driver at fault by driver age

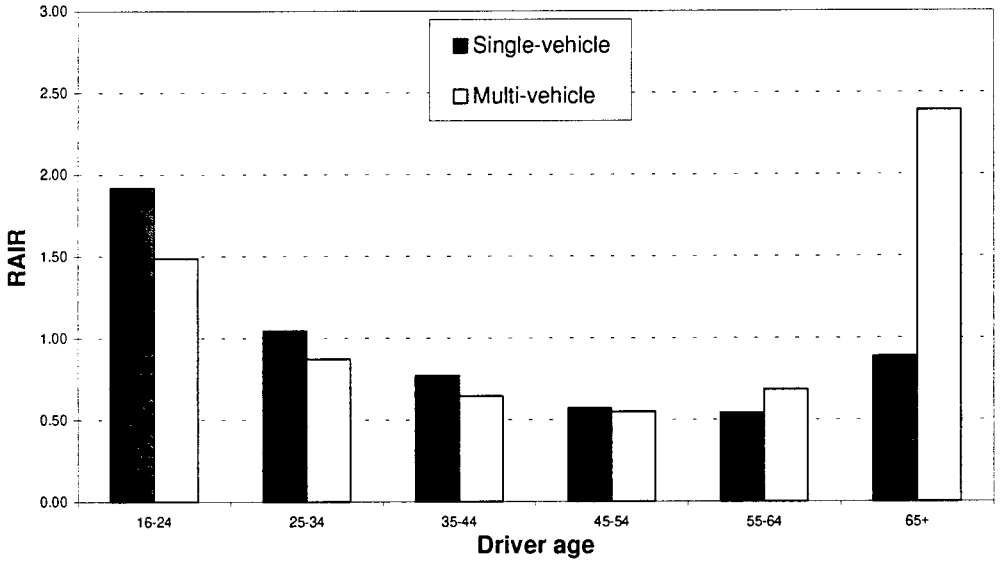

Figure 2. Relative accident involvement ratios for driver age

4.1.2. Driver Gender

The analysis of the driver at fault by gender shows that males have more fatal accidents. The accident data show that 78 percent and 70 percent of the total drivers at fault in single- and multi-vehicle accidents respectively were males (Figure 3). This could be partially explained by the fact that traditionally males drive more than females or the potential higher risk-taking behavior of males. Considering the exposure data, males represent 73 percent of the driving population involved in multi-vehicle accidents and somewhat verify the assumption of driving more. Moreover, analyzing the involvement ratios by gender, it could be concluded that even though

males are more likely to cause single-vehicle accidents, females are more likely to cause multi-vehicle accidents (Figure 4). This may be explained by the different risk levels that each gender is willing to take as well as the possible accident location. When considering the type of accident, single- vs. multi-vehicle accidents, males are more likely to cause a single-vehicle accident, while females show no difference between single- and multi-vehicle accidents.

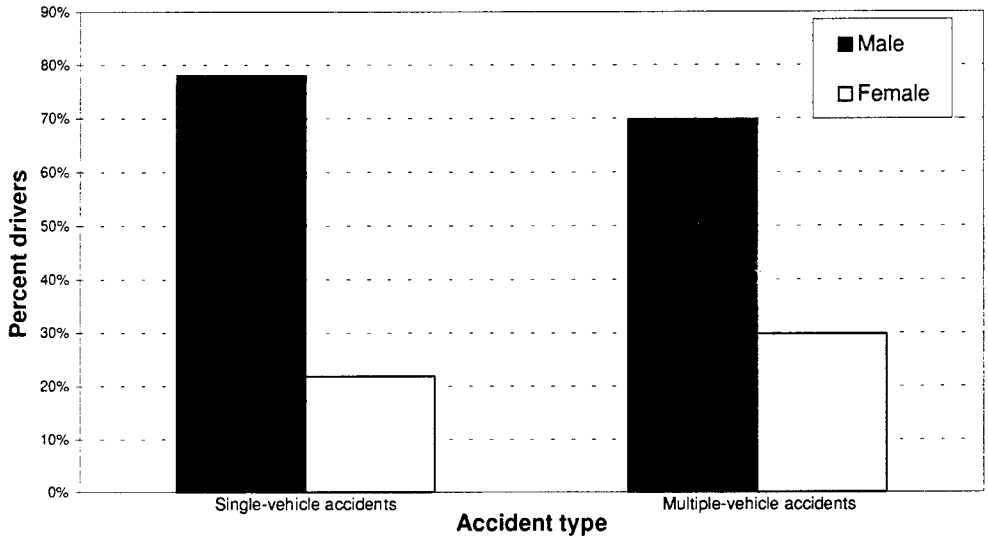

Figure 3. Fatal accident percentages for driver at fault by driver gender

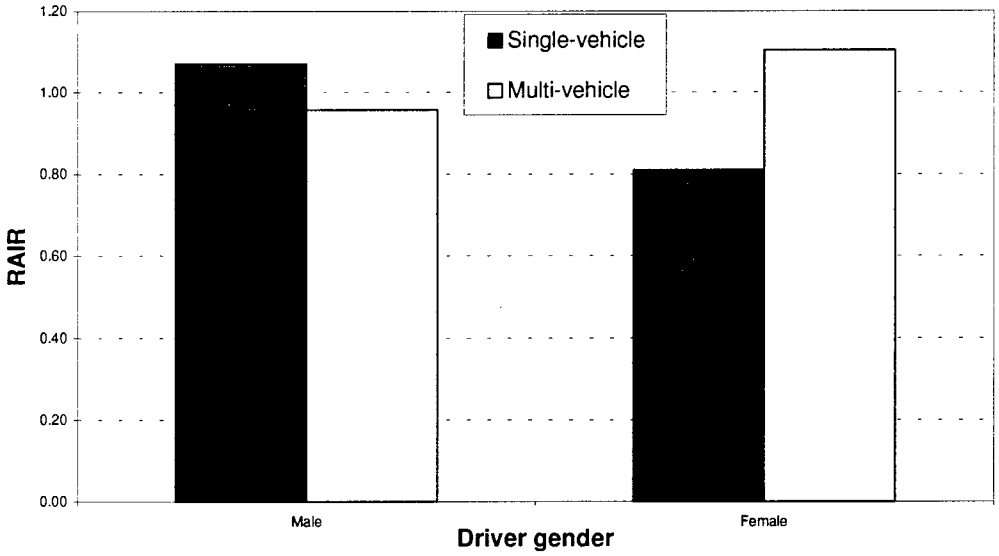

Figure 4. Relative accident involvement ratios for driver gender

Analyzing driver age by gender, a common pattern to that observed for driver age emerges with some variations between the genders. Male and female drivers above 65, which have involvement ratios close to 2.5, are the most likely group to be involved in fatal multi-vehicle accidents. For

younger drivers, since males have considerably higher ratios than females, it can be concluded that young females are safer than young males. These trends are also similar to those observed in other studies and thus, southeastern region does not exhibit any different characteristics.

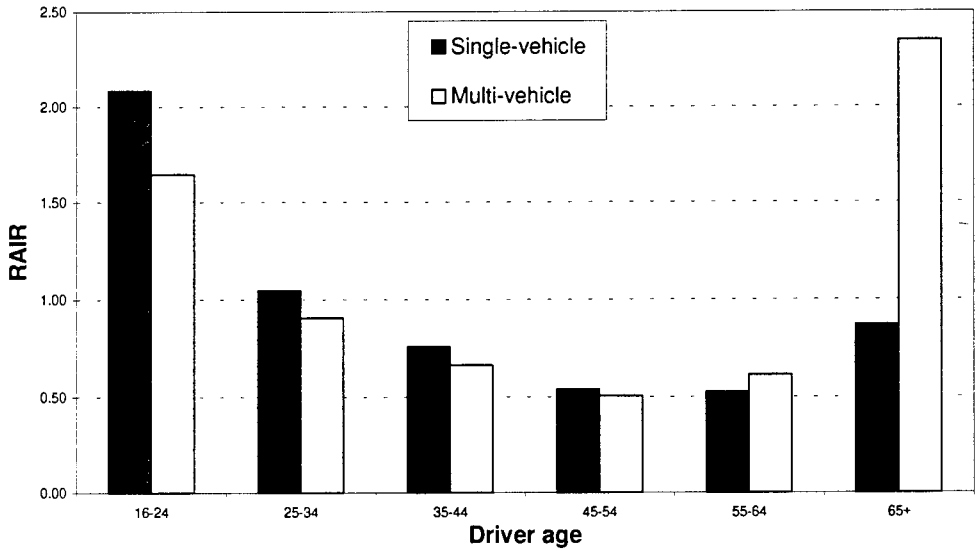

Figure 5. Relative accident involvement ratios for males by driver age

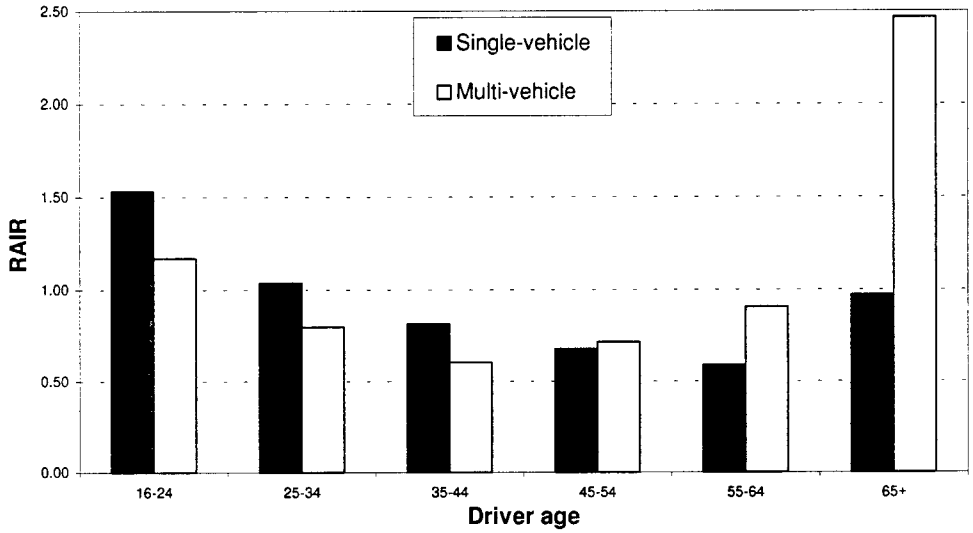

Figure 6. Relative accident involvement ratios for females by driver age

4.1.3. Vehicle Age

Several new safety devices have been introduced lately in vehicles, such as anti-lock brakes and airbags. Therefore, it is reasonable to assume that older vehicles, which lack these technologies, are less safe than newer ones. Moreover, due to constant wear, older vehicles may be more likely to be involved in accidents because they may not respond properly or maintained regularly. If it is

assumed that people prefer buying new cars as long as their income allows them, the vehicle age could be considered as an indirect economic variable. In addition, the relationship between this variable, due to its possible economic relationship, and the number of fatalities in the Southeast region is of special interest because the region is the one with the lowest income in the USA.

To perform the analysis, the age of vehicles was grouped in four categories, which follows the vehicle depreciation age categories. Figure 7 shows the accident distribution by age of vehicles at fault. It could be observed that the 6-10 year-old category contains the larger number of vehicles at fault in fatal single- and multi-vehicle crashes. Considering exposure to accidents (Figure 8), vehicles in the 11-15 year group showed the highest ratios for both single- and multi-vehicle accidents. The data also indicate an increase of the ratios as vehicle ages increase and confirm the expected result that newer vehicles are safer than older ones.

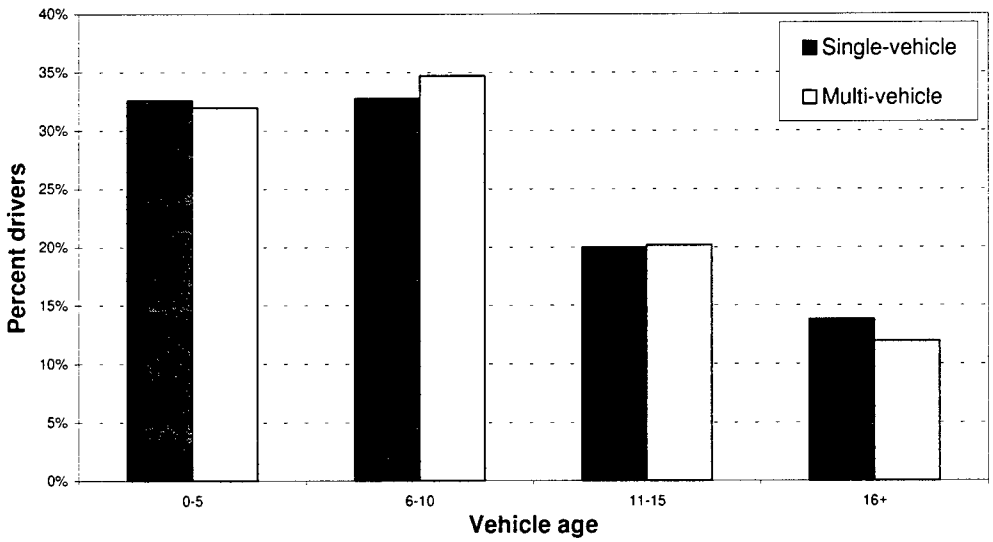

Figure 7. Fatal accident percentages for vehicle at fault by vehicle age

To identify whether there is a different pattern of vehicle age in the Southeast, the not-at-fault vehicle age involved in accidents was compared to the vehicle age of the total registered vehicles in the United States. Using vehicle age information for the total of 198 million vehicles registered in 1996 (American Automobile Manufacturers Association, 1997), the results did not show that more older vehicles are driven in the Southeast than the rest of the nation. In fact, Figure 10 contradicts this assumption indicating an opposite trend, but the differences between the values presented by this figure were not statistically significant. Therefore, even though there is a

correlation between vehicle age and fatal accidents for the Southeast, this finding could not be attributed to more older cars driven in this region in comparison to the rest of the c ountry.

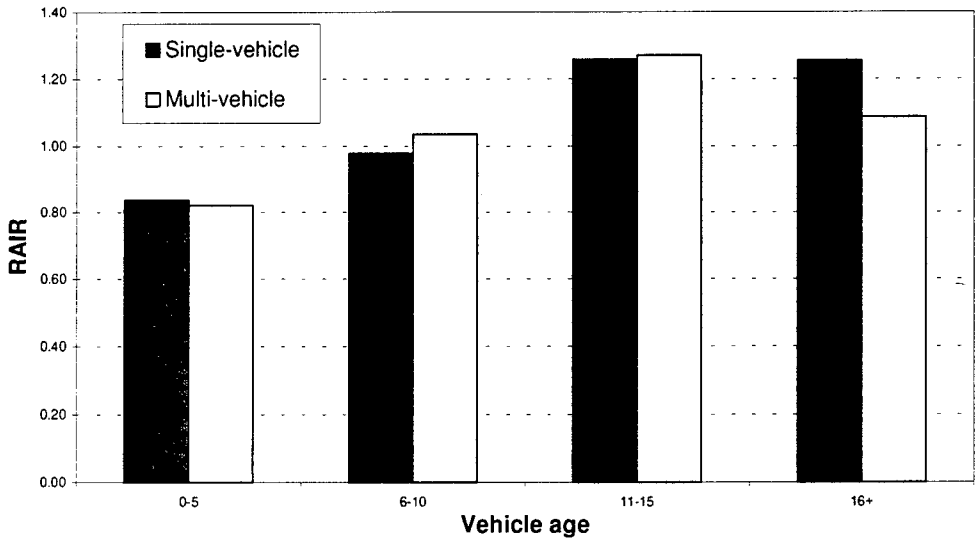

Figure 8. Relative accident involvement ratios for vehicle age

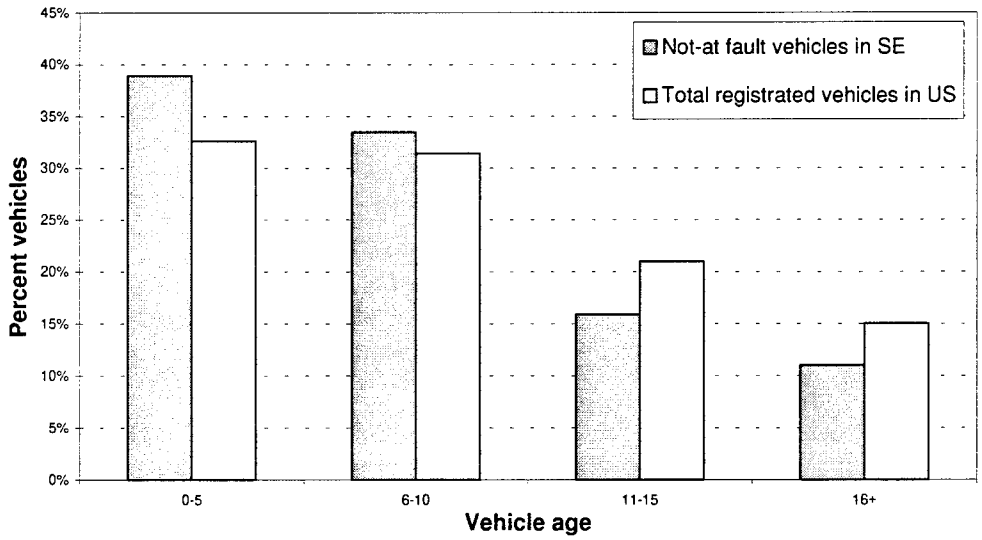

Figure 9. Total number of registered vehicles in the USA vs. not-at fault vehicles

4.1.4. Vehicle Type

Vehicle type could also identify those vehicles that are more likely to be involved in fatal accidents due to specific vehicle performance characteristics. Figure 10 shows that two-door automobiles followed by four-door automobiles and pickups present the highest at-fault vehicle frequency in single-vehicle accidents—all above 20 percent. The same three types are also the highest for multi-vehicle accidents but with four-door automobiles having the highest percentage

(40 percent). Considering exposure (Figure 11), two-door vehicles were found to be the vehicle type with the highest ratio for both single- and multi-vehicle accidents. However, four-door vehicles show a similar ratio to that of two-door vehicles for multi-vehicle accidents. Sport utility vehicles, pickups, and motorcycles show high accident rates for single-vehicle accidents as well.

These findings are somewhat expected, since two-door automobiles are typically sport cars and thus, more capable to speed, while four-door automobiles are likely to be driven in urban settings where more vehicles may be present and thus, more likely to be involved in multi-vehicle accidents. The significantly high rates of the pickups and sport utility vehicles in single-vehicle accidents may indicate a different risk-taking behavior of these drivers—bigger vehicles provide an image of invisibility and thus, more risks are taken. This may not be a Southeast only problem, since vehicle registration data show that the number of such vehicles has doubled in the past 5 years (American Automobile Manufacturers Association, 1997).

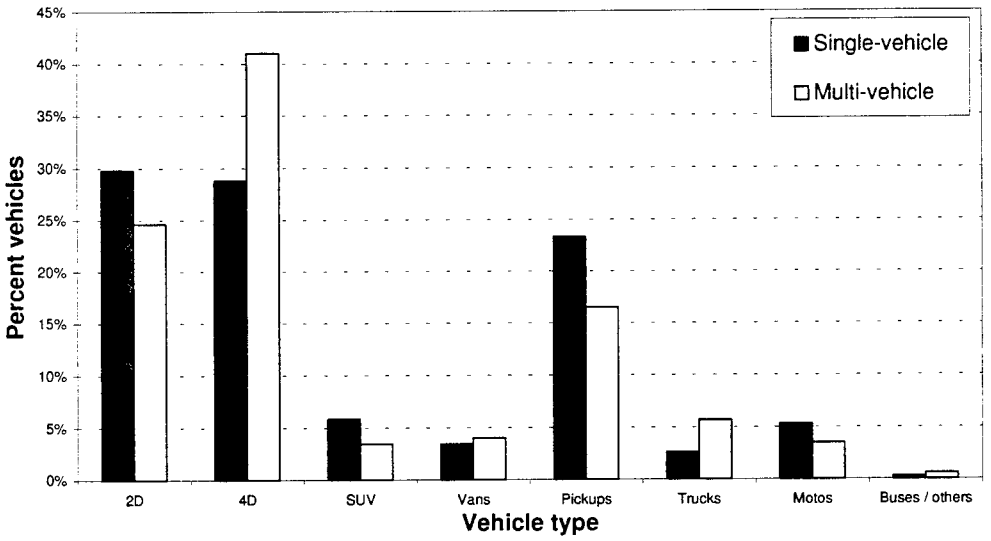

Figure 10. Fatal accident percentages for vehicle at fault by vehicle type

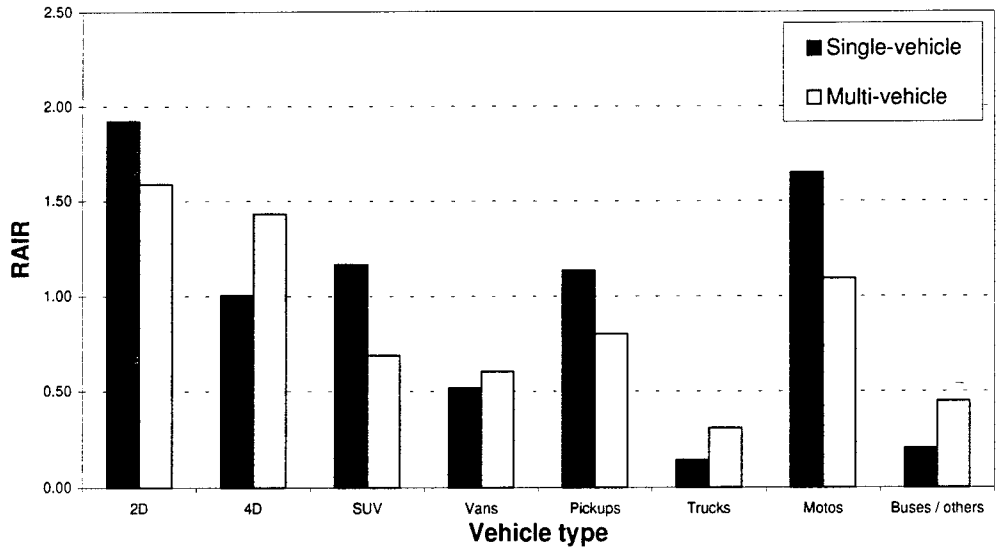

Figure 11. Relative accident involvement ratios for vehicle type

4.1.5. Roadway Classification Type and Number of Lanes

Previous research showed that road type and number of lanes have an important impact in the fatal vehicle crashes (Zegeer et al., 1994). Such findings are particularly important for the Southeast due to its rural characteristics. From the total of 36,223 fatal crashes reported in 1994, 63 percent of occurred in rural areas and presented more than twice the fatal rates of those in urban areas: 2.26 to 1.08 per 100 MVMT respectively (U.S. Department of Commerce, 1996). Additionally, according to the 1992 Highway Safety Performance report (U.S. Department of Transportation, 1995), two-lane roads have higher fatality rates (2.33 accidents per 100 MVMT) than all roadways (1.56 accidents per 100 MVMT). Although this type of road system makes up 80 percent of the roadway network in the United States, 90 percent of rural roads carry lower volumes with less than 1,000 vehicles per day (Zegeer et al., 1994). In rural areas, where the demand for transportation is lower, this type of roads is generally the basis of the road network. Consequently, people who live in rural areas, and specifically in the southeast considering that this region has 11 percent more rural areas than the national average (U.S. Department of Commerce, 1996), are at a higher risk for fatal accidents.

The accident distributions for drivers at-fault indicate that 74 percent of the single-vehicle accidents and 64 percent of multi-vehicle accidents occurred in rural roads, while 75 percent and

85 percent of single- and multi-vehicle accidents respectively occurred in two-lane roads. Figure 12 shows the accident distribution for drivers at fault by road classification. Most of single-vehicle accidents occurred on rural collector roads while the fewest were on urban interstates. These results are somewhat expected since rural roads tend to have higher speed limits and urban interstates provide less chances for single-vehicle accidents. For multi-vehicle accidents the highest occurrence is for rural arterial roads and the lowest for urban collectors roads. These results are also expected due to the higher number of vehicles and higher speeds on rural arterial roads.

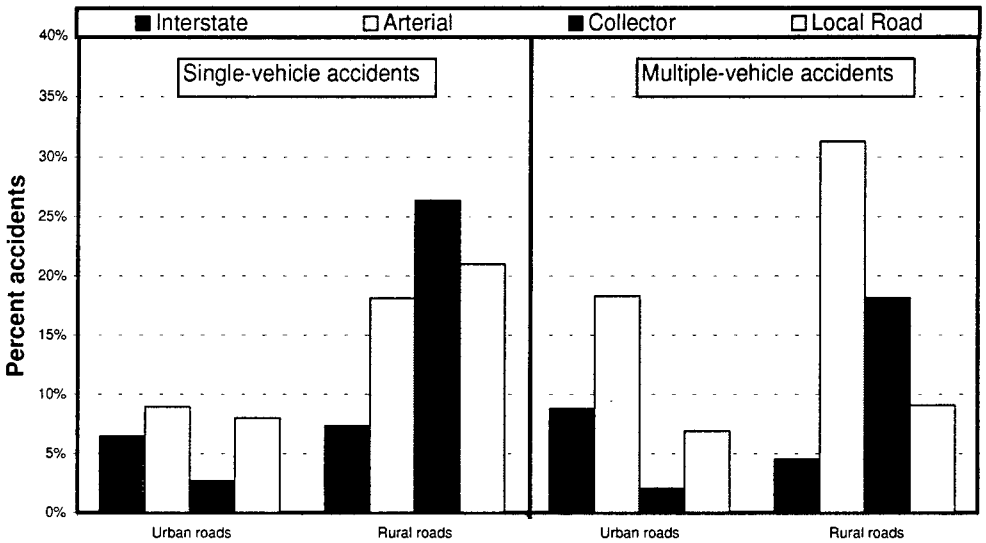

Figure 12. Fatal accident percentages for vehicle at fault by road classification

Since drivers at fault and drivers not-at fault have the same road conditions for multi-vehicle accidents, the accident propensity analyses were bounded only to single-vehicle accidents for these variables. Figure 13 indicates that all rural roads have higher accident ratios than urban. It is important to remark the special hazard that local rural roads have in single-vehicle accidents not only because this type of road has a high RAIR but also because a large proportion of the total number of accidents occurs on them. On the other hand and as it was expected, the number of lanes was found to be indirectly proportional to the relative involvement ratios for single-vehicle accidents (Figure 14). Even though 75 percent of the total single-vehicle accidents occurred on two-lane roads, the ratio for this number of lanes is just slightly above 1.0. As the exposure data indicate, two-lane roads also carry a significant volume of travel. Contrary conclusion would be stated for one-lane type of roads which has a ratio close to 2.5. However,

the fact that just 1 percent of the total number of single-vehicle accidents occurred on these roads made this finding not significant. One-lane roads are typically freeway ramps and freeway access roads which may pose specific problems for drivers such as high curvature or grade. These problems may explain these higher rates.

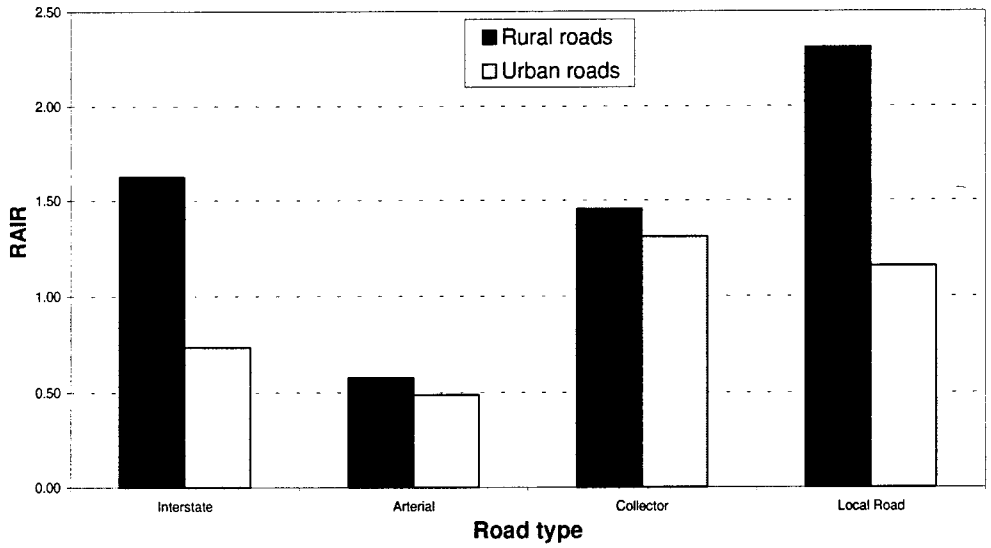

Figure 13. Relative accident involvement ratios for road classification

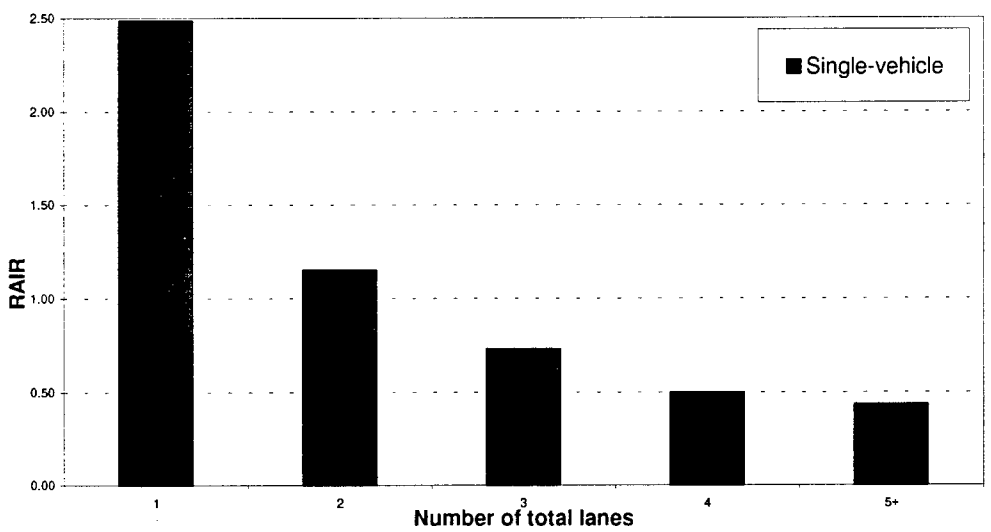

Figure 14. Relative accident involvement ratios for number of lanes

4.2. Socioeconomic Variables

An overview of the socioeconomic variables selected for this study is presented in this section. Using the 1990 Census information, table 4 summarizes the characteristics for the eight states that make the southeastern United States (see Appendix A). As this table indicates, all southeastern states have lower median household incomes and lower educational indexes[1] than the rest of the country. The Southeast also has, on average, lower per capita income and higher percentage of population below the poverty level. The low socioeconomic conditions associated to the higher fatality rates for this region could suggest a positive relationship between these variables and fatal rates; better economic and educational status seem to result in lower fatality rates. However, the average unemployment rate for the southeast is lower than the national average and may suggest a negative relationship between this variable and fatality rates. Previous research has already hypothesized this inverse relationship between unemployment rates and fatal accidents. A study by Wagenaar (1984) found that high rates of unemployment would lead to less motor vehicle travel, causing a reduction in the exposure to the risk of accident involvement. In addition, every state except Florida has shown a considerably higher percentage of rural population in the Southeast. As indicated in the previous section, the percentage of rural population may also have a negative impact on fatal vehicle crashes, which then could partially explain the highest fatal rates reported in the Southeast.

Specific relationships between these socioeconomic variables and fatal vehicle accidents in the Southeast are presented in the following sections. By using the same methodology used for the accident variables, the socioeconomic conditions of the drivers involved were analyzed by relating their residence zip code to the census socioeconomic information. Smaller differences in the involvement ratios are more significant than those observed by the accident variables because these variables are already normalized to the local population. In order to establish how socioeconomic conditions affect the groups at risk already identified by the previous accident related variables, multivariable analyses were also performed. The primary findings of this analysis are shown in the following sections while all analysis performed are presented in Appendix B.

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[1] Educational index represents a ratio between four educational levels: 0. Non high school completation, 1. High school diploma, 2. Some college, 3. College degree and 4 Graduate degree. Consequently, a lower educational index of a group indicates lower percentage of high education attainment.

Table 4. Socioeconomic conditions for the southeastern states

State	Population (Persons)	Rural popul. (%)	Education (Index) [1]	Unemploy -ment (%)	Household income ($)	Per capita income ($)	Pop. Below poverty (%)
Alabama	4,040,587	39.67	1.25	6.87	23,597	11,486	18.34
Florida	12,937,926	15.21	1.41	5.78	27,483	14,698	12.69
Georgia	6,478,216	36.77	1.35	5.74	29,021	13,631	14.65
Kentucky	3,685,296	48.17	1.17	7.37	22,534	11,153	19.03
Mississippi	2,573,216	52.93	1.21	8.43	20,136	9,648	25.21
North Carolina	6,628,637	49.68	1.33	4.79	26,647	12,885	12.97
South Carolina	3,486,703	45.34	1.28	5.58	26,256	11,897	15.37
Tennessee	4,877,185	39.13	1.25	6.41	24,807	2,255	15.70
SOUTHEAST	**44,707,766**	**35.50**	**1.32**	**6.03**	**26,045**	**12,916**	**15.31**
USA	**248,709,873**	**24.79**	**1.45**	**6.31**	**30,270**	**14,420**	**13.12**

4.2.1. Median Household Income

The household income is probably the economic variable that best represents the drivers' economic conditions since it considers the income of all persons above 15 years in the household, whether related to the householder or not. Even though the average household income is usually less than average family income, since there is a large number of single-person households, the household income considers drivers from the age groups of higher risk, i.e. teenagers, whose income usually depends on their parents.

In order to determine the effect of this economic variable on fatal accidents in the Southeast, the local median household income for the involved drivers was grouped into four categories. Almost one-half of the drivers at fault in fatal accidents in the Southeast belong to the $20,000-30,000 category while 25 percent belongs in localities with household incomes less than $20,000. The fact that these two categories comprise more than 75 percent of the accidents may support the argument that household income is related to fatal accidents (Figure 15). Different trends are noticed for single- and multi-vehicle accidents when considering exposure (Figure 16). Drivers who belong to lower median household income are more likely to be involved in single-vehicle accidents. On the other hand, no statistical correlation was found between median household income and multi-vehicle accidents. As mentioned previously, lower income families are more likely to have older vehicles or vehicles not maintained properly which may partially explain their higher single-vehicle rates. The lack of a relationship between income and multi-vehicle

accidents may be the attributed to the fact that most of these accidents occur in rural areas where traffic densities may be lower (68 percent on rural roads).

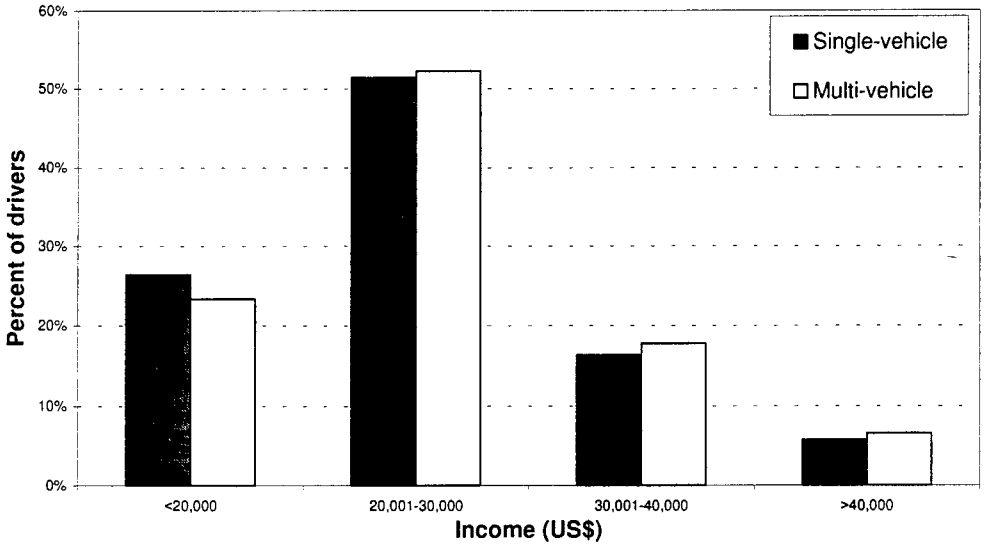

Figure 15. Fatal accident percentages for driver at fault by median household income

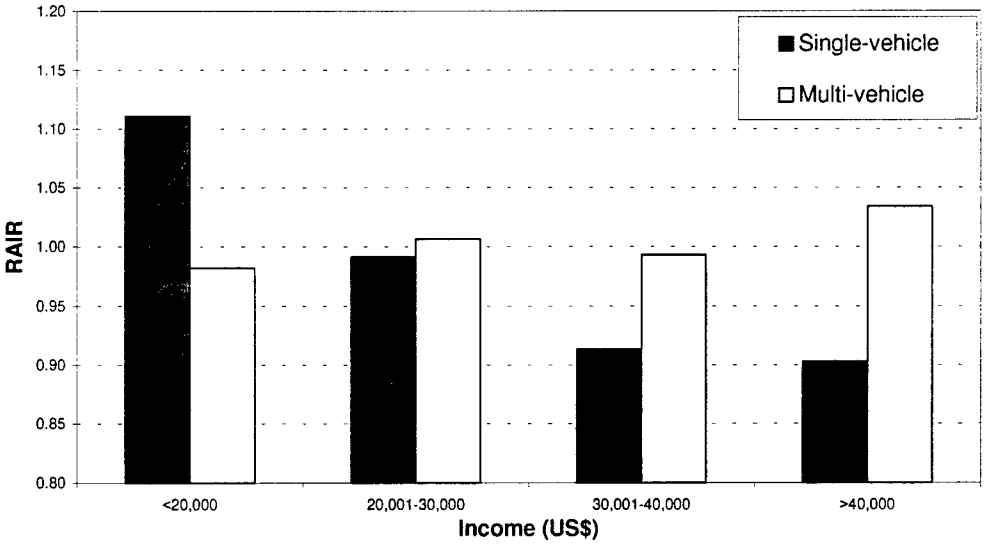

Figure 16. Relative accident involvement ratios for median household income

4.2.2. Per Capita Income

The second economic variable analyzed was the per capita income, which is the mean income computed for every person in a particular group of the population. Figure 17 shows the at-fault drivers' distribution for this variable. A similar pattern as that of the median household income is observed and drivers with per capita income less than $15,000 cause more than 85 percent of the accidents. Accident exposure analysis (Figure 18) also showed that drivers with the lower income category are the more likely to cause single-vehicle accidents. However, contrary to the median household income, per capita income was found statistically significant for multi-vehicle accidents. Individuals who belong to the higher per capita income showed the highest accident propensity for multi-vehicle accidents. This trend cannot be easily explained since higher income individuals are more likely to have newer vehicles. It is possible then to hypothesize that there may be some explanation based on risk-taking behavior where owners of newer vehicles may overestimate the abilities of their new vehicles. Therefore, additional socioeconomic variables are needed to explain these trends.

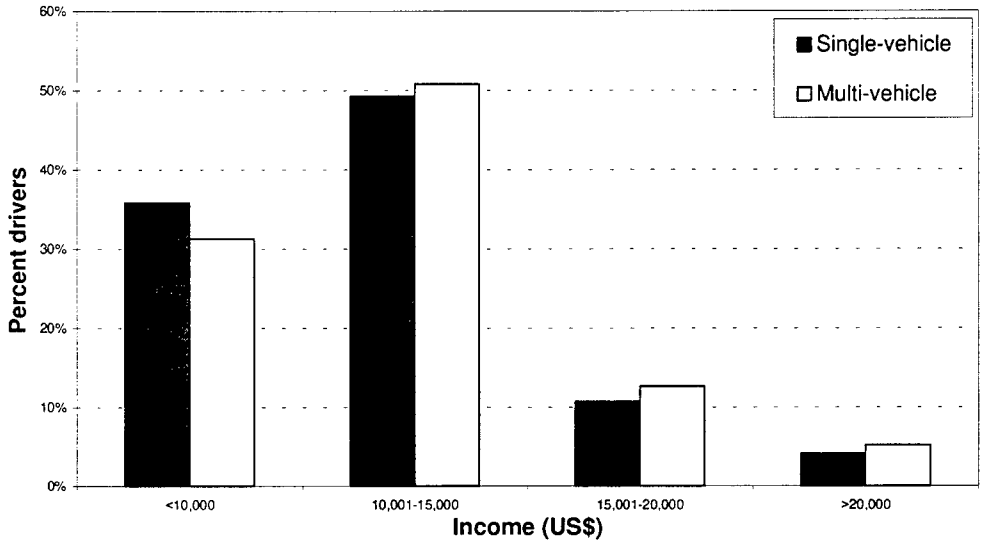

Figure 17. Fatal accident percentages for driver at fault by per capita income

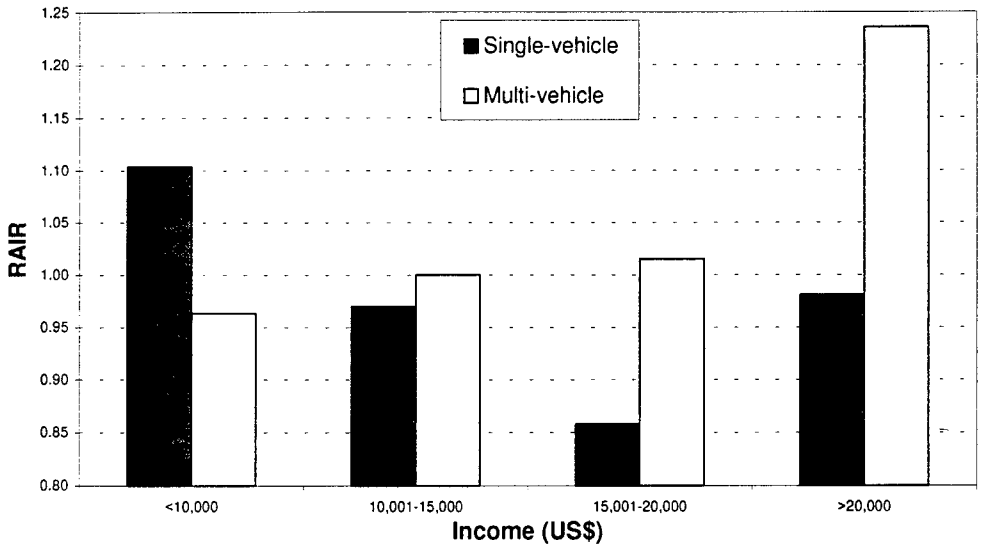

Figure 18. Relative accident involvement ratios for per capita income

4.2.3 Percentage of the Population Below Poverty Status

Using the Census definition of poverty level, the percentage of population below the poverty status was used as an additional economic indicator to fatal accidents. As the data in figures 19 (drivers at fault) and 20 (accident ratios) indicate this variable shows congruent results with the other economic variables. Overall for single-vehicle accidents, higher accident propensity is found for the high percentages of the population below poverty status. Multi-vehicle accidents, on the other hand, did not present any statistical differences.

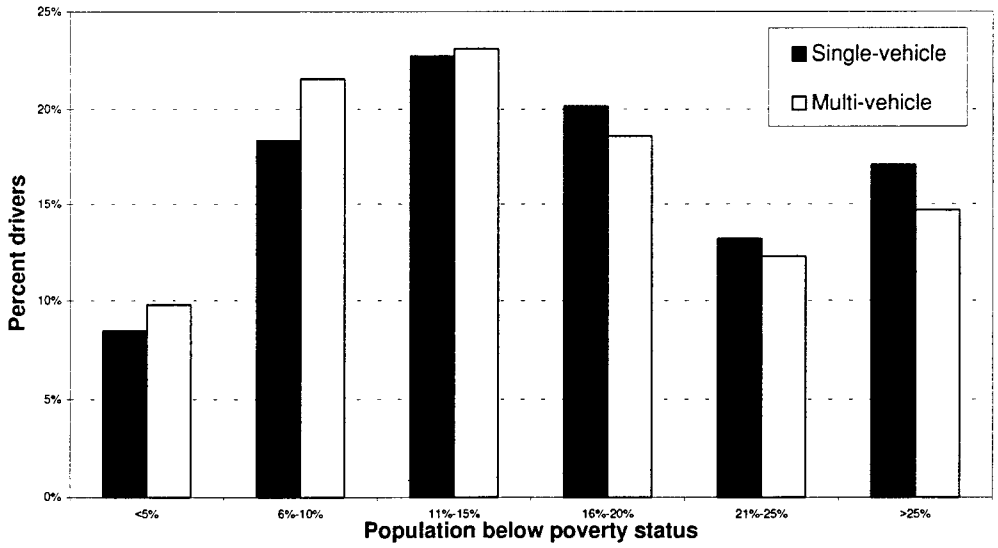

Figure 19. Fatal accident percentages for driver at fault by poverty level

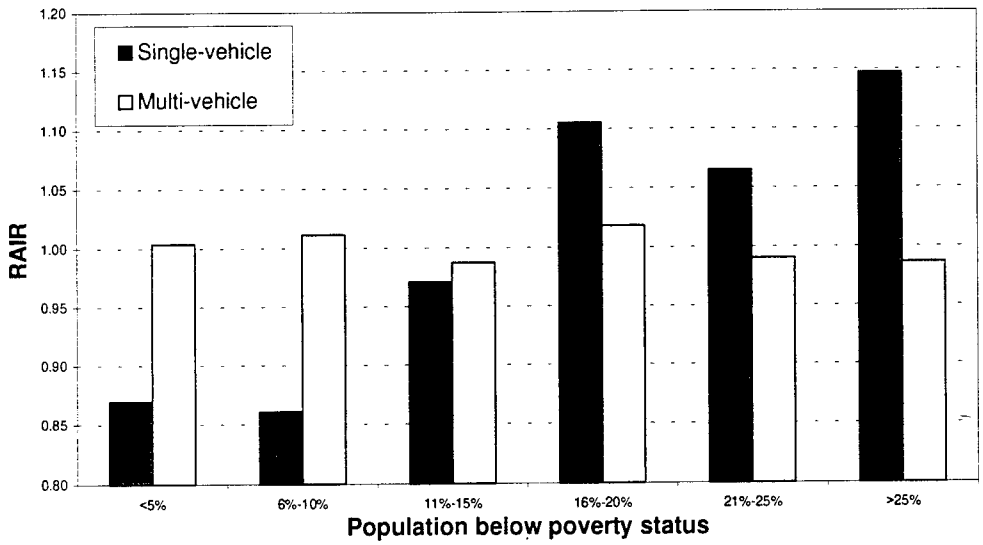

Figure 20. Relative accident involvement ratios for population below poverty status

4.2.4. Unemployment

Unemployment is an additional economic variable that could provide a regional estimate of the well being of the region's population. Most of at-fault drivers (45 percent) belong to localities where the unemployment rate was below the regional rate (6 percent). This finding would confirm that unemployment has a negative influence in fatal accidents (Figure 21). However, considering exposure to accidents (Figure 22), the propensity to be involved in single-vehicle accidents increases with increases in the unemployment rates. Moreover, multi-vehicle accidents are not affected by the level of unemployment, since differences between the rates are not statistically significant.

Since the unemployment rate is slightly lower for the Southeast than the national rate may suggest that unemployment does not have a direct relationship with fatal accidents in the Southeast. In spite of this, unemployment is probably a variable that alters differently the individual driving behavior (Wagenaar, 1984). For some cases, employment uncertainty may cause a reduction in non-essential driving and consequently lower fatality rates; in others cases, high unemployment rates might cause more accidents because the aggressive driving patterns due to higher mental stress. It is important to notice that unemployment rates not only affect the individuals who actually lost their jobs but they could impact the rest of the community. According to these results, the general accident distribution matches the first hypothesis

indicating higher unemployment rates cause lower accidents, while the accident propensity follows the second hypothesis indicating that drivers from higher unemployment localities are more potentially dangerous in single-vehicle accidents.

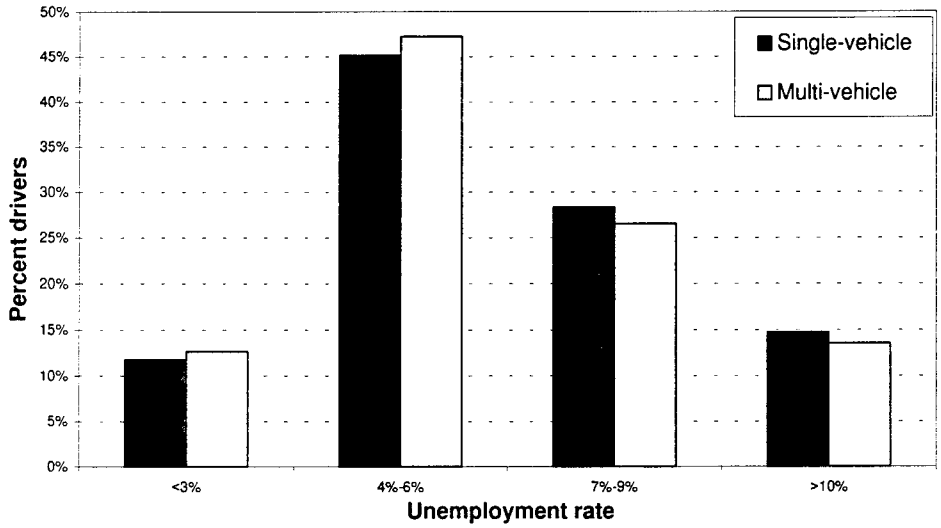

Figure 21. Fatal accident percentages for driver at fault by unemployment rate

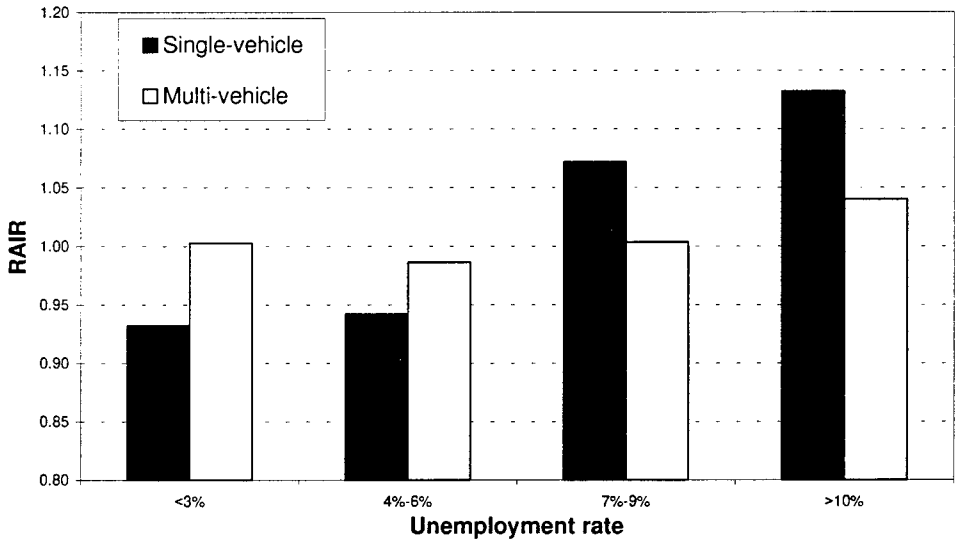

Figure 22. Relative accident involvement ratios for unemployment rate

4.2.5. Educational Attainment

A weighted score was calculated to determine quantitatively the impact of the education in fatal vehicle accidents. Indexes, which are ratios expressed in decimal, were computed for four educational levels: Non high school (0), high school degree (1), some college (2), bachelor degree (3), and graduate degree (4)[2]. A greater index indicates better education level, but it is not arithmetically scaled. Figure 23 shows the accident distribution of at-fault drivers based on the educational index. In general, most of drivers (80 percent) causing fatal accidents belonged to localities where the educational index was below that of the national average (1.5). Analyzing the regional accident propensity (Figure 24), slight differences indicate that drivers of lower educational are more likely to be involved in single-vehicle accidents, but the 1.5-2.0 group of drivers had the highest propensity in multi-vehicle accidents. However, educational level is not a statistically significant variable contributing to multi-vehicle accidents. A possible explanation for increased single-vehicle accident involvement trend may be the lack of driver education, which typically is part of high school education.

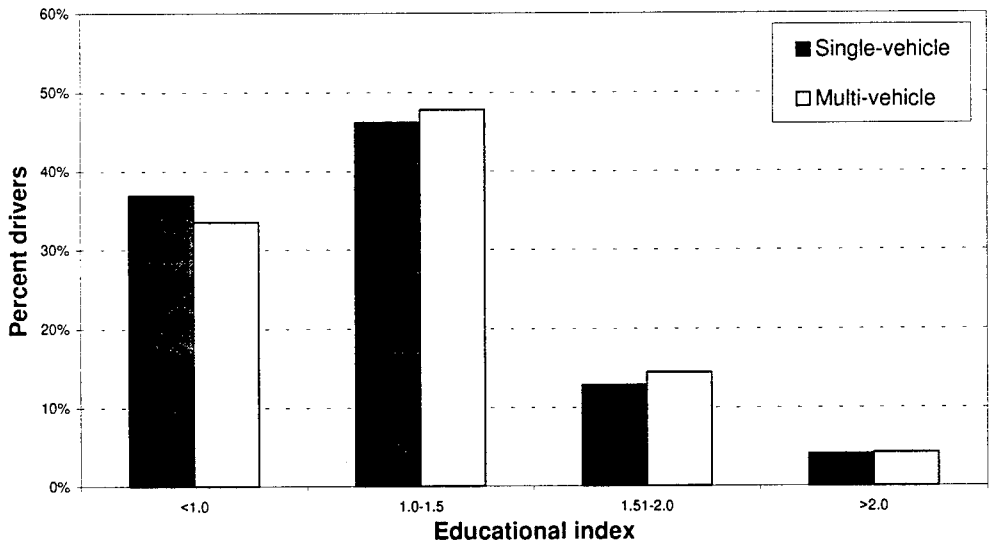

Figure 23. Fatal accident percentages for driver at fault by education attainment

[2] Numbers in parenthesis are the weight of education level used in the computations.

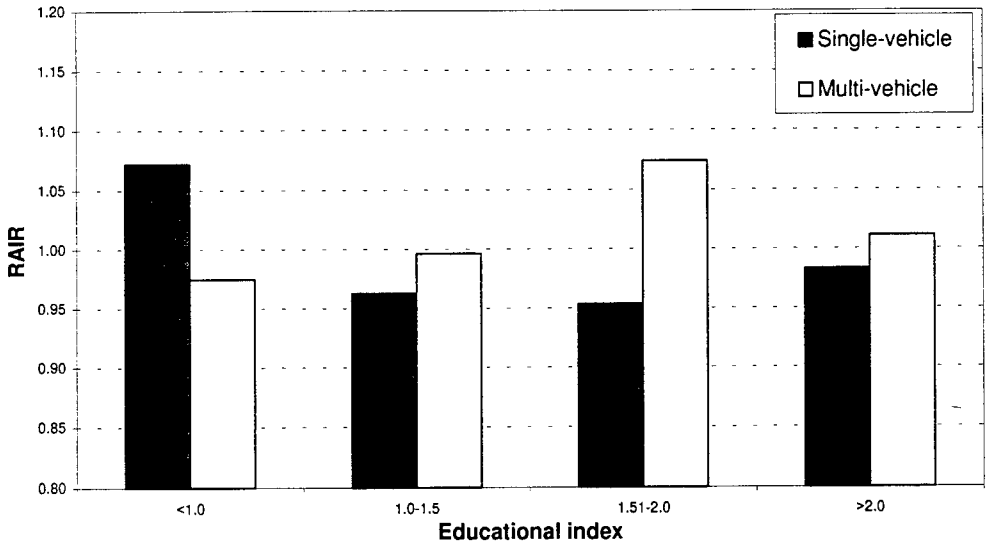

Figure 24. Relative accident involvement ratios for education attainment

4.2.6. Rural Population

Rurality is an important characteristic in fatal accident analysis since most of the fatal accidents in the US (57 percent) as well as the Southeast (68 percent) occur in rural areas. Percentage of rural population could be considered as an indicator of the rural condition of the drivers' residence. Approximately one-third of at-fault drivers is contained in areas with 100 percent rural population (Figure 25) and it confirms the association between the majority of fatal accidents with rural areas. The impact of rurality in fatal accidents is considerably higher when accidents are normalized to the population due to the fact that rural areas have low density of population. The accident propensity trends show an expected pattern where rural and semi-rural drivers are more likely to be involved in single-vehicle accidents, and urban and semi-urban drivers in multi-vehicle accidents (Figure 26). This finding was statistically significant and supports the basic accident trends. For the Southeast region, this finding is more important due to the higher percentage of fatal accidents in rural areas and higher percentages of rural population.

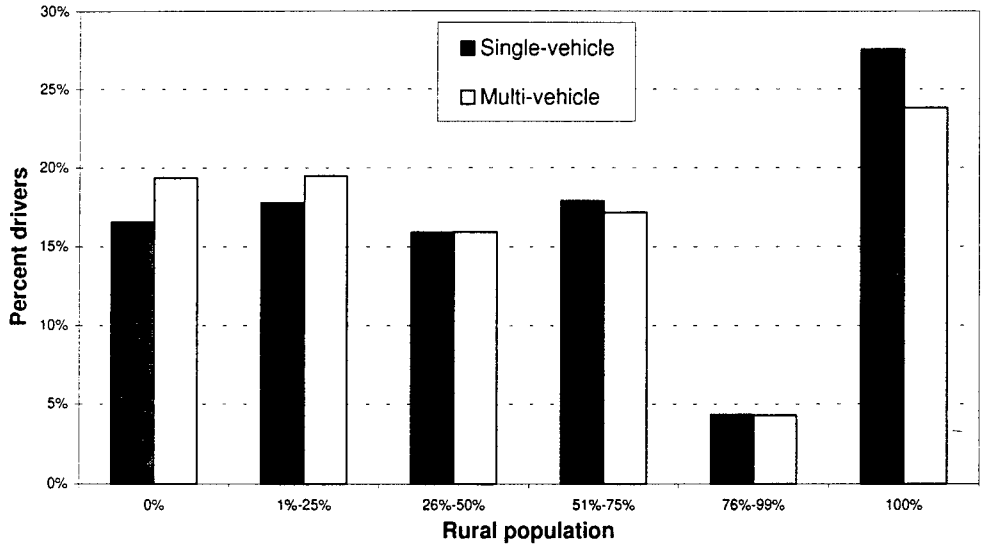

Figure 25. Fatal accident percentages for driver at fault by rural population

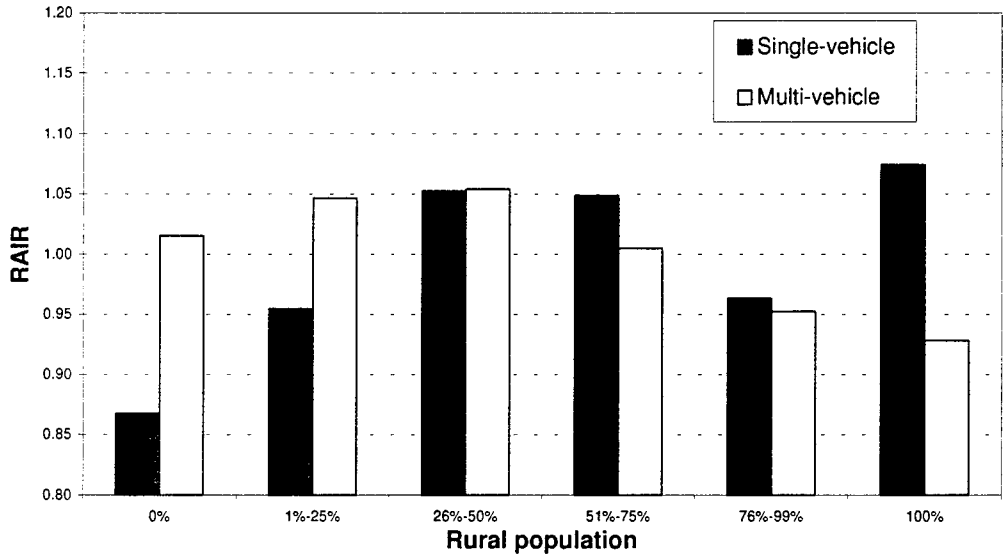

Figure 26. Relative accident involvement ratios for rural population

4.3. Multivariable Analysis

Multidimensional analyses were performed to identify the effects of the socioeconomic variables on the accident propensity for the accident variables. In the following, a positive relationship means that better socioeconomic conditions reduce accident propensity ratios, while a negative relationship means that better socioeconomic conditions increase accident propensity ratios. Even though all combinations between the accident and socioeconomic variables were tested, the results discussed in this section are only for those variables and relationships that showed statistical significance. Appendix B shows the complete set of results.

Positive relationships identified in the previous sections revealed some negative relationships with this analysis when specific at-risk groups and/or conditions are considered. A negative relationship is easily explained because specific at-risk groups may have different behavior with the changes of the socioeconomic conditions than those observed by the general pattern. An example of this could be younger drivers, who usually are students. If their income increases (median household income and per capita income), they would be more inclined to drive for pleasure and thus, increase their exposure to accidents. Notice that in this particular example, the socioeconomic variable could negatively influence the accident propensity of this age group. Additionally, when other at-risk groups are added, different influences of socioeconomic aspects would impact accident rates in either positive or negative way.

Significant influences were found when the rural population was combined with driver age for the at-risk groups of driver age identified previously. For this combination, younger and older drivers showed different trends. Younger drivers in single-vehicle accidents showed an increase on the accident propensity corresponding to rural population increases, while accident propensity decreased (with the increase of rural population) for older drivers in multi-vehicle accidents. These findings coincide with the findings obtained from the combination of driver age and road classification. Younger drivers are more likely to be involved in single-vehicle accidents, in which rural roads have a major impact, while older drivers are more likely to be involved in multi-vehicle accidents, in which urban roads have a major impact. The combination of unemployment and driver age showed also that rates had a negative influence over older drivers in multi-vehicle accidents, and negative influence over younger drivers in single-vehicle

accidents. The pattern noted previously for increased single-vehicle involvement with increases unemployment rates (Figure 22) is may be attributed to the high rates of younger drivers who have the highest ratios for single-vehicle accidents among all age groups.

The combination of driver gender and socioeconomic variables showed some significant differences between the genders. Moreover, the socioeconomic patterns noted for each gender irrespective of the variable added showed a similar trend. As the rural population increases, the accident propensity increases for both sexes in single-vehicle accidents. This result was expected, since there is an important link between fatal accidents and rurality especially for single-vehicle accidents. On the other hand, the rest of the socioeconomic variables showed different influences over each gender. In general most of the socioeconomic variables (income, education, poverty level) had negative influences over males for both single- and multi-vehicle accidents, but positive influences over females. This finding indicates opposite driving attitudes between genders in different economic scenarios. At lower socioeconomic conditions, males seem to drive more dangerously than females. This could be partially explained by the assumption that lower socioeconomic aspects may affect a driver behavior by increasing the level of aggressiveness, and males are more prone to such a behavior.

Analyzing the socioeconomic influences on the at-risk groups for age and gender similar results in general were found with those obtained from the at-risk age groups. However, differences are noticed for some combinations. The rural condition has a larger impact on females than on males for the younger age group in both single- and multi-vehicle accidents. Similarly, unemployment rates for females have higher impact in the negative relationship found for the younger driver group and in the positive relationship found for the oldest one. The variable of education revealed a pattern when it was separated by age and gender. A positive relationship for all female age groups was noticed in multi-vehicle accidents. However, a negative relationship for males in at-risk groups was noticed in single-vehicle accidents. The negative relationship of accident propensity for younger male drivers when combined to education could be explained by the fact that the education level determined by the index does not accurately reflect the younger drivers' education. The educational index is a weighted score of population education attainment and it is

only one category for high school education. Therefore, educational differences for this particular group were not possible to accurately measure using the census information.

In combining the socioeconomic variables to vehicle type specific characteristics, relationships for the at-risk groups were also noticed. In general, the economic variables had a positive influence for two- and four-door vehicle types in both single- and multi-vehicle accidents. This result was expected indicating that these two automobile types are more likely to cause accidents when the economic conditions are lowered. Additionally, other vehicle types showed overall similar patterns confirming the hypothesis that lower income is linked with less safe vehicles and therefore with higher propensity to cause fatal accidents in the Southeast. As far as rurality, higher propensity for all types of vehicles, except vans and trucks, was noticed with the increasing percent of rural population for single-vehicle accidents. No statistically significant results were noticed in multi-vehicle accidents. Finally, unemployment rates and education levels did not show any major differences when combined with vehicle type.

While combining socioeconomic aspects with driver age and vehicle type simultaneously additional relationships were observed. The economic variables had a negative influence for the younger drivers when driving four-door vehicles in single-vehicle accidents and for the older drivers for four-door vehicles in multi-vehicle accidents. For these particular combinations, rising incomes had negative influences over fatal accidents. The increase in the income of these two age groups, who generally are either students or retired people, may lead to more driving for pleasure in family vehicles and thus, be more exposed to accidents. However, this finding was not true or statistically significant for other types of vehicles. In fact, the youngest age group driving pickups was positively related to the economic variables in single-vehicle accidents. Another significant finding obtained for the at-risk groups driving pickups was in relation to rurality. Both age groups (younger and older) had higher propensity to be involved in fatal accidents when the rural population percentage increased. This finding confirms the hazardous association between pickups and rurality for these at-risk age groups in the Southeast.

Summarizing, even though, overall positive relationships between socioeconomic variables and accident propensity ratios were noticed for the independent variable analysis, some specific at-

risk groups showed negative relationships after the multivariable analysis. However, most of these negative relationships could be explained by the socioeconomic aspects which affect specific groups differently in fatal accidents. Moreover, identifying these particular interactions, it is possible to understand the effects of the socioeconomic variables over specific at-risk groups on fatal accidents for the Southeast.

5. CONCLUSIONS / RECOMMENDATIONS

According to safety records, the southeast region of the US ranks highest in number of fatalities as well as fatality rate per 100 millions vehicle-miles traveled. The differences between the socioeconomic characteristics in this region compared to other regions might explain these higher fatality rates. This report presented the relationship of 12 independent variables obtained in conjunction of the 1994-1996 FARS data and the 1990 Census data for the Southeast United States. General considerations about the frequency of fatal accidents, as well as their plausible causes based on the socioeconomic differences were hypothesized. The accident propensity analysis was based on the quasi-induced exposure technique, which allows to identify a driver at fault and develop accident ratios. Specific conclusions from the analysis presented in the preceding include the following:

1. The driver age showed two important at-risk groups for fatal accidents. Young drivers (under age 25), who had the higher number of accidents in both single- and multi-vehicle crashes, are the most likely group to be involved in a fatal accident. Older drivers (greater than 65) had the second highest number of fatal accidents in multi-vehicle crashes and are the most likely group to be involved in multi-vehicle accidents. These trends are not different than past research and thus, not different for the Southeast.
2. With respect to gender, male drivers have a higher likelihood to be involved in fatal accidents than females, and more so for single-vehicle accidents. However, the propensity to be involved in accidents was not different for either gender. In general, younger females seem to be safer than younger males, but opposite results appear in older ages.
3. For the vehicle age, the results show that the 6-10 year-old vehicles had the higher frequency in fatal accidents but the 11-15 year-old group was found to be the group with higher accident propensity in both types of accidents. Even though this result suggests a correlation between vehicle age and fatal accidents for the Southeast, this finding could not be attributed to more older cars driven in this region than the rest of the country.
4. When examining the vehicle type, two-door vehicles were found to have the higher accident propensity in single- and multi-vehicle accidents. Four-door vehicles have the higher number of accidents in multi-vehicle crashes and the second higher accident propensity in multi-

vehicle accidents. Pickups, normally associated as typical vehicles in this zone, were also identified as a type of vehicle at risk for single-vehicle accidents. Motorcycles showed very high propensity in single-vehicle accidents but only 5 percent of the total at-fault drivers were driving motorcycles.

5. A considerably higher percentage of accidents occurred in rural and two-lane roads in the Southeast. Analyzing specifically the road type, most of single-vehicle accidents occurred on rural collectors while the lowest was on urban interstates. For multi-vehicle accidents the highest occurrence is for rural arterials and the lowest for urban collectors. Number of lanes was found inversely proportional to accident propensity for single-vehicle accidents.
6. The eight states in the Southeast had lower median household income, per capita income, education level and population above the poverty level in comparison to the national average. The low socioeconomic conditions associated to the higher fatality rates for this region suggest a positive relationship between the socioeconomic variables and fatal rates; better economic and educational status seem to result in lower fatality rates. However, the average unemployment rate for the Southeast, which was lower than the national average, may suggest a negative relationship between this variable and fatality rates.
7. In general, according to the accident propensity analyses, drivers at fault who belong to areas with low socioeconomic characteristics were found more likely to be involved in single-vehicle accidents. This statement was also true for unemployment.
8. A common correlation for the socioeconomic variables and fatal accidents could not be identified in multi-vehicle accidents. However, independent findings for some socioeconomic variables indicate different at-risk groups than those observed by the single-vehicle accidents. The higher per capita income group and the 1.5-2.0 education level group were found to be the most likely groups to be involved in multi-vehicle accidents.
9. Although, overall positive relationships between socioeconomic variables and accident propensity ratios were noticed, different influences of the at-risk groups were observed in the correlation between socioeconomic variables with others. Most of these influences could be explained by the socioeconomic aspects which could affect groups differently on fatal accidents.

As this study showed, there are some findings that reveal a relationship between the selected socioeconomic variables and fatal accidents for the southeastern United States. The influence of the socioeconomic variables on fatal accidents was obvious when these variables were compared between regions (Southeast vs. the rest of the country). Additional findings using the at-fault drivers' information showed that a lower socioeconomic status caused a higher single-vehicle accident propensity. Moreover, microanalysis provides a better understanding for the real influences of socioeconomic variables on fatal crashes. From the literature review, it seems that the state of explaining and predicting accidents based on macro-models that relate the economy with accidents is still deficient. It should also be stated that these models, although in some cases achieve a good fitting, do not allow to clearly identify the influence of socioeconomic variables on accidents.

The data presented here showed that there are indeed relationships between the socioeconomic variables examined and fatal accident rates in the Southeast. These relationships were more obvious with the introduction of the multivariable analysis where variables were combined. This analysis not only revealed trends not apparent in the preliminary analysis of the variables alone but explained some of the initial patterns identified in the preliminary analysis. However, the classification of the data in a large number of cells when combining three or more variables did not allow for an adequate number of accidents and thus, some of the trends observed could not be statistically substantiated. Therefore, one direction of future research could be the expansion of the data base to more than three years and the development of a more detailed multivariable analysis as the one presented here. This would allow for a better understanding of the three way interrelations among the variables and provide additional information regarding the impact of the socioeconomic variables on fatal accidents in the Southeast.

The lack of detailed socioeconomic information for each driver involved in a fatal accident lead to the use of the average values of the drivers' residence zip code. Even though these data could be considered acceptable surrogate measures of the drivers' characteristics, since drivers tend to live in areas that are close to their socioeconomic characteristics, the range and variability within the zip code is unknown and bias could be introduced in estimating their relationships to accident

characteristics. However, data describing area conditions, such as rurality, unemployment, and poverty level, are accurate indicators of the socioeconomic conditions of the drivers' residence.

Therefore, an additional direction of future research on this topic could focus on the development of a micro-model that would be able to define these relationships using the specific socioeconomic characteristics of the drivers involved in the accident. Such micro-models could identify more clearly the relationships between accident factors and driver characteristics and allow for determining the effects of these variables on fatal accident occurrence. Thus, the introduction of new socioeconomic variables into the fatal accident reports is proposed here. This information could be obtained by the police officers when they complete the accident report and could be limited only to fatal accidents to reduce the level of effort required to collect these additional data. The proposed additional data to be collected consists only of two basic descriptors: 1. household income, defined in the broad categories used here; and 2. education level, defined as the highest degree obtained. The other variables used here--rurality, unemployment, and poverty level--will also be used in conjunction with the new data to develop these micro-models. Using these new data, it is then possible to develop a direct relationship between the accident factors and socioeconomic characteristics of the drivers involved in accidents and establish specific countermeasures aiming to reduce accidents in the Southeast.

The findings of this study as well as findings from previous studies (Stamatiadis et al., 1998) have also pointed out the relationship between the age of the vehicle and fatal accidents and the higher ratios of younger drivers for single-vehicle accidents. Obviously, older vehicles are less safe than newer vehicles and the age of the vehicle is closely tied to a variety of social factors. The data here show that the age of the vehicle is reversely proportional to the single-vehicle accident involvement. While newer vehicles are safer and have added safety features, compared to older vehicles, they could be also viewed as means to reduce the safety margins set by the drivers. This is particularly true for the younger drivers in single-vehicle accidents. Older vehicles present the other end of the problem, where antiquated vehicles are still driven. Vehicle inspection programs may then be used as a countermeasure aiming to identify vehicles with safety related deficiencies. Finally, to address the young driver related problems, driver education seems to be the reasonable countermeasure for improving their safety. Specific

programs that would present to young drivers the problems of rural roads, since this is the area where most accidents occur, and their potential for single-vehicle accidents are required to increase their awareness. Moreover, the facts of handling older vehicles could be also presented within a driver education program and the potential perils of new vehicles could be demonstrated. The lack of vehicle inspection and driver education in several of the southeast states may also be contributing factors to accident occurrence and the reinstatement of such programs may be a necessity.

It is believed that these two countermeasures, driver education and vehicle inspection, are an important first step towards improving the safety of all drivers in the Southeast and impacting the fatality, and in general, accident rates in the region. The proposed continuation of this study with either approach, expanded database or collected additional personal information, could only enhance the knowledge gained so far and provide additional information regarding the factors that may contribute to the increased fatal accident rates of the region. The continuation of the research will provide a more detailed examination of these factors and allow for the development of countermeasures aiming to reduce the fatal rates in the Southeast.

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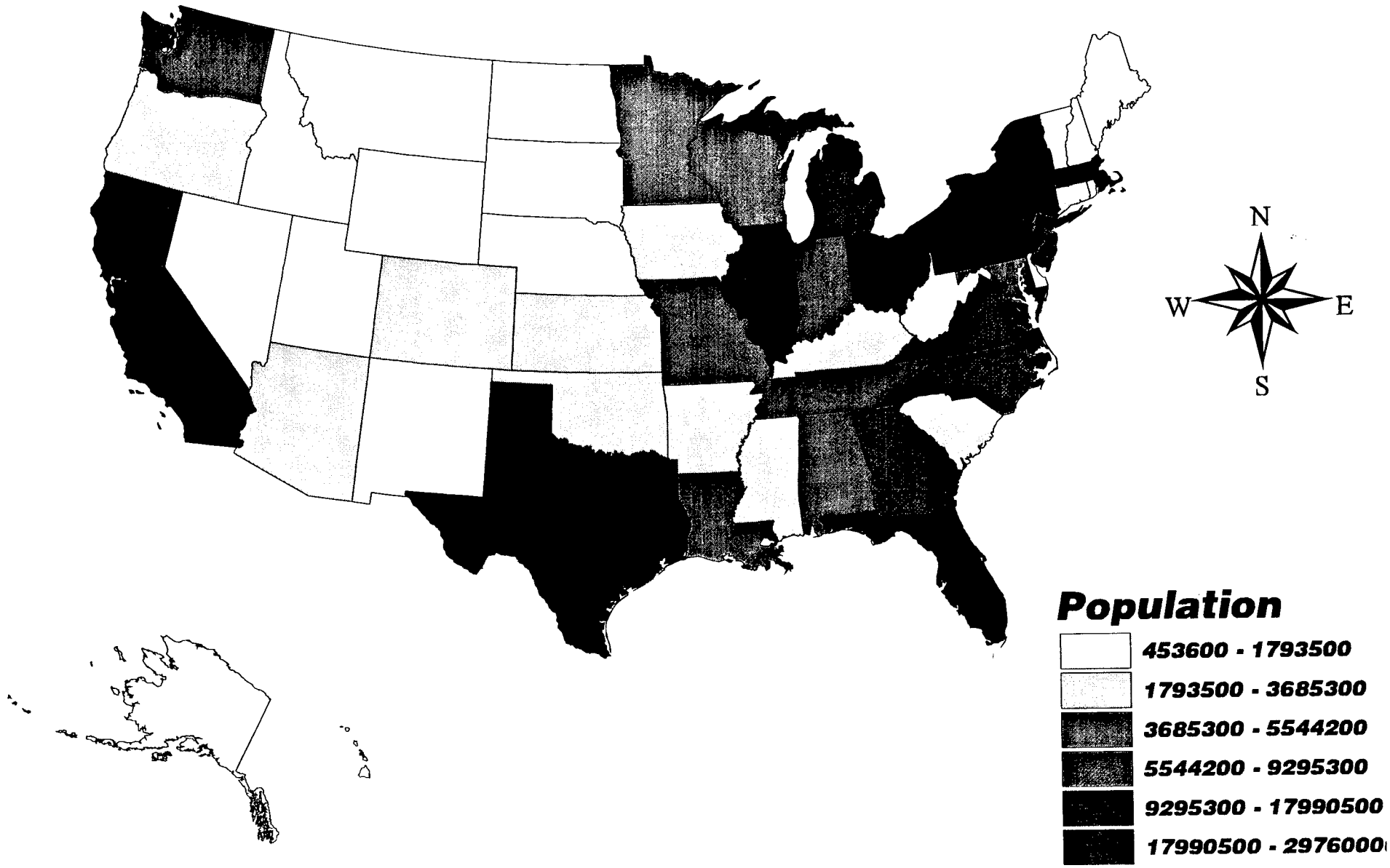
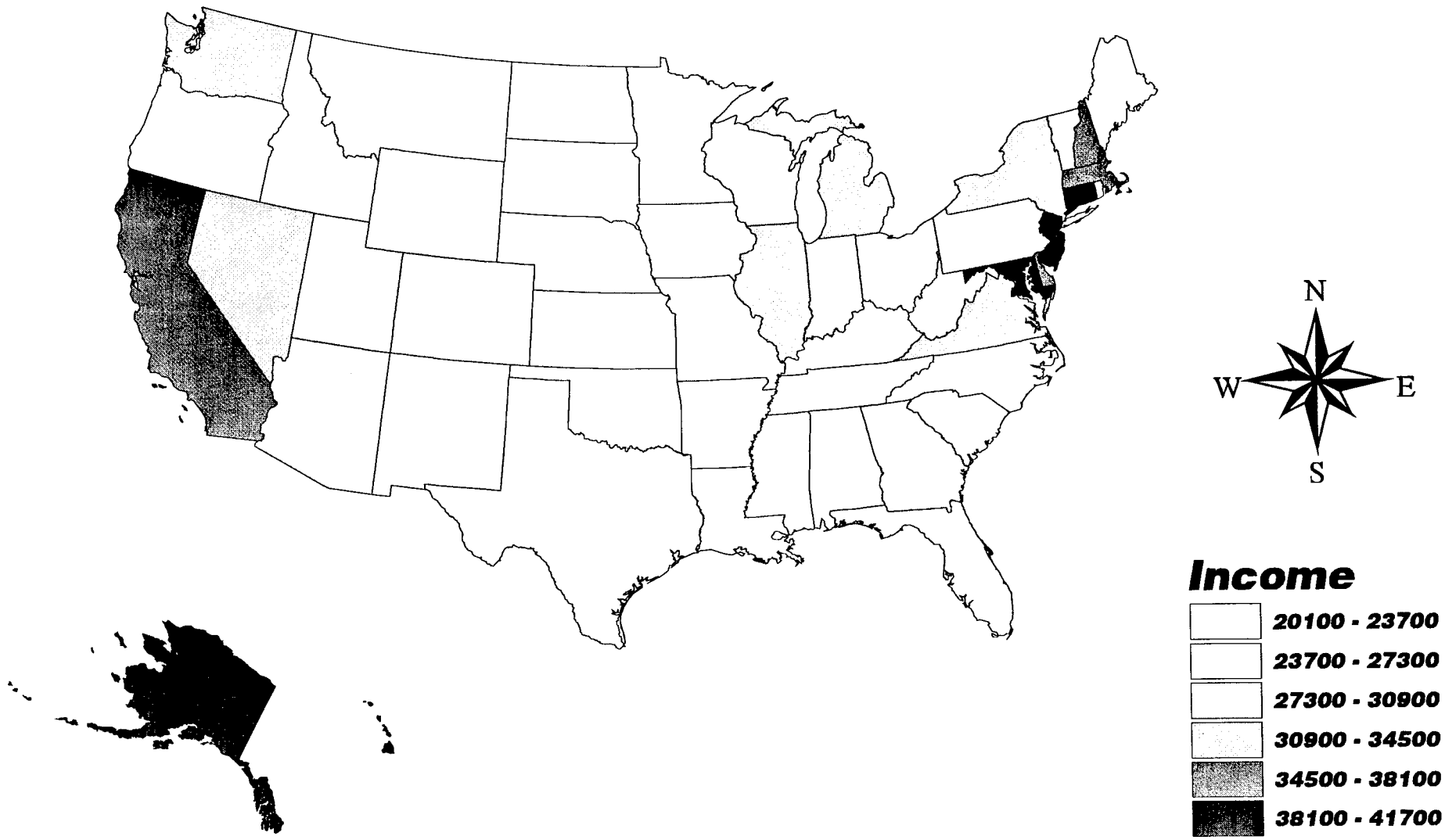
APPENDIX A

SOCIAL ECONOMY OF THE UNITED STATES BY STATE LEVEL

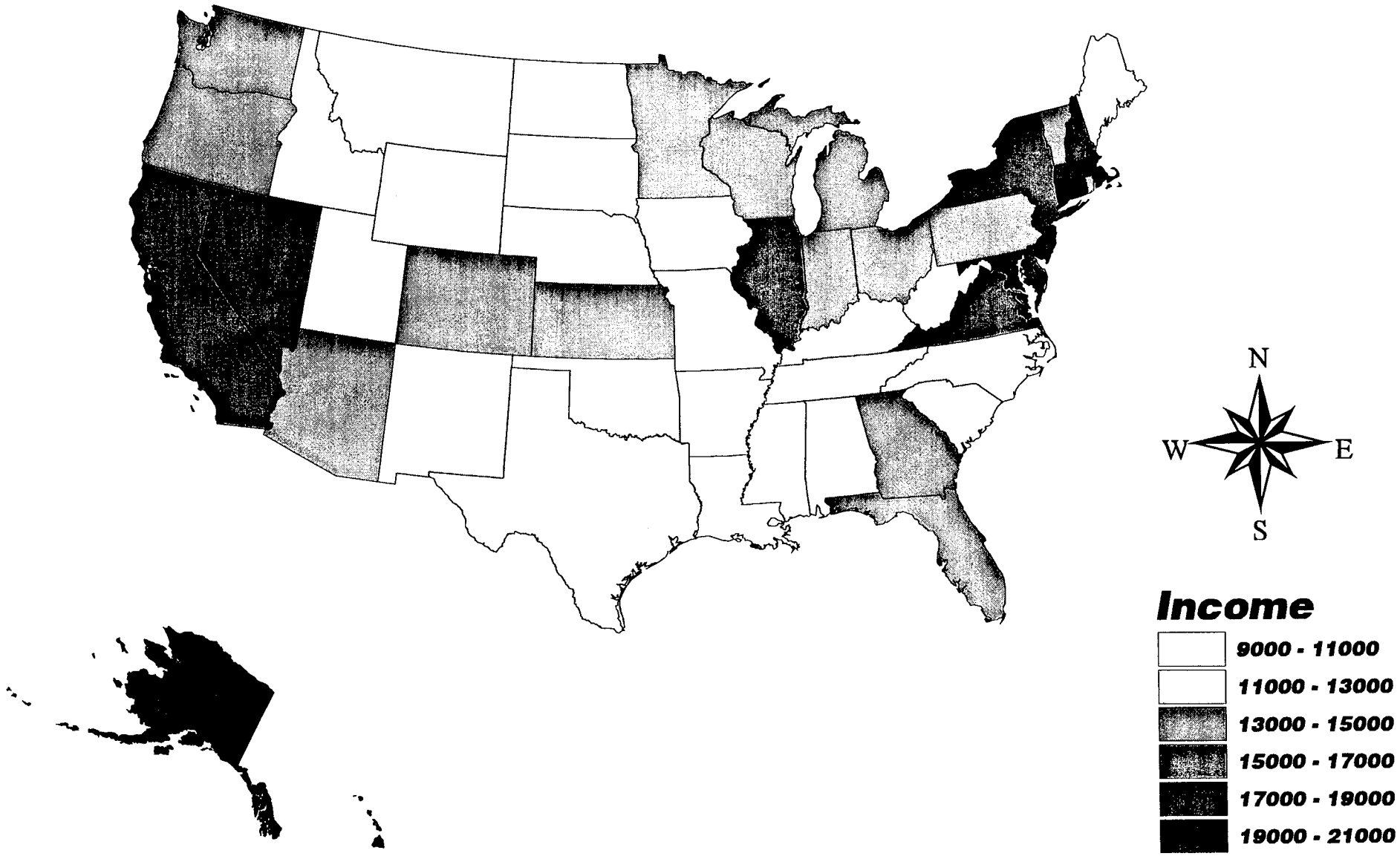
Population (1989)



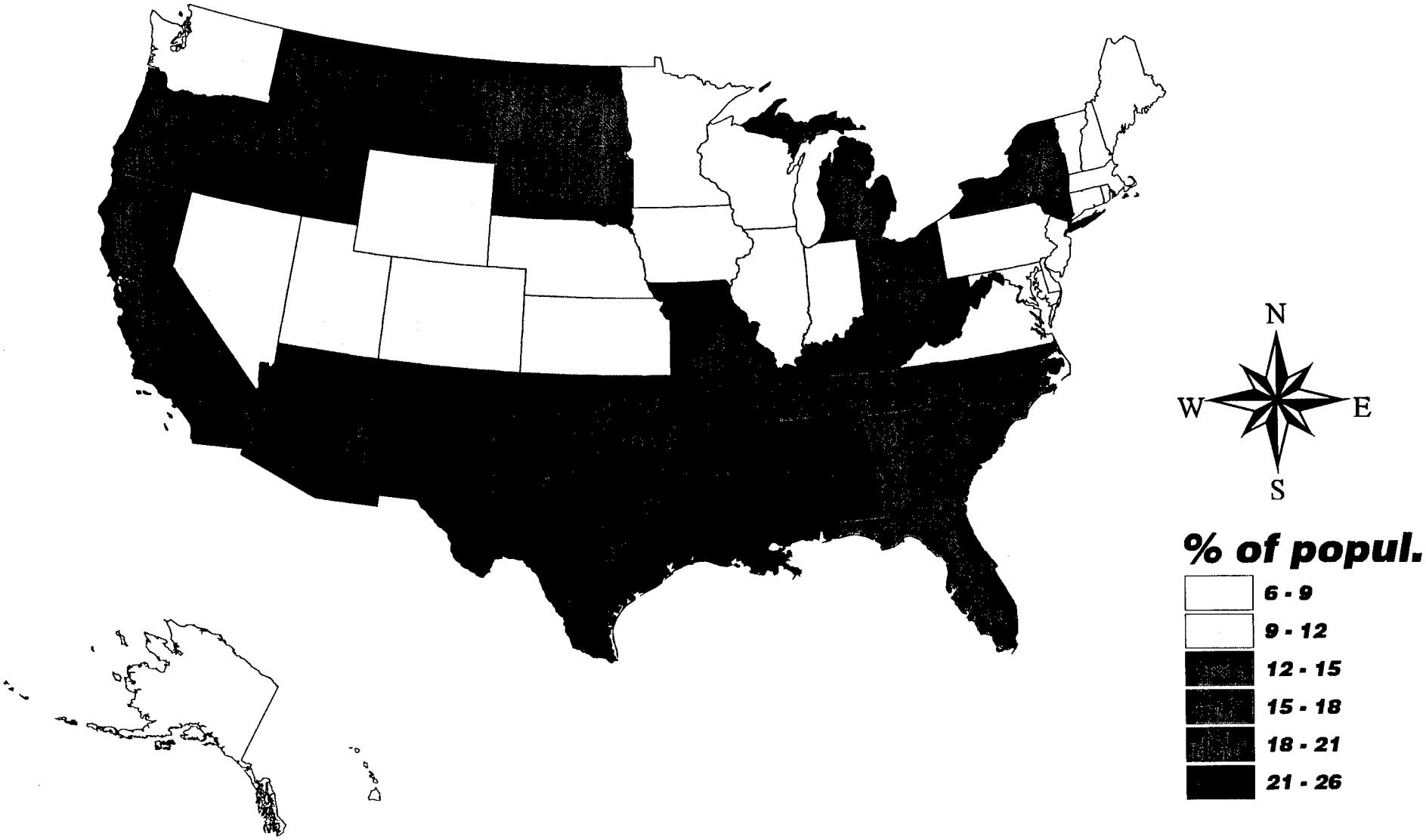
Median Household Income (1989)



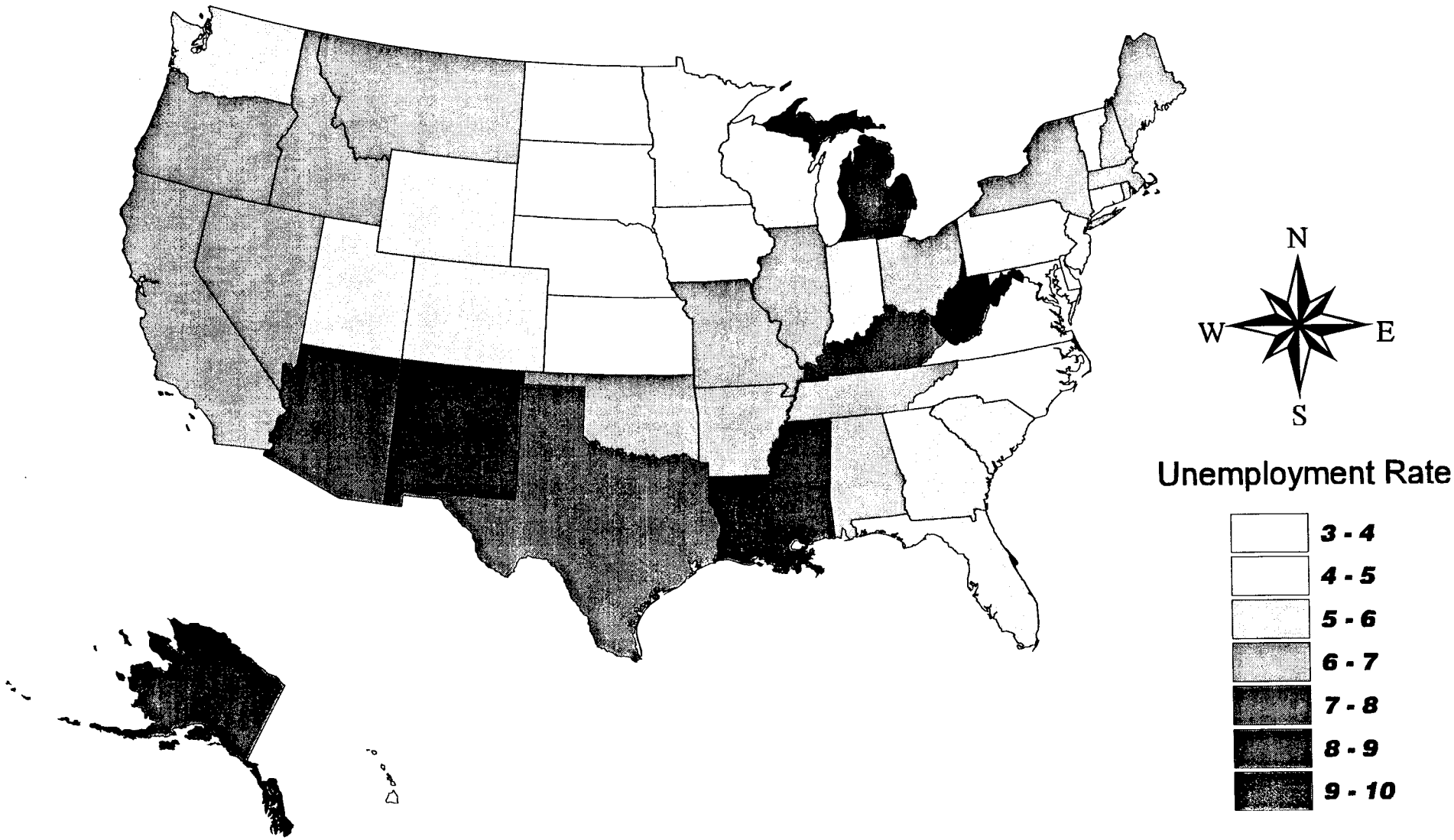
Per Capita Income (1989)



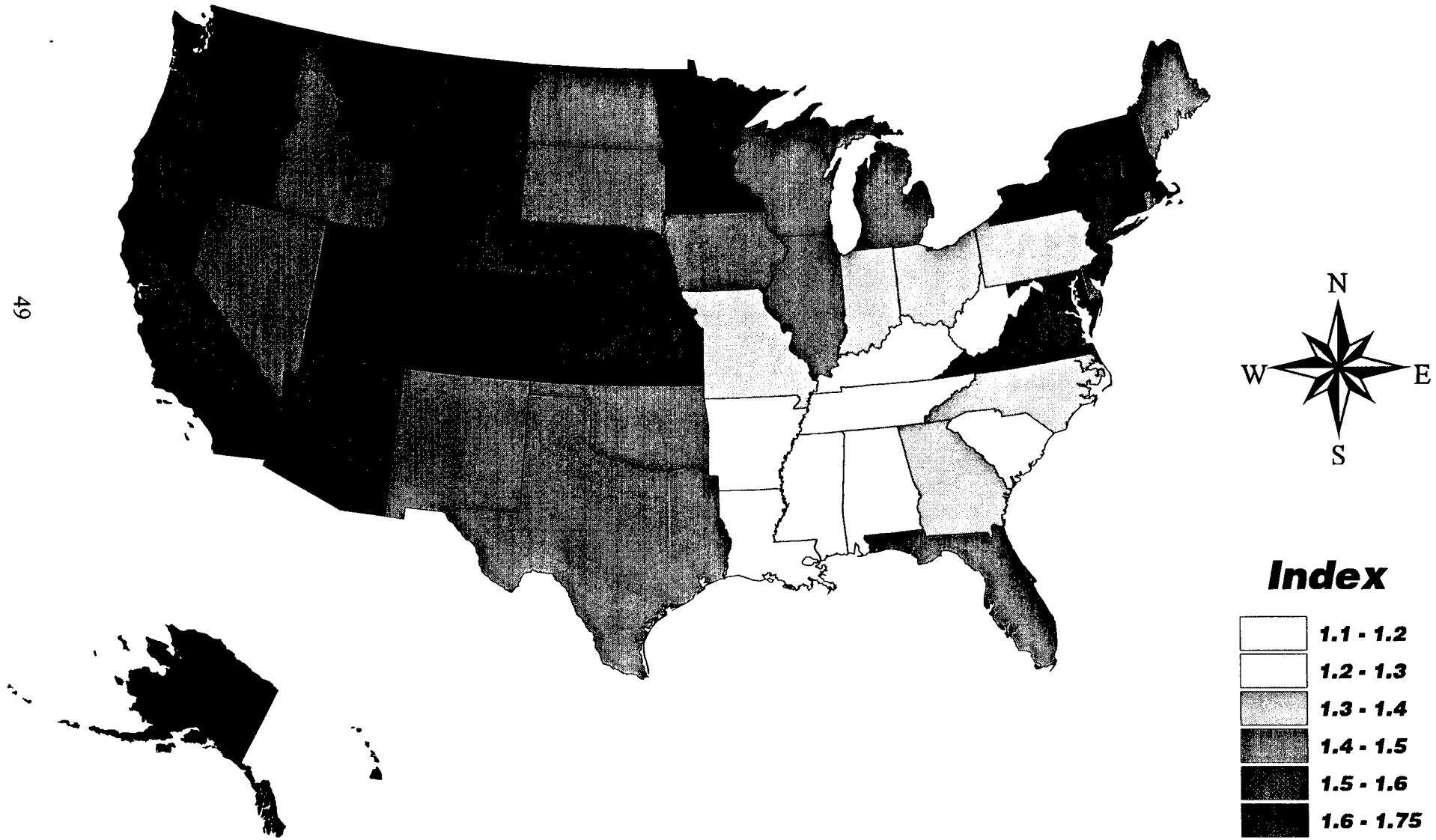
Percentage Below Povery Level (1989)



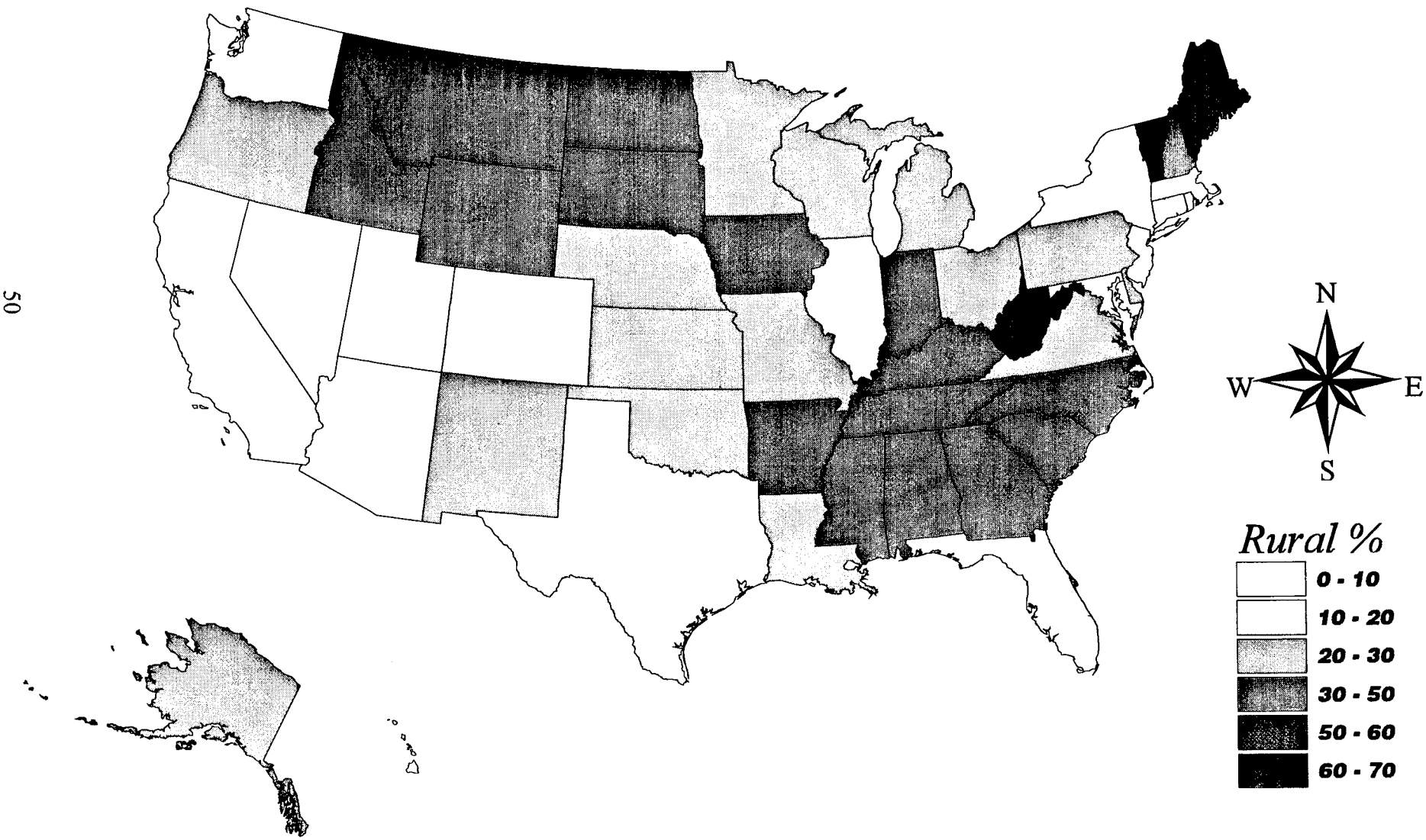
Unemployment (1989)



Education Attainment (1989)



Percentage of Rural Population (1989)



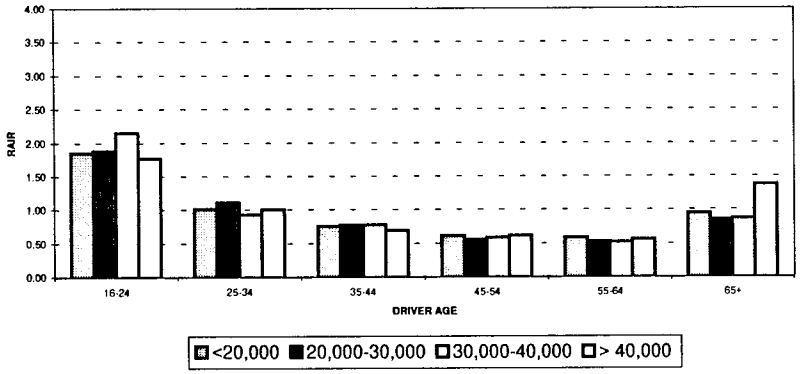
APPENDIX B

MULTIVARIABLE ANALYSIS

B.1. SOCIOECONOMIC VARIABLES AND DRIVER AGE

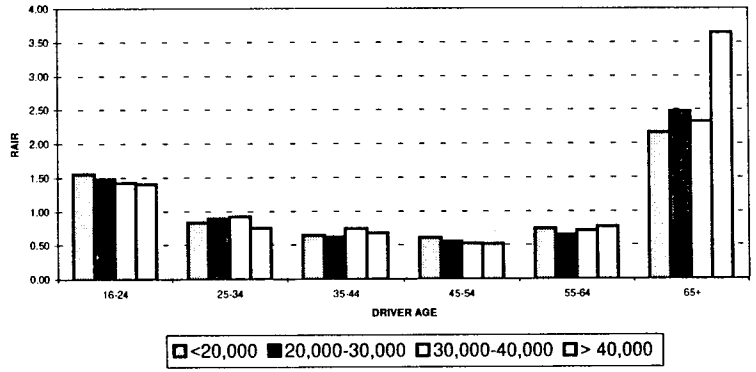
Accident exposure by Median household income and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



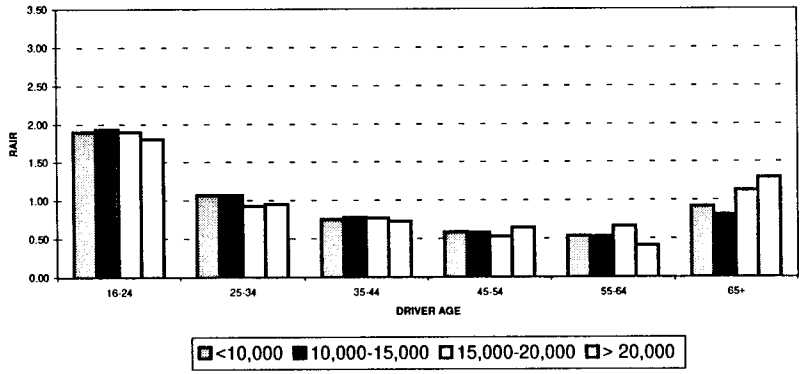
Accident exposure by Median household income and driver age

Effect of at-fault driver and its iteraction in multiple vehicle accidents



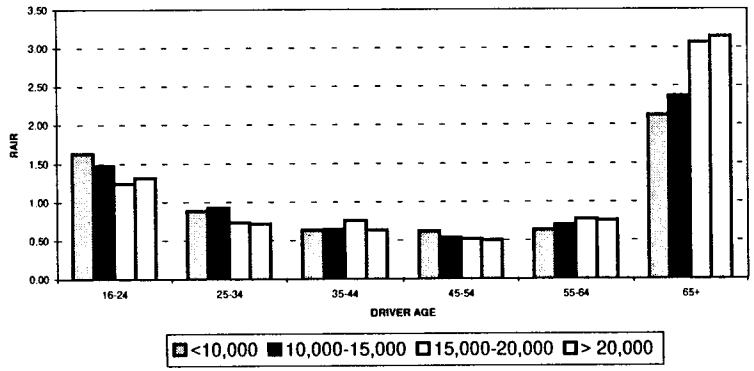
Accident exposure by Per capita income and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



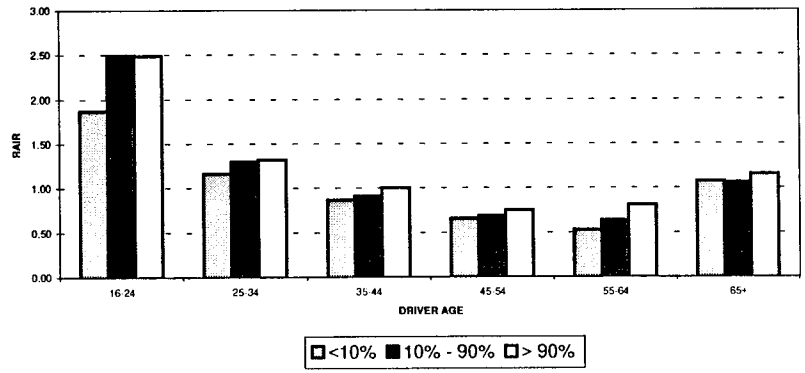
Accident exposure by Per capita income and driver age

Effect of at-fault driver and its iteraction in multiple vehicle accidents



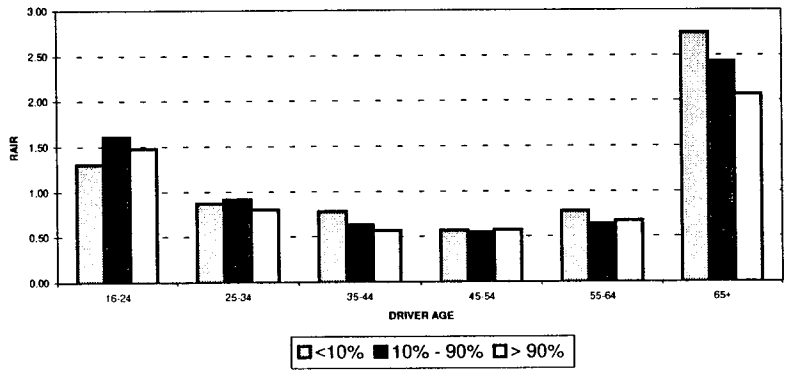
Accident exposure by Rural population and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



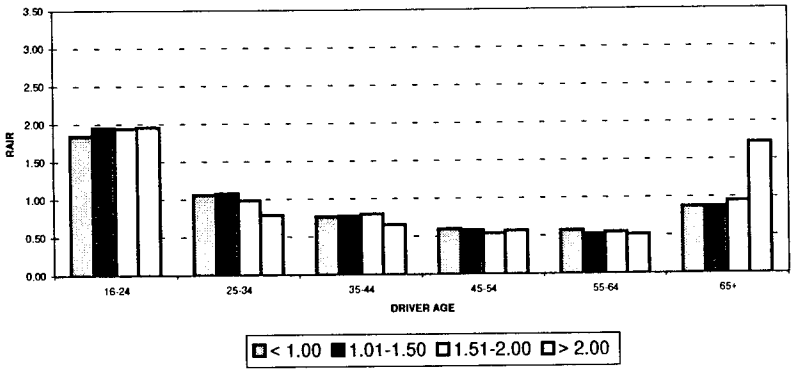
Accident exposure by Rural population and driver age

Effect of at-fault driver and its iteraction in multiple vehicle accidents



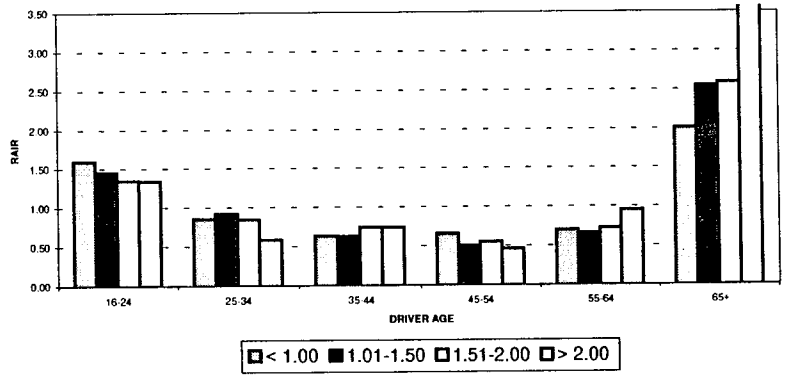
Accident exposure by Educational level and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



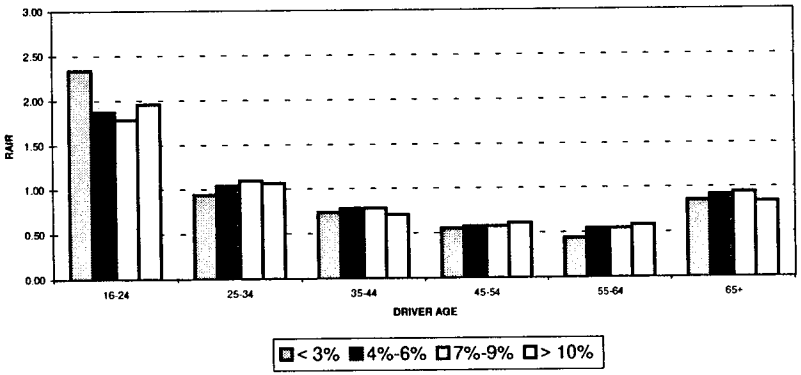
Accident exposure by Educational level and driver age

Effect of at-fault driver and its iteraction in multiple vehicle accidents



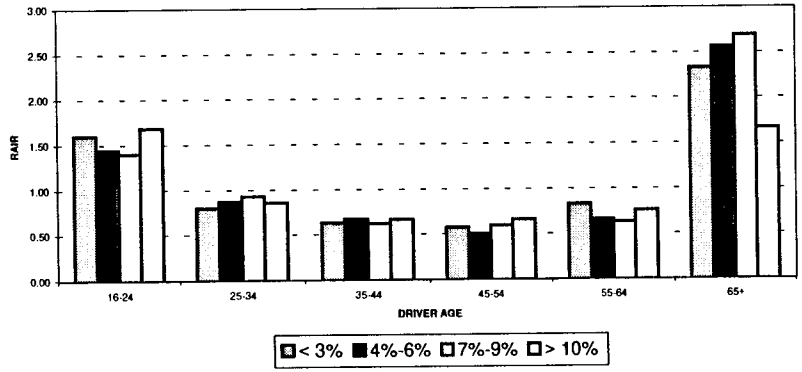
Accident exposure by Unemployment and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



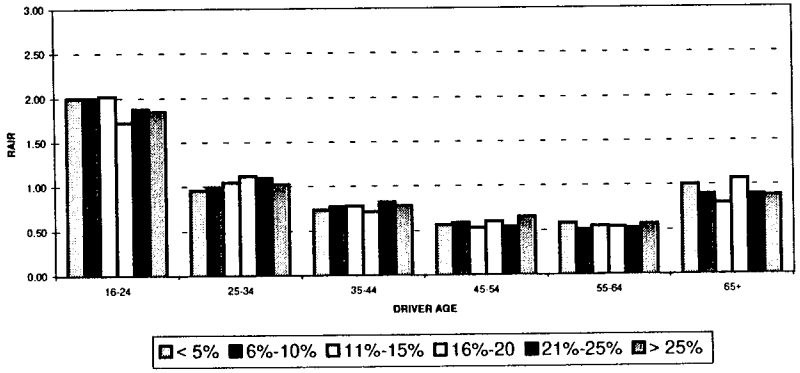
Accident exposure by Unemployment and driver age

Effect of at-fault driver and its iteraction in multiple vehicle accidents



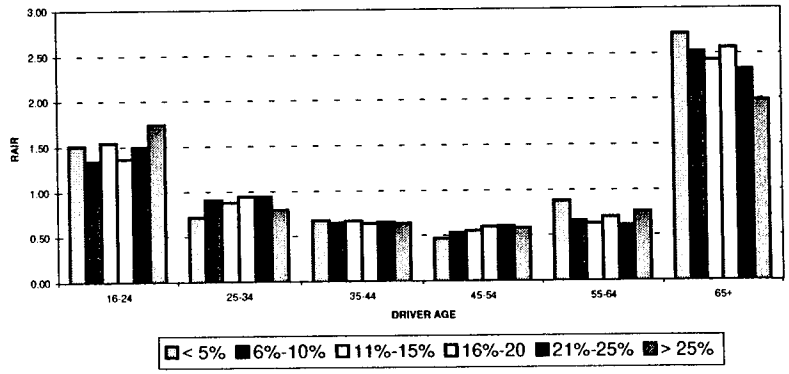
Accident exposure by Population below poverty level and driver age

Effect of at-fault driver and its iteraction in single vehicle accidents



Accident exposure by Population below poverty level and driver age

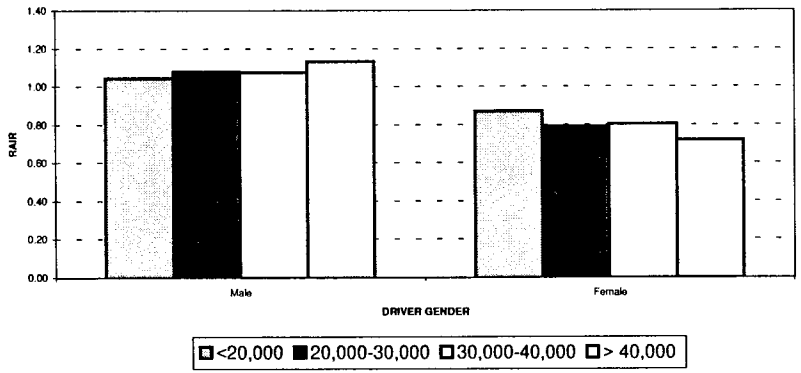
Effect of at-fault driver and its iteraction in multiple vehicle accidents



B.2. SOCIOECONOMIC VARIABLES AND DRIVER GENDER

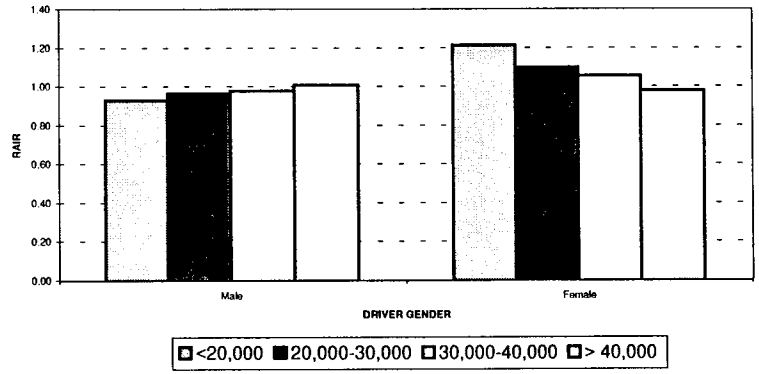
Accident exposure by Median household income and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



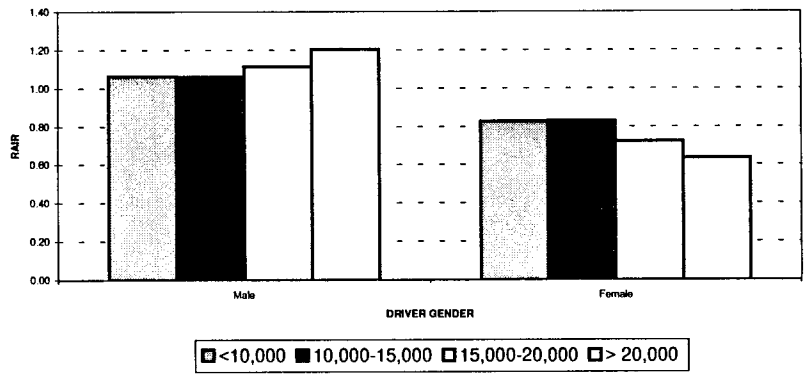
Accident exposure by Median household income and driver gender

Effect of at-fault driver and its iteraction in multiple vehicle accidents



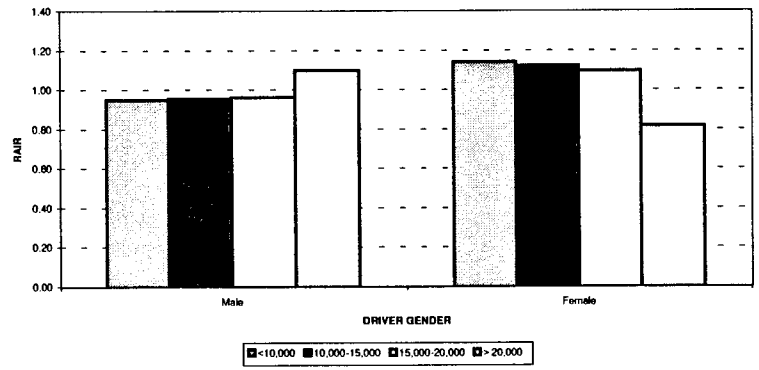
Accident exposure by Per capita income and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



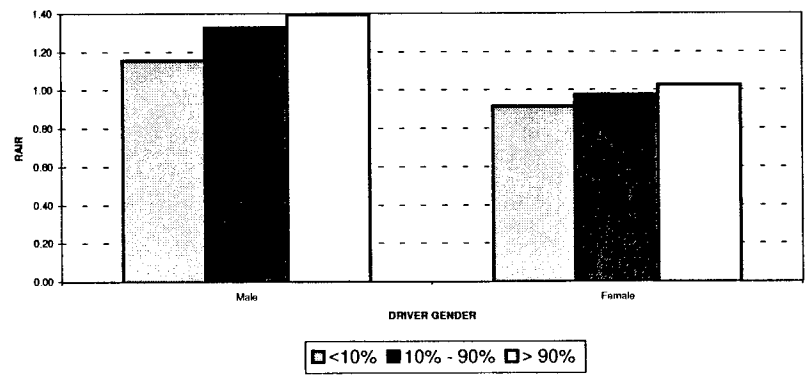
Accident exposure by Per capita income and driver gender

Effect of at-fault driver and its iteraction in multiple vehicle accidents



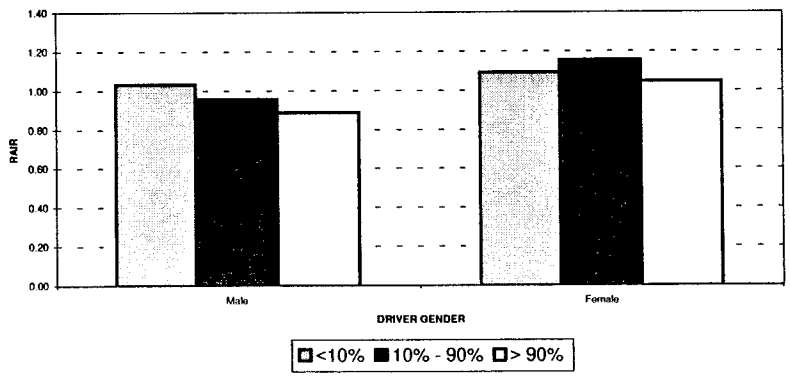
Accident exposure by Rural population and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



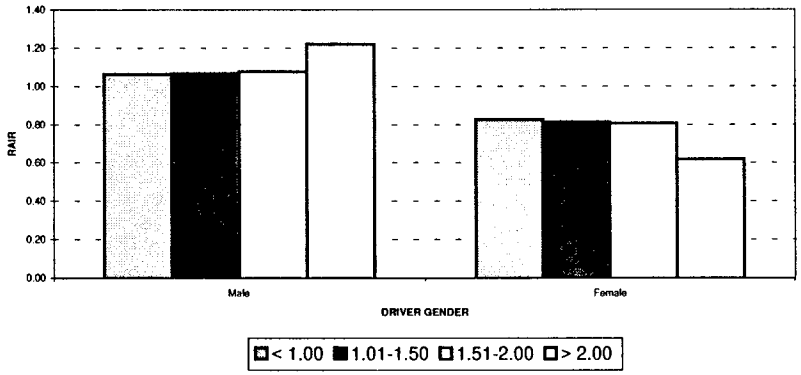
Accident exposure by Rural population and driver gender

Effect of at-fault driver and its iteraction in multiple vehicle accidents



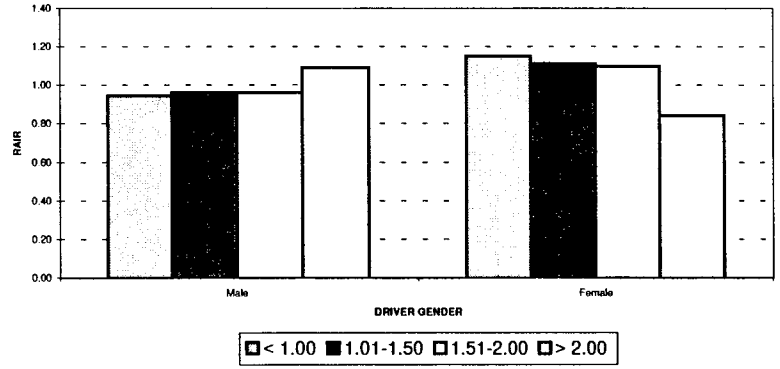
Accident exposure by Educational level and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



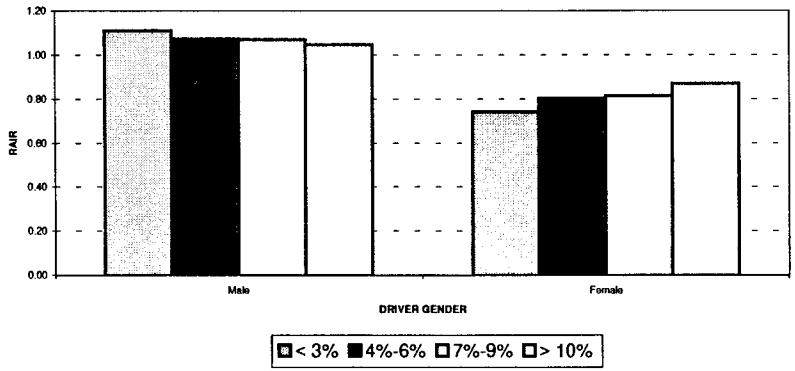
Accident exposure by Educational level and driver gender

Effect of at-fault driver and its iteraction in multiple vehicle accidents



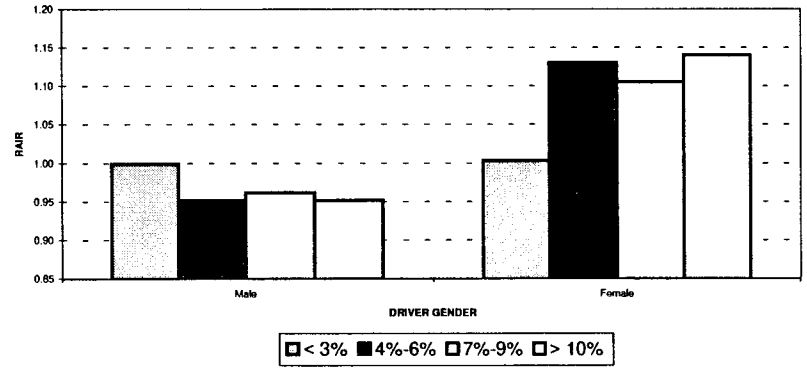
Accident exposure by Unemployment and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



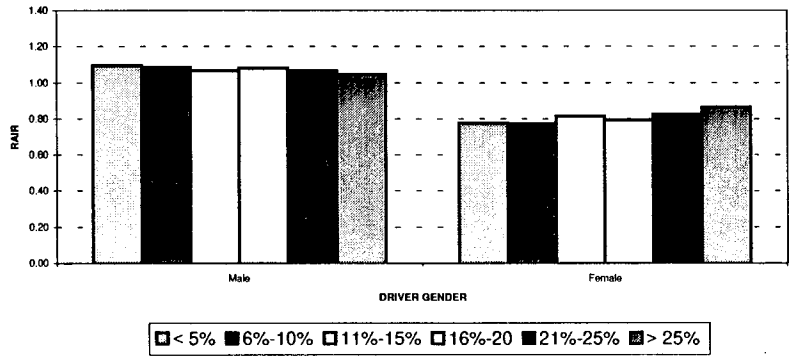
Accident exposure by Unemployment and driver gender

Effect of at-fault driver and its iteraction in multiple vehicle accidents



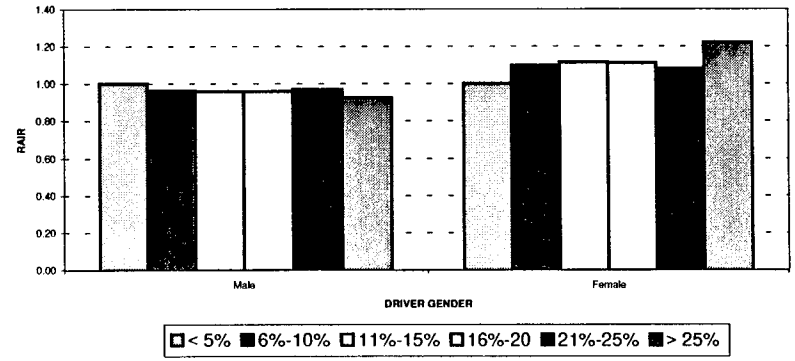
Accident exposure by Population below poverty level and driver gender

Effect of at-fault driver and its iteraction in single vehicle accidents



Accident exposure by Population below poverty level and driver gender

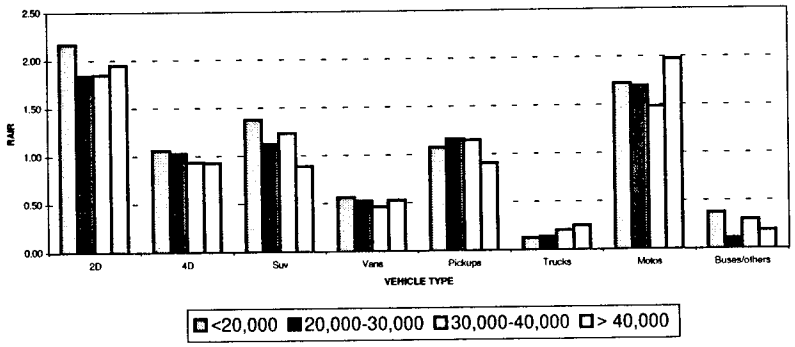
Effect of at-fault driver and its iteraction in multiple vehicle accidents



B.3. SOCIOECONOMIC VARIABLES AND VEHICLE TYPE

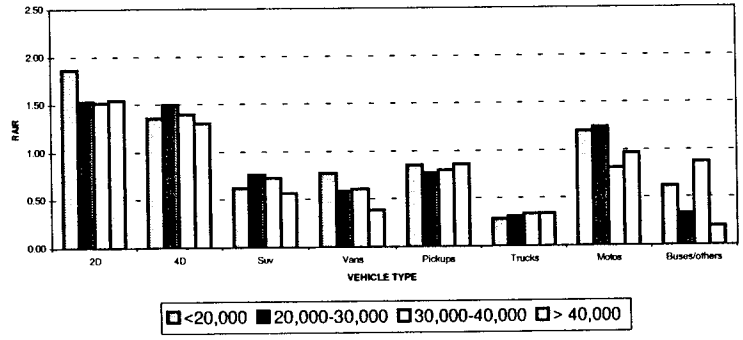
Accident exposure by Median household income and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



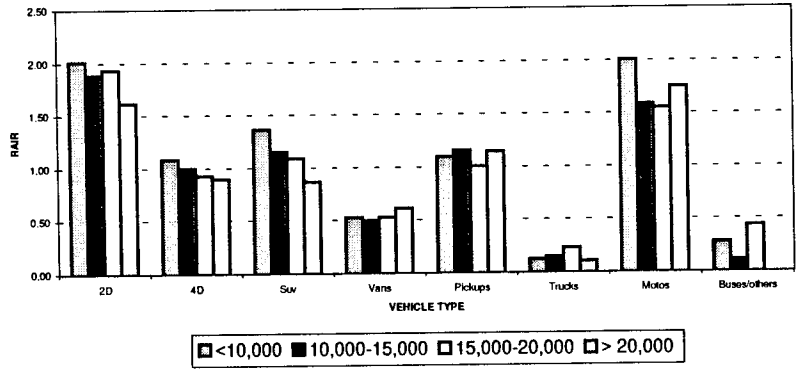
Accident exposure by Median household income and vehicle type

Effect of at-fault driver and its iteraction in multiple vehicle accidents



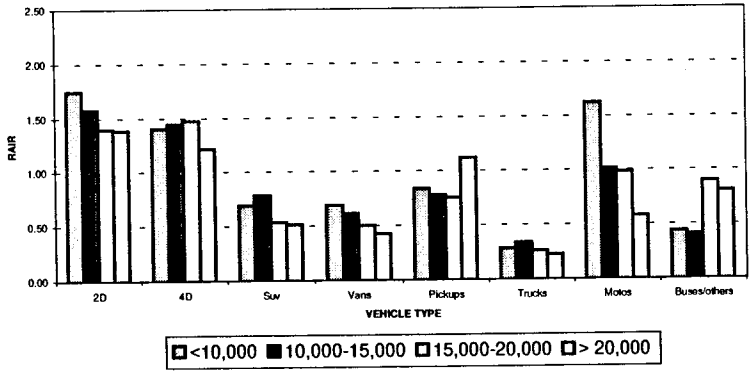
Accident exposure by Per capita income and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



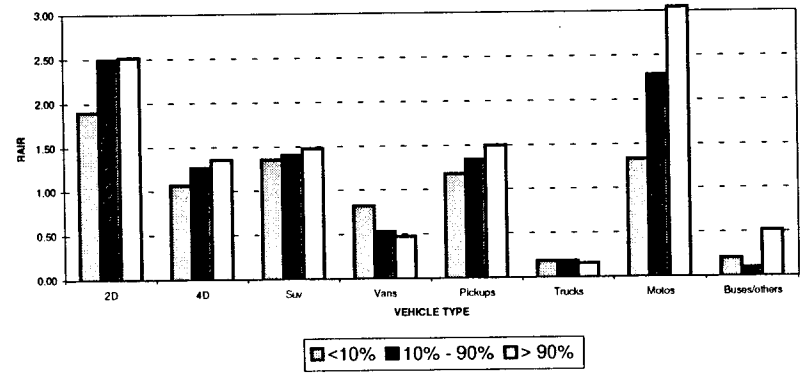
Accident exposure by Per capita income and vehicle type

Effect of at-fault driver and its iteraction in multiple vehicle accidents



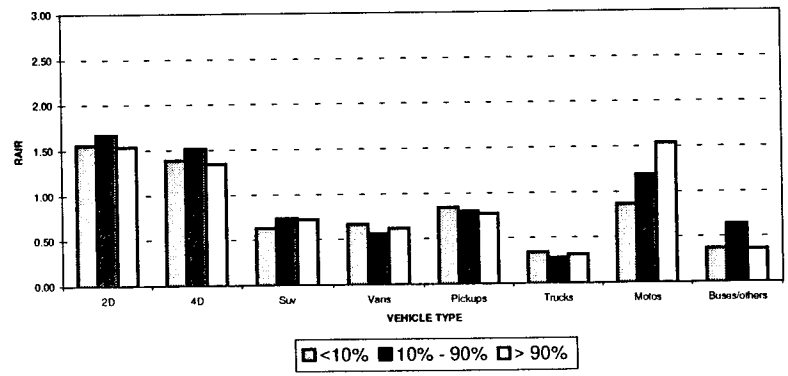
Accident exposure by Rural population and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



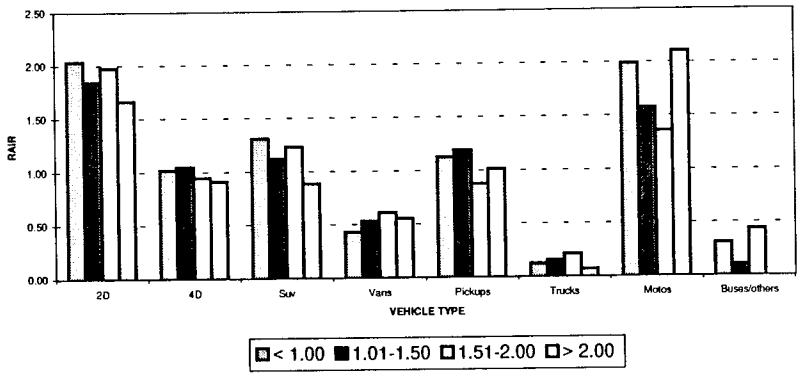
Accident exposure by Rural population and vehicle type

Effect of at-fault driver and its iteraction in multiple vehicle accidents



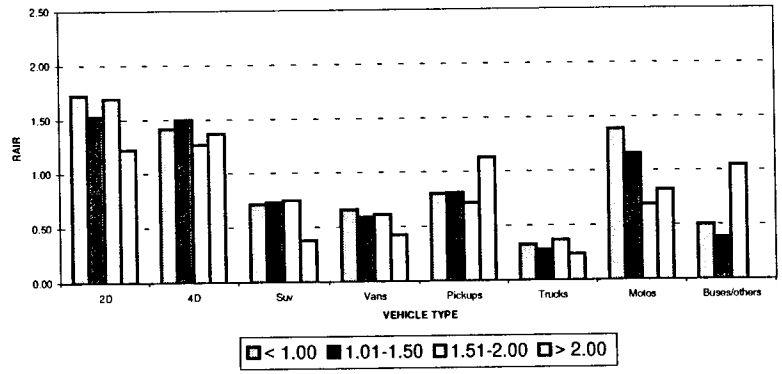
Accident exposure by Educational level and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



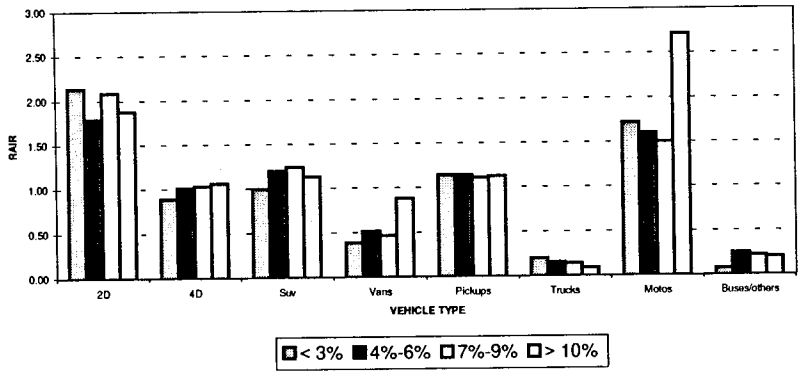
Accident exposure by Educational level and vehicle type

Effect of at-fault driver and its iteraction in multiple vehicle accidents



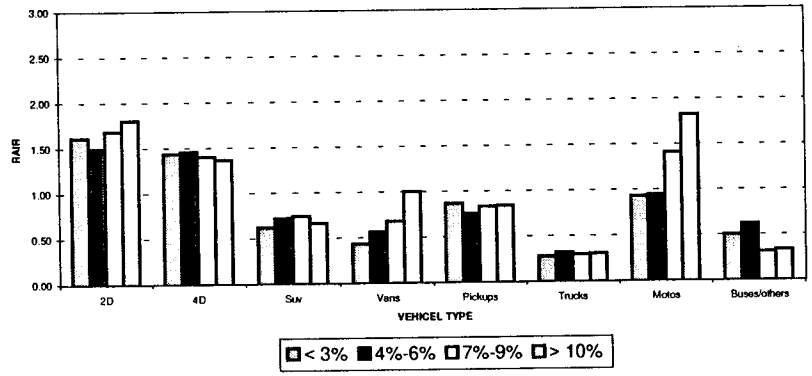
Accident exposure by Unemployment and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



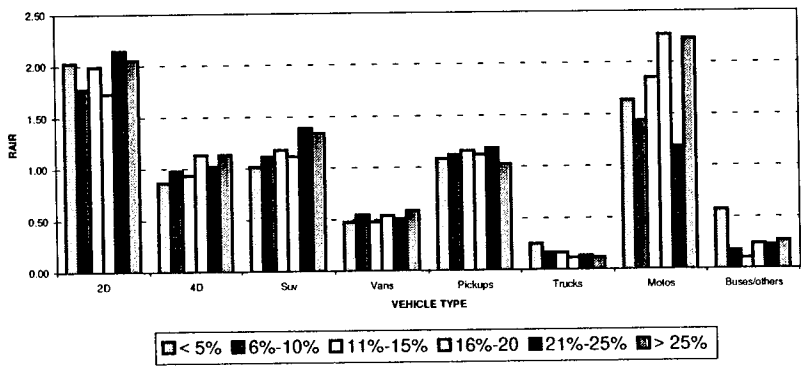
Accident exposure by Unemployment and vehicle type

Effect of at-fault driver and its iteraction in multiple vehicle accidents



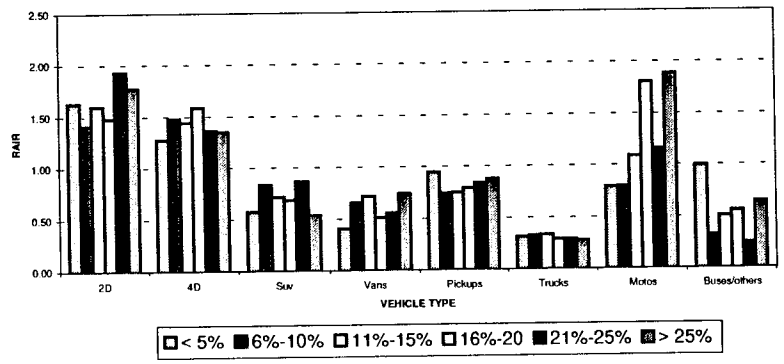
Accident exposure by Population below poverty level and vehicle type

Effect of at-fault driver and its iteraction in single vehicle accidents



Accident exposure by Population below poverty level and vehicle type

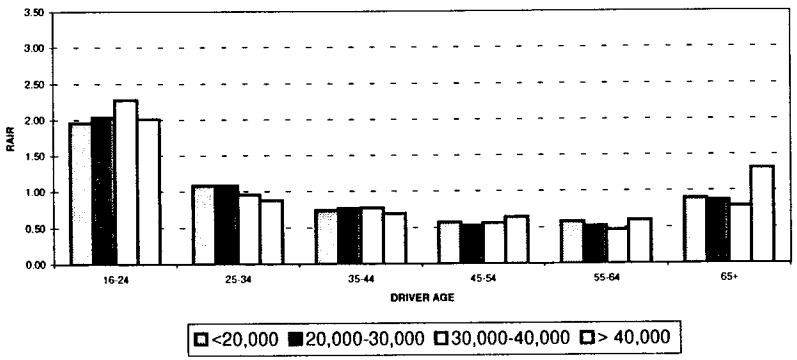
Effect of at-fault driver and its iteraction in multiple vehicle accidents



B.4. SOCIOECONOMIC VARIABLES, DRIVER GENDER AND DRIVER AGE

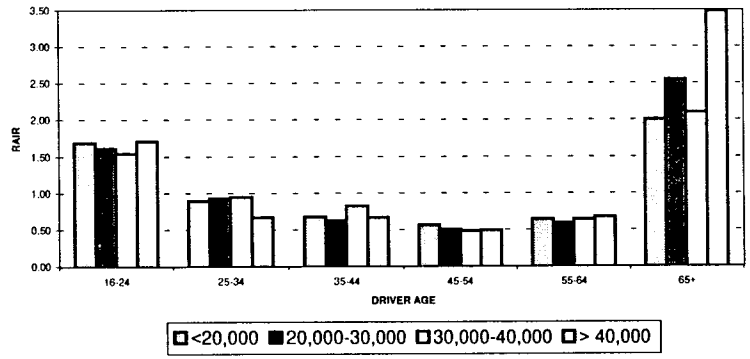
Accident exposure by Median household income, driver age and gender

Effect of at-fault male driver and its iteraction in single vehicle accidents



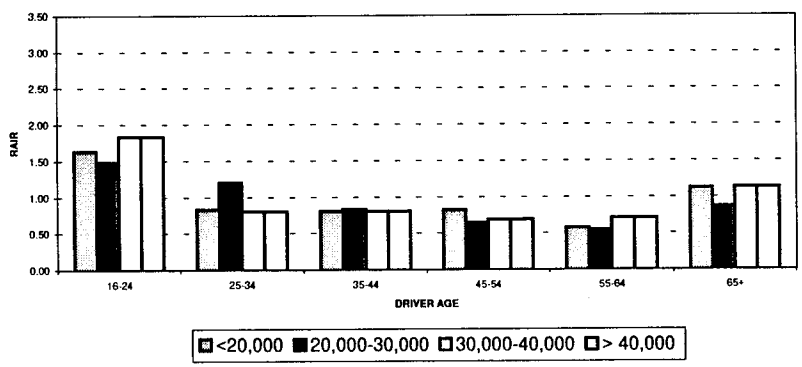
Accident exposure by Median household income, driver age and gender

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



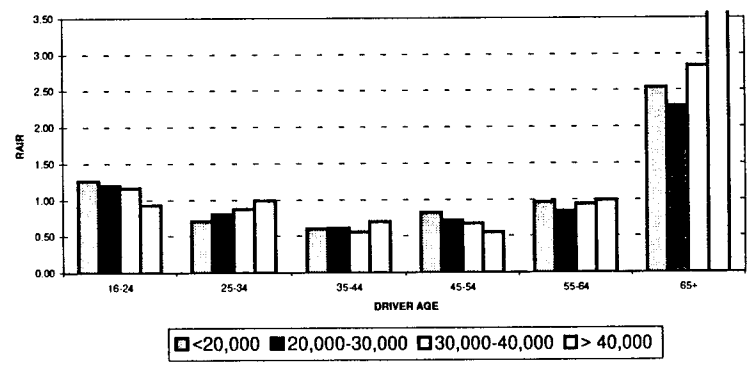
Accident exposure by Median household income, driver age and gender

Effect of at-fault female driver and its iteraction in single vehicle accidents



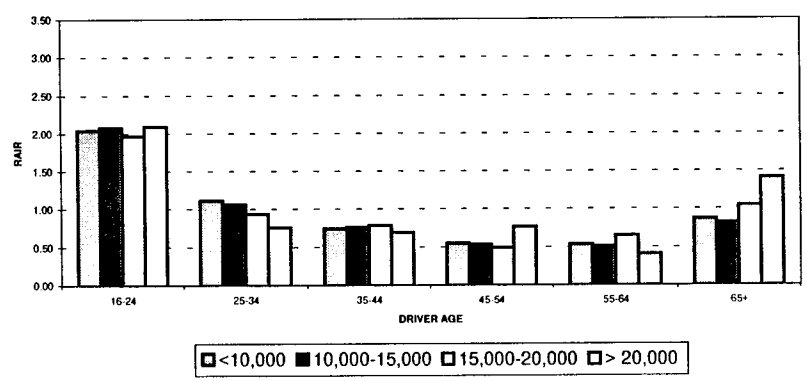
Accident exposure by Median household income, driver age and gender

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



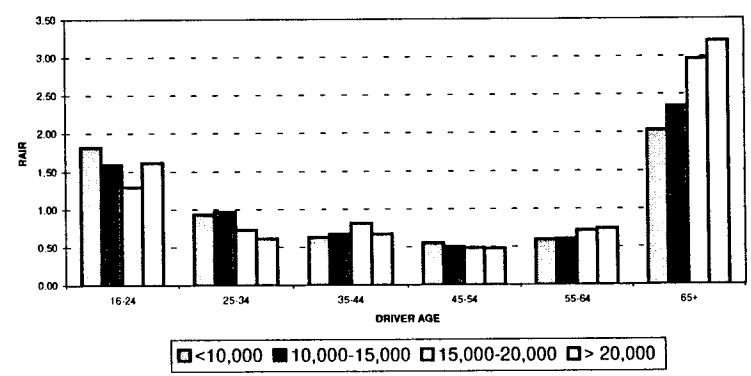
Accident exposure by Per capita income, gender and driver age

Effect of at-fault male driver and its iteraction in single vehicle accidents



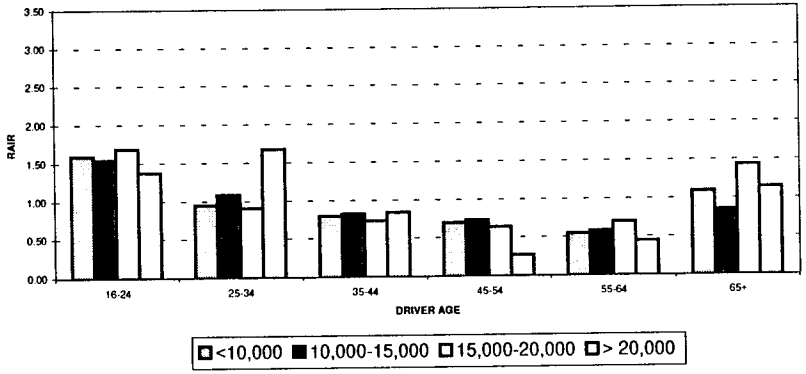
Accident exposure by Per capita income, gender and driver age

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



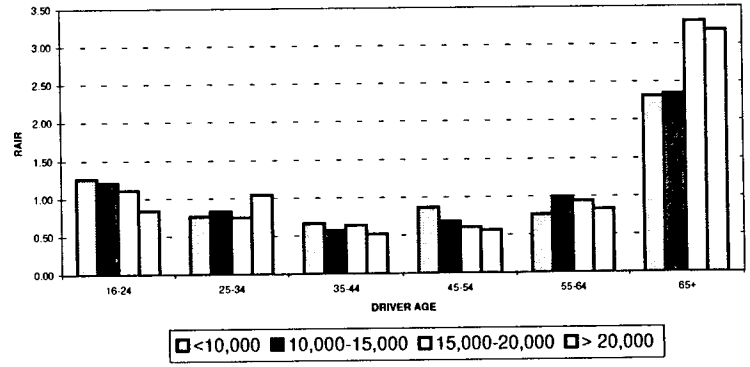
Accident exposure by Per capita income, gender and driver age

Effect of at-fault female driver and its iteraction in single vehicle accidents



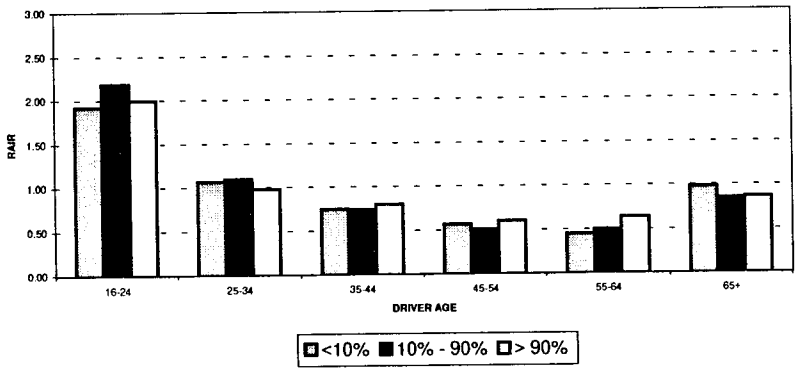
Accident exposure by Per capita income, gender and driver age

Effect of at-fault female driver and its iteraction in multiple vehicle accidents



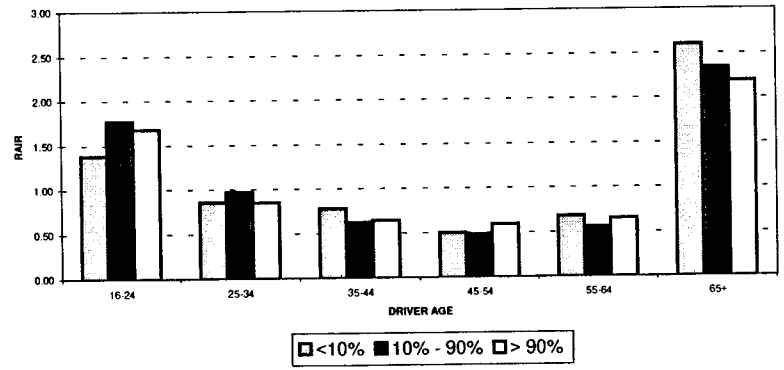
Accident exposure by Rural population, gender and driver age

Effect of at-fault male driver and its iteraction in single vehicle accidents



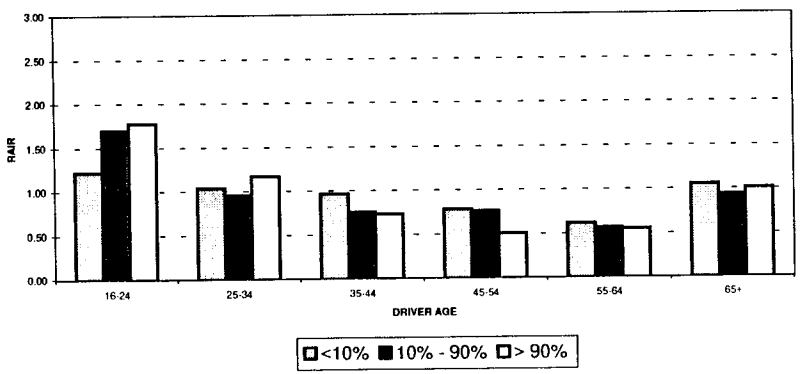
Accident exposure by Rural population, gender and driver age

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



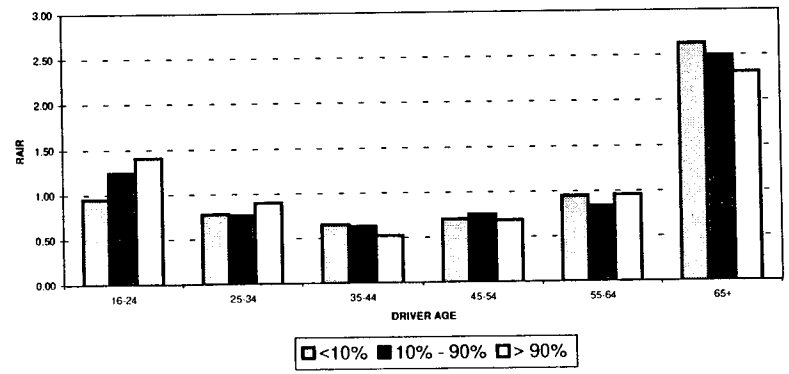
Accident exposure by Rural population, gender and driver age

Effect of at-fault female driver and its iteraction in single vehicle accidents



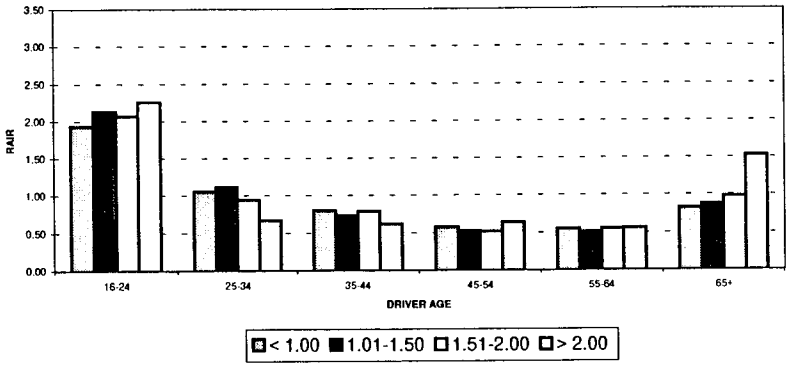
Accident exposure by Rural population, gender and driver age

Effect of at-fault female driver and its iteraction in multiple vehicle accidents



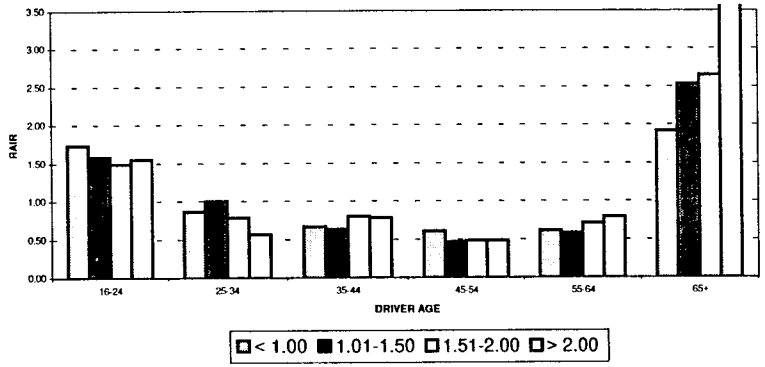
Accident exposure by Educational level, gender driver age

Effect of at-fault male driver and its iteraction in single vehicle accidents



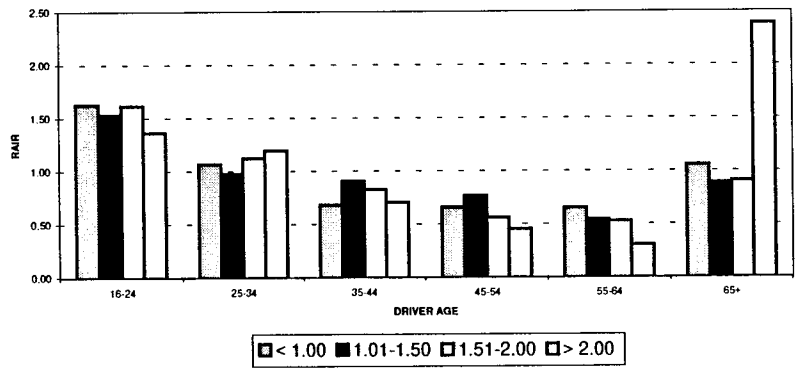
Accident exposure by Educational level, gender driver age

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



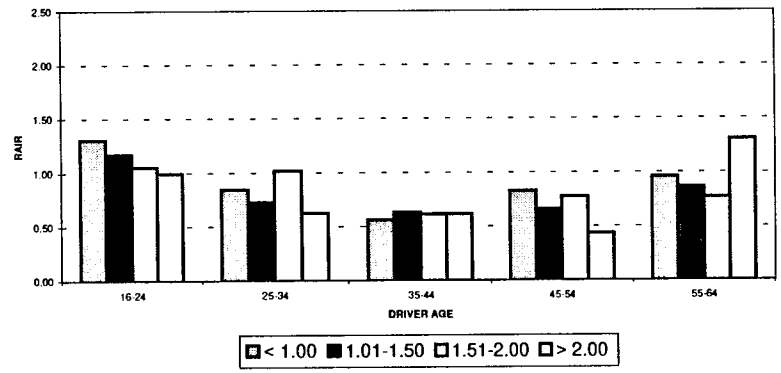
Accident exposure by Educational level, gender driver age

Effect of at-fault female driver and its iteraction in single vehicle accidents



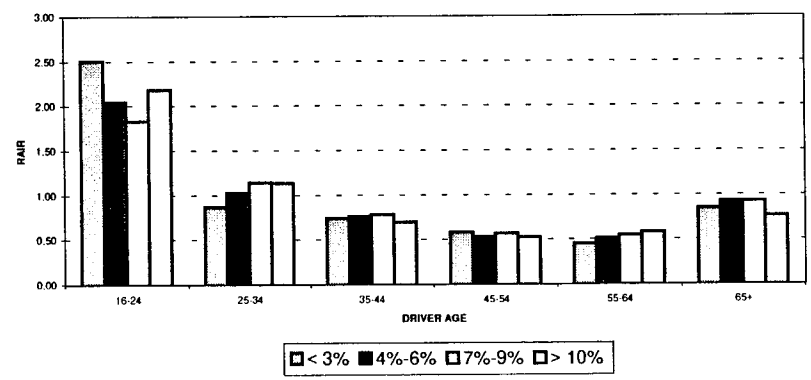
Accident exposure by Educational level, gender driver age

Effect of at-fault female driver and its iteraction in multiple vehicle accidents



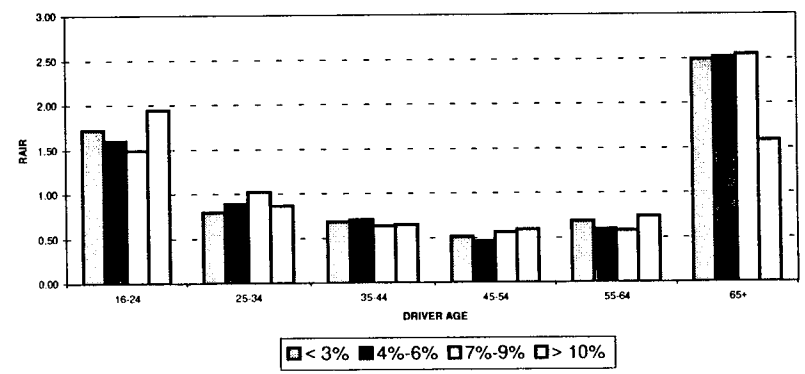
Accident exposure by Unemployment, gender and driver age

Effect of at-fault male driver and its iteraction in single vehicle accidents



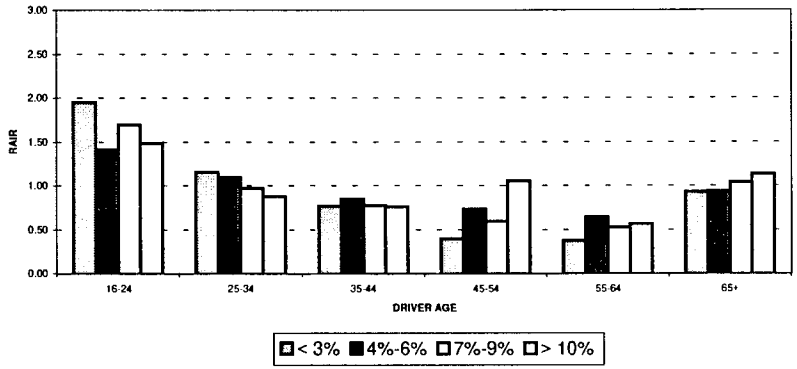
Accident exposure by Unemployment, gender and driver age

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



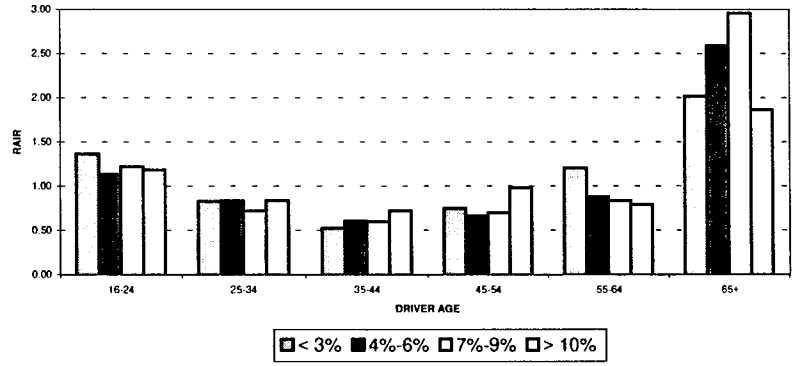
Accident exposure by Unemployment, gender and driver age

Effect of at-fault female driver and its iteraction in single vehicle accidents



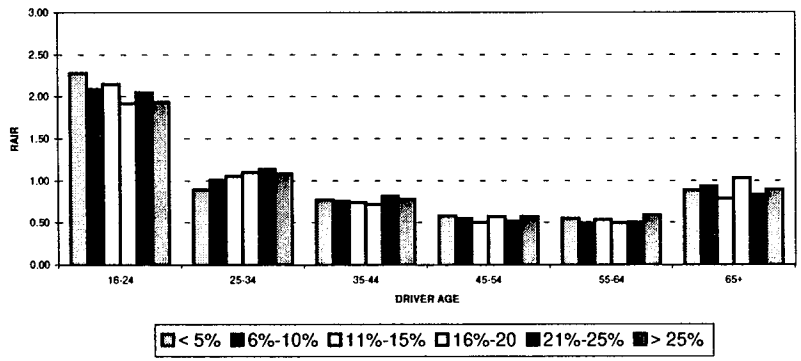
Accident exposure by Unemployment, gender and driver age

Effect of at-fault female driver and its iteraction in multiple vehicle accidents



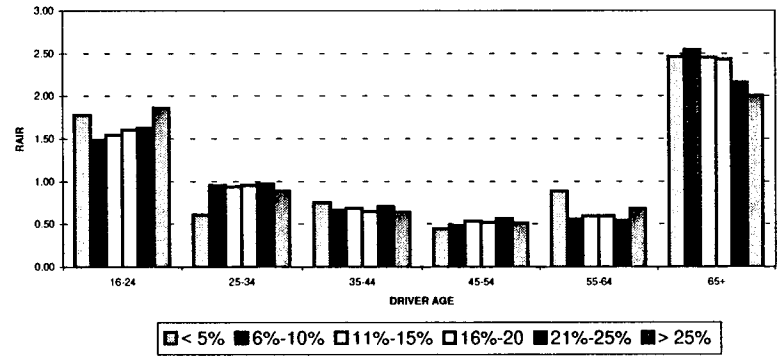
Accident exposure by Population below poverty level, gender and driver age

Effect of at-fault male driver and its iteraction in single vehicle accidents



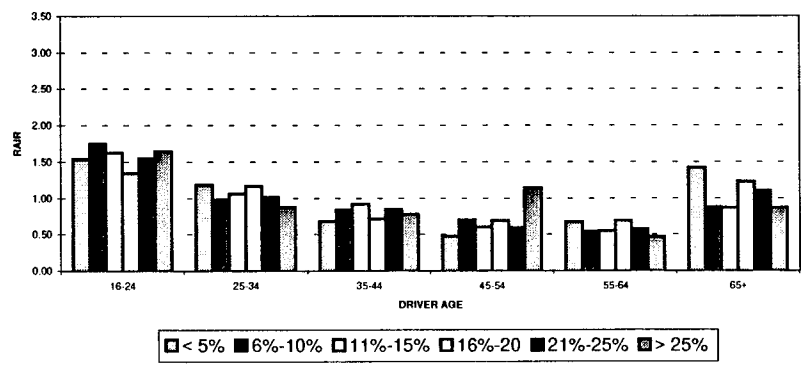
Accident exposure by Population below poverty level, gender and driver age

Effect of at-fault male driver and its iteraction in multiple vehicle accidents



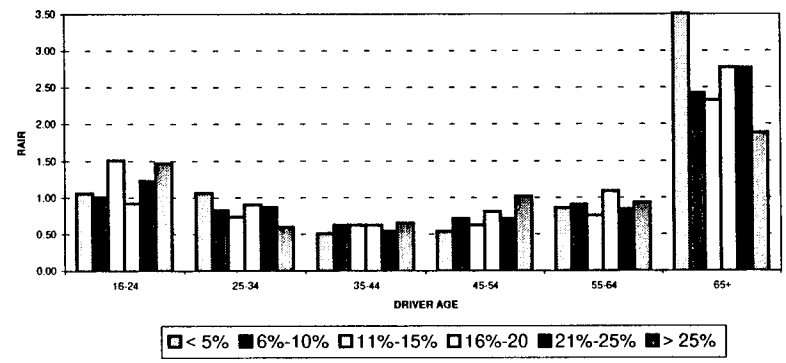
Accident exposure by Population below poverty level, gender and driver age

Effect of at-fault female driver and its iteraction in single vehicle accidents



Accident exposure by Population below poverty level, gender and driver age

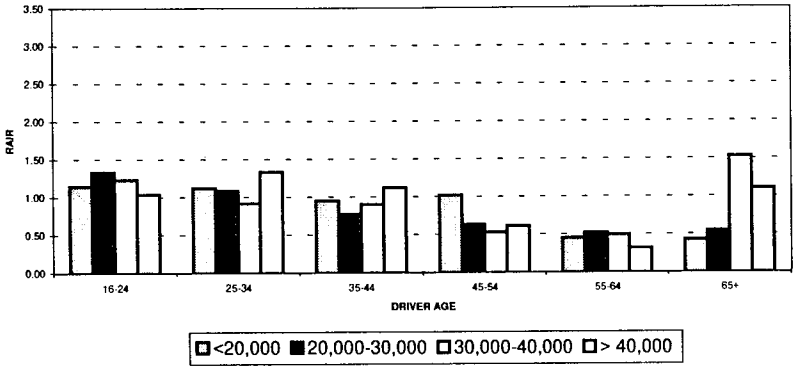
Effect of at-fault female driver and its iteraction in multiple vehicle accidents



B.5. SOCIOECONOMIC VARIABLES, VEHICLE TYPE AND DRIVER AGE

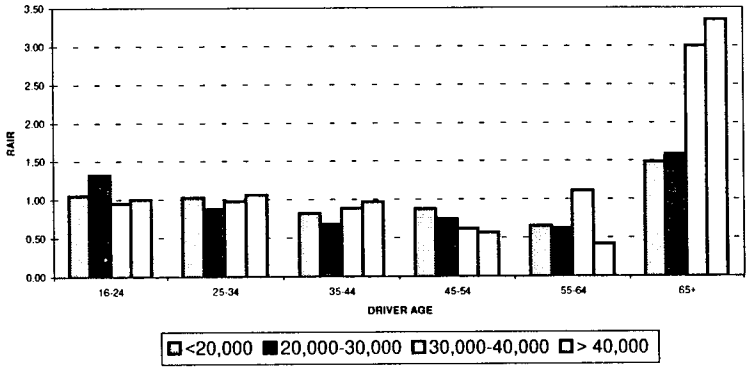
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



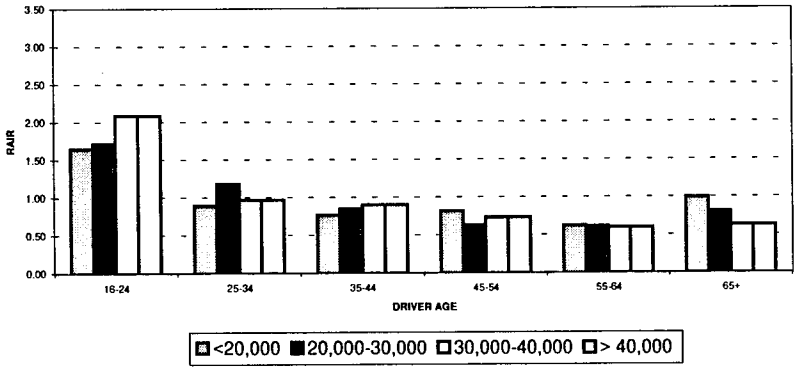
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



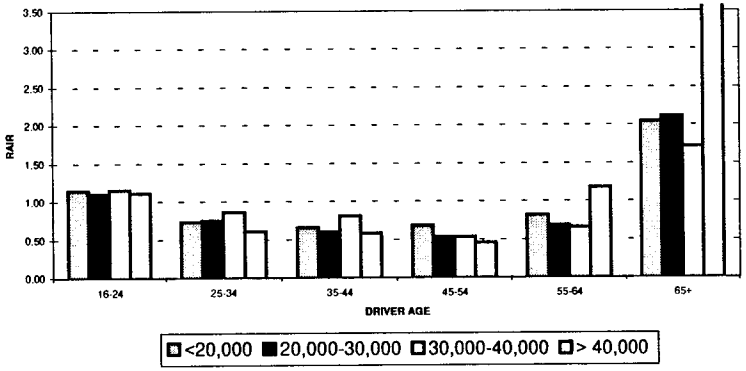
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



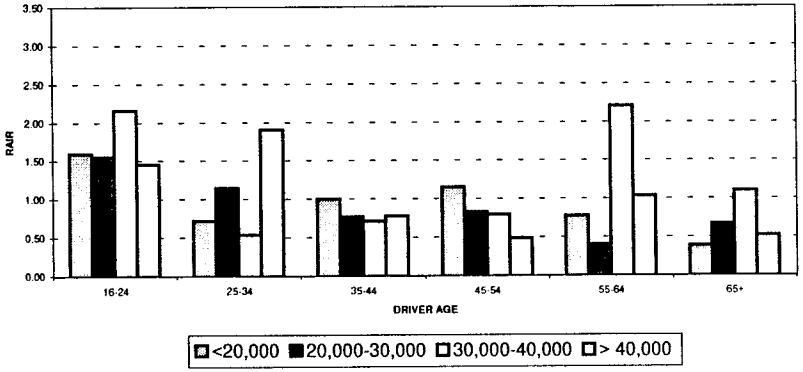
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



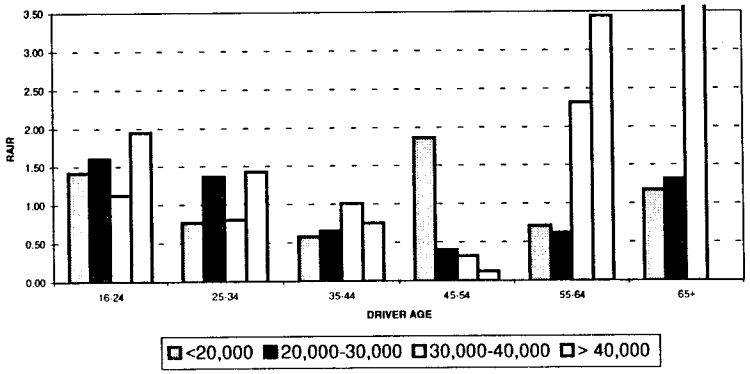
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault SUV vehicle and its iteraction in single vehicle accidents



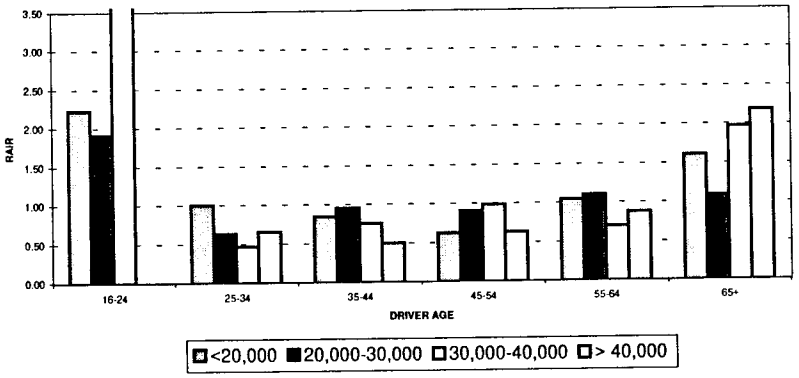
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



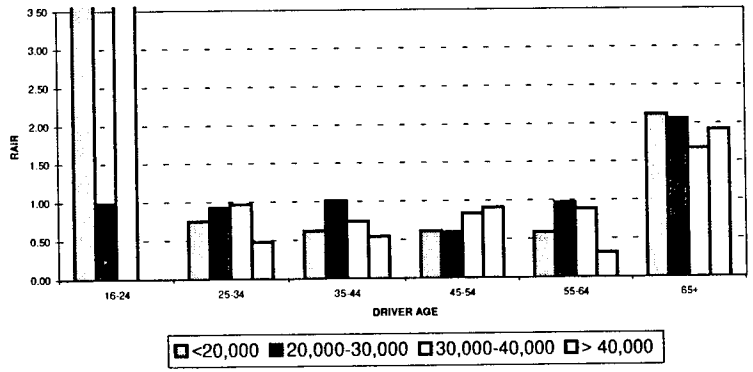
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault VAN vehicle and its iteraction in single vehicle accidents



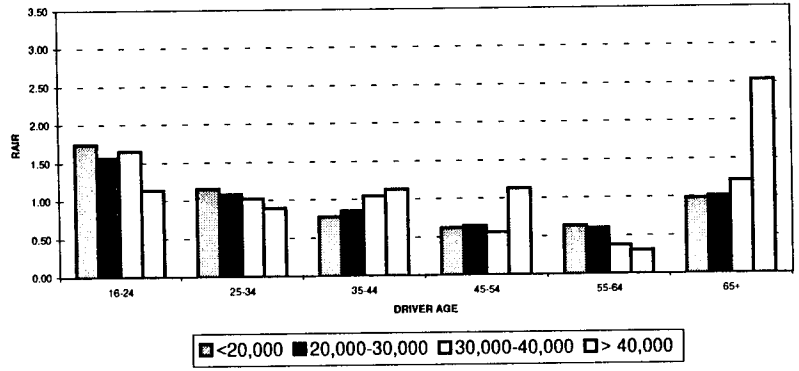
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault VAN vehicle and its iteraction in multiple vehicle accidents



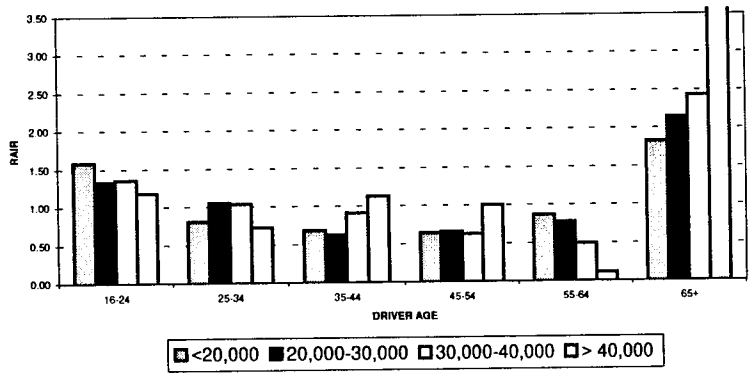
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



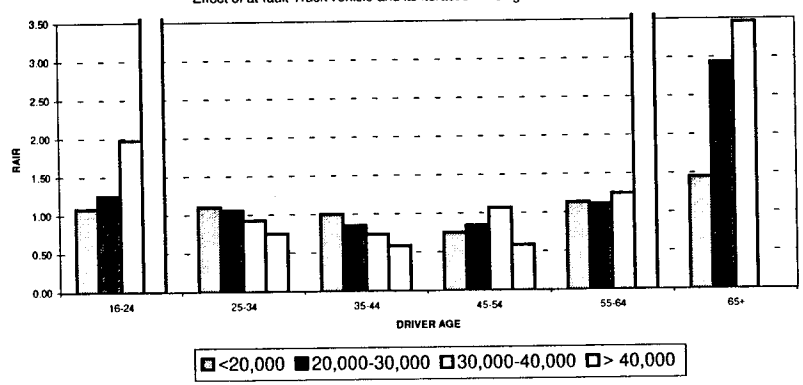
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



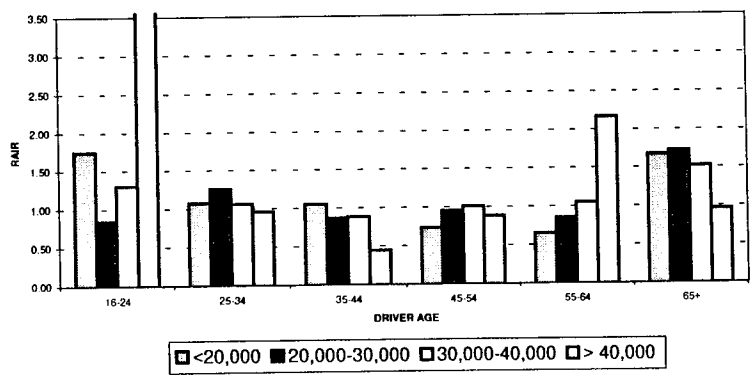
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Truck vehicle and its iteraction in single vehicle accidents



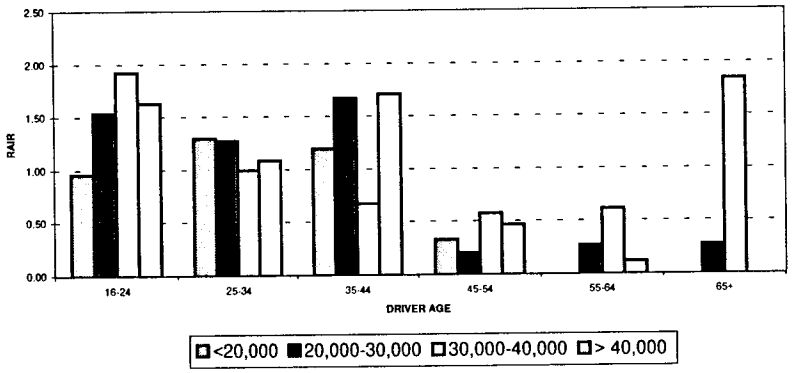
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Truck vehicle and its iteraction in multiple vehicle accidents



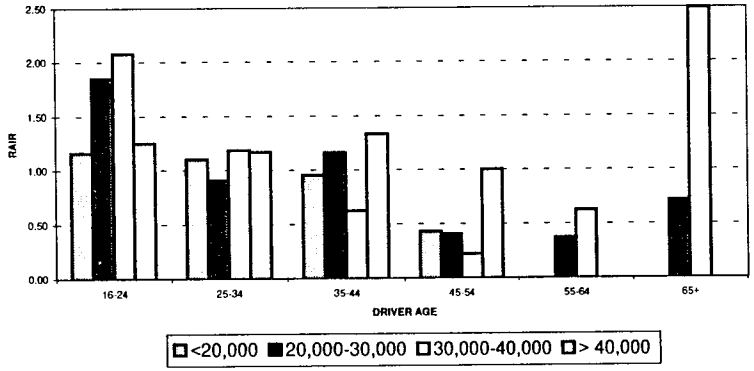
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Motorcycle vehicle and its iteraction in single vehicle accidents



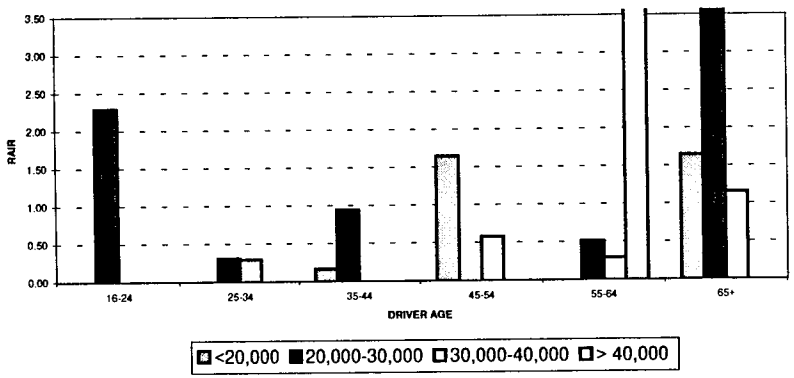
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Motorcycle vehicle and its iteraction in multiple vehicle accidents



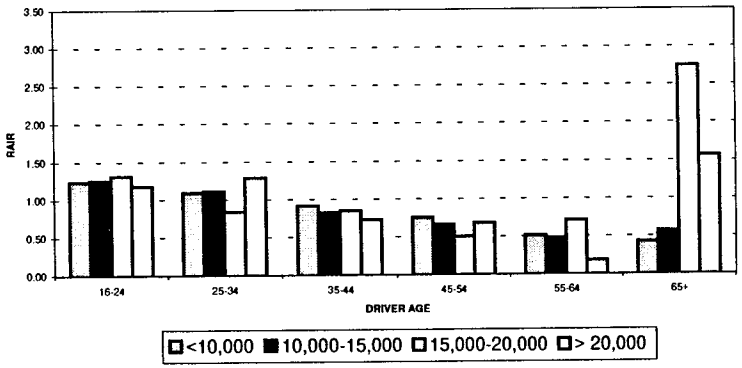
Accident exposure by Median household income, driver age and vehicle type

Effect of at-fault Bus (other) vehicle and its iteraction in multiple vehicle accidents



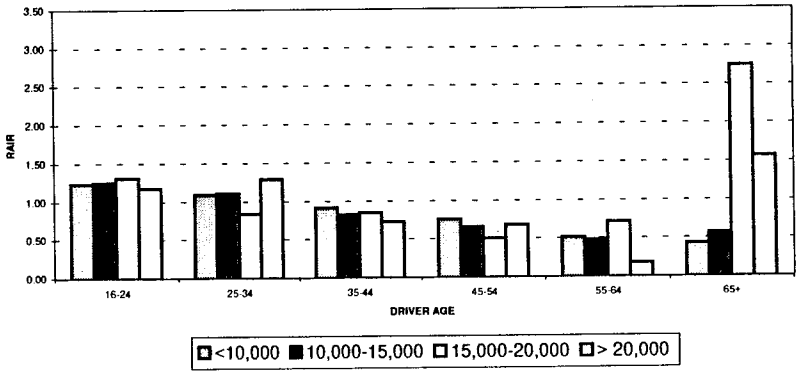
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



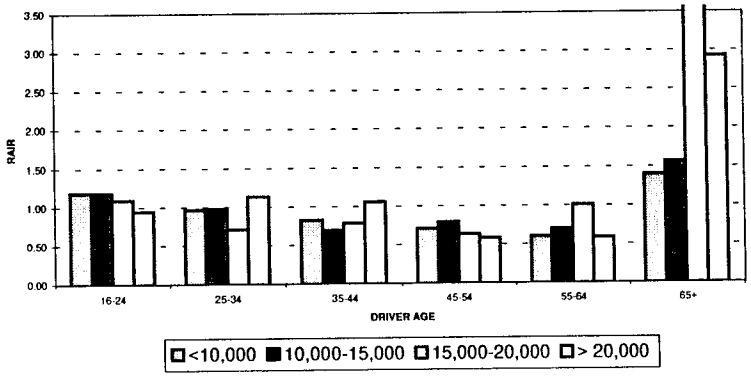
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



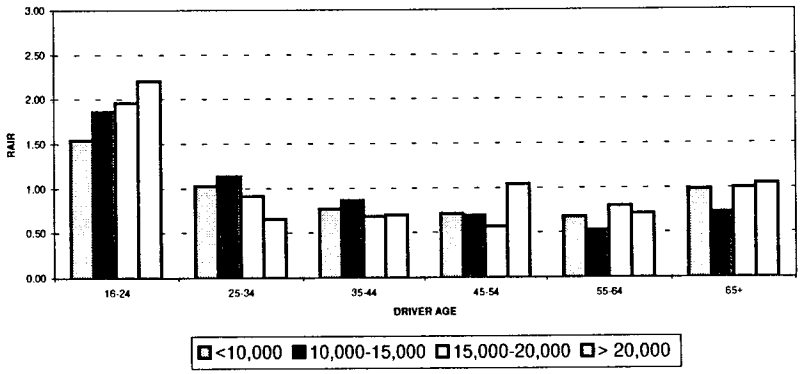
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



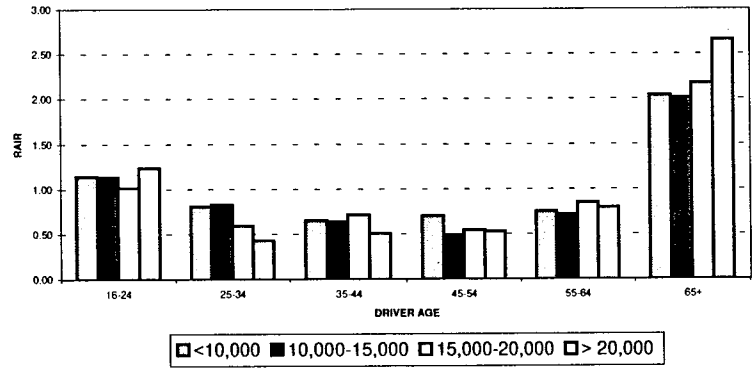
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



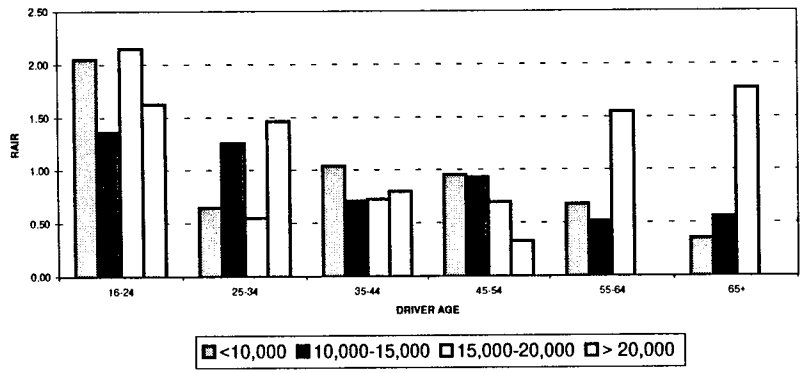
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



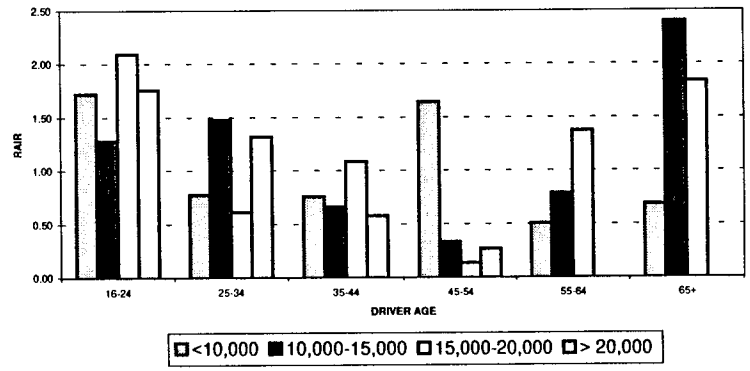
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in single vehicle accidents



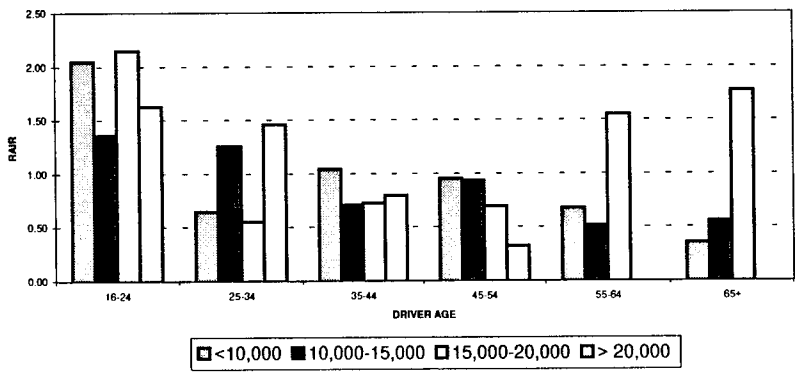
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



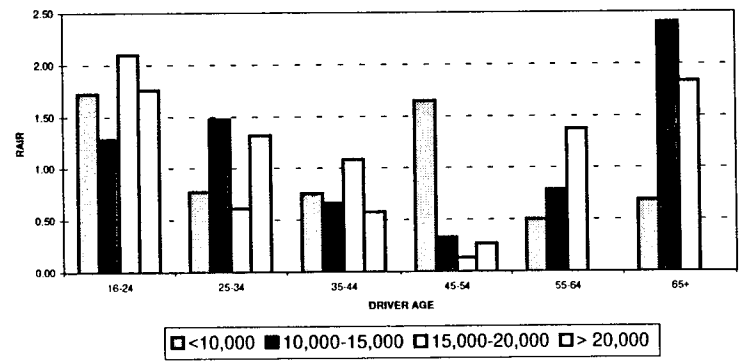
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault VAN vehicle and its iteraction in single vehicle accidents



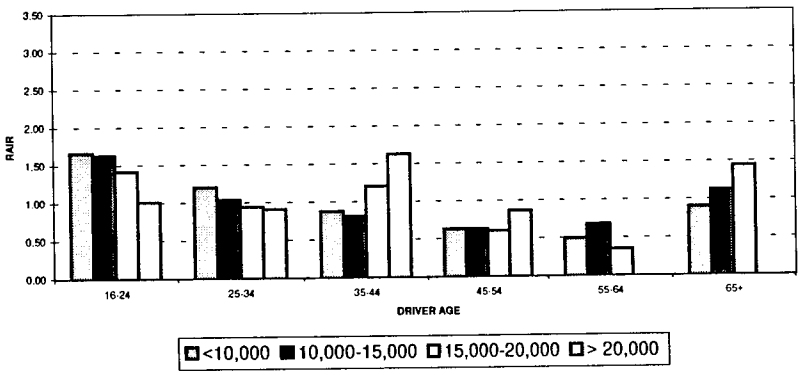
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault VAN vehicle and its iteraction in multiple vehicle accidents



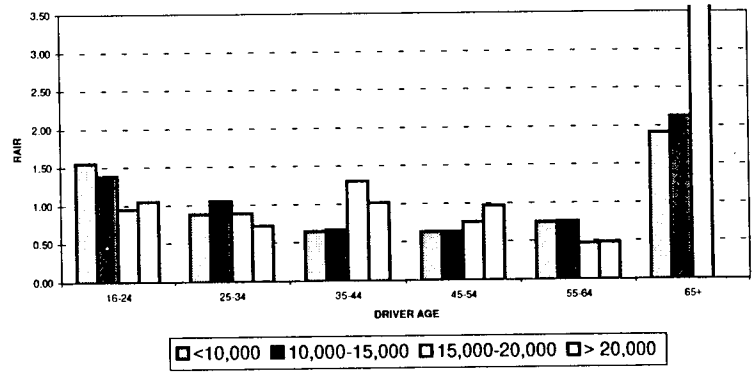
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



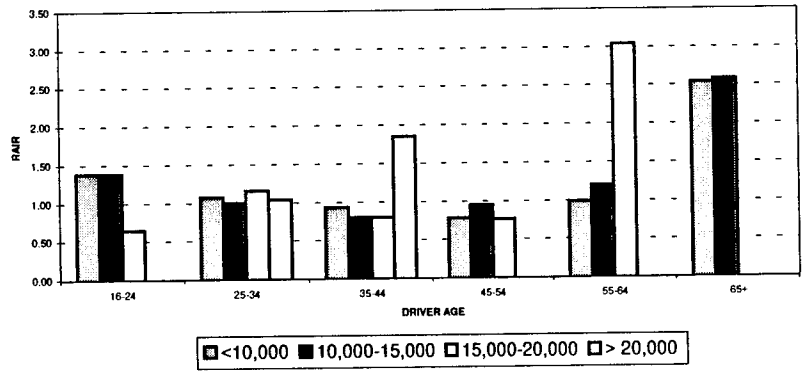
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



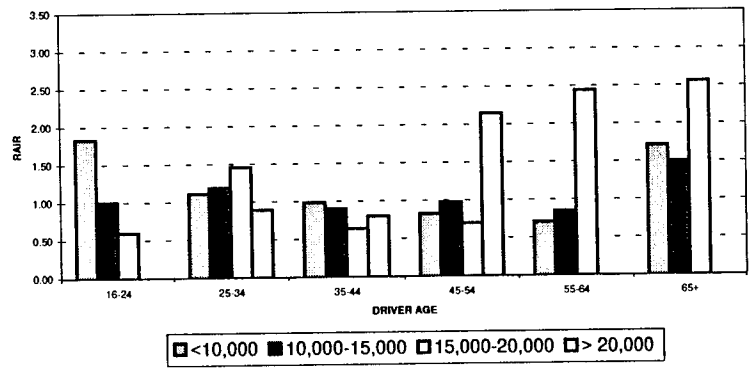
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in single vehicle accidents



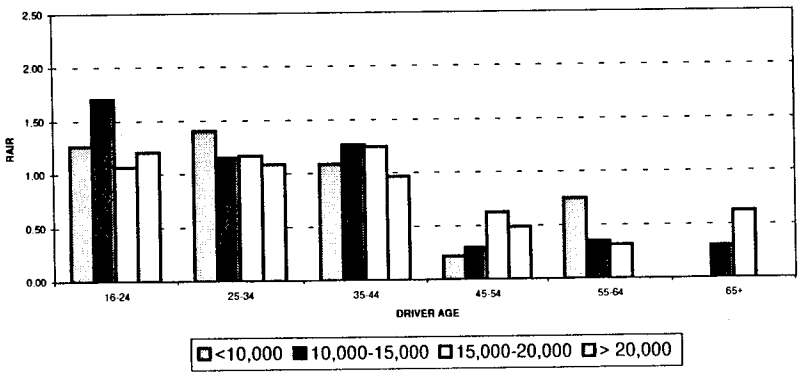
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in multiple vehicle accidents



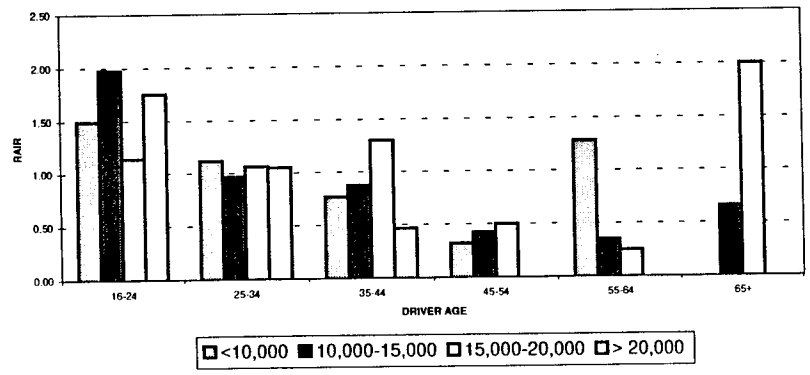
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Motorcycle vehicle and its iteraction in single vehicle accidents



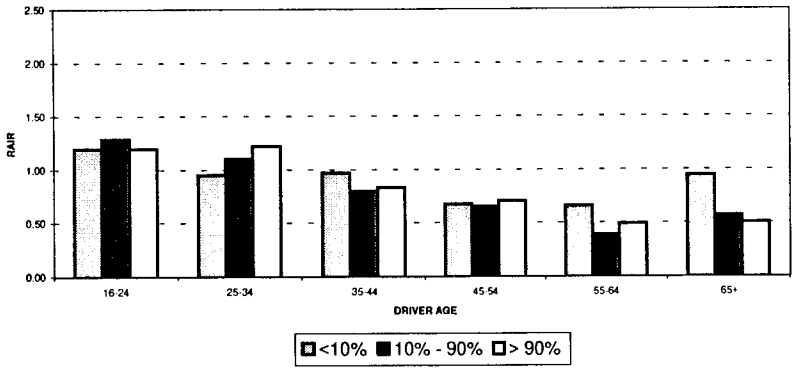
Accident exposure by Per capita income, vehicle type and driver age

Effect of at-fault Motorcycle vehicle and its iteraction in multiple vehicle accidents



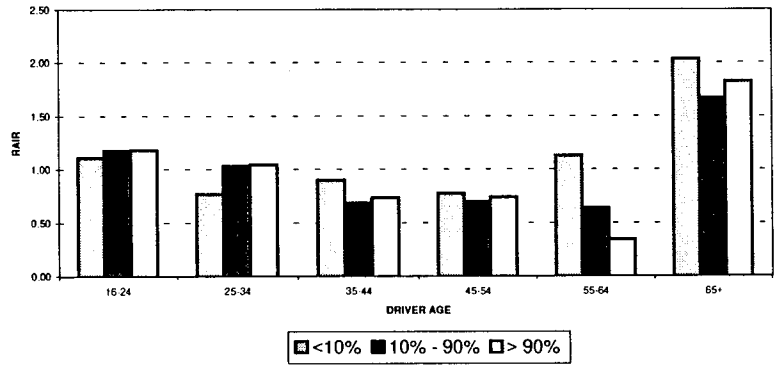
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



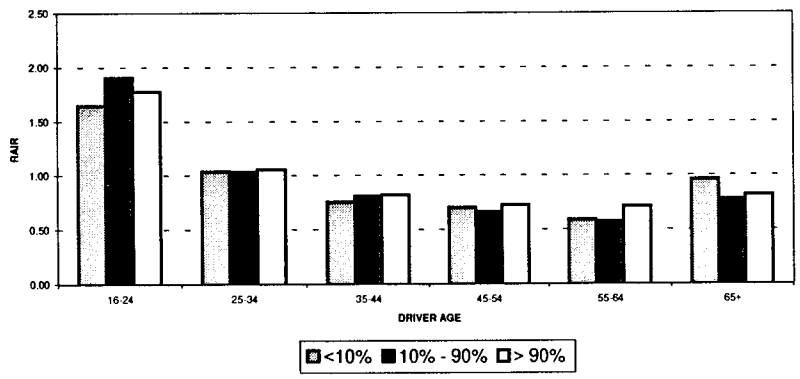
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



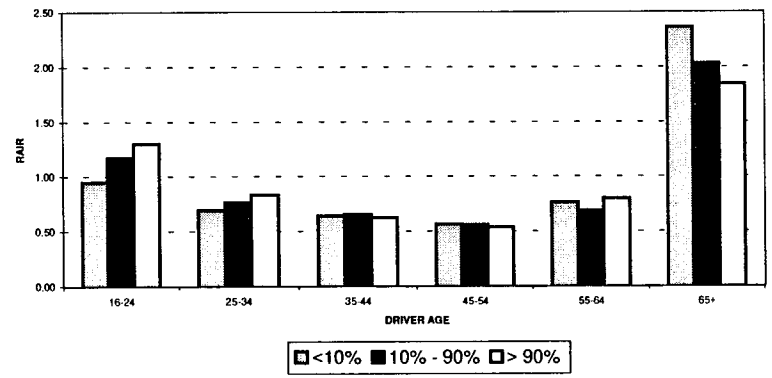
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



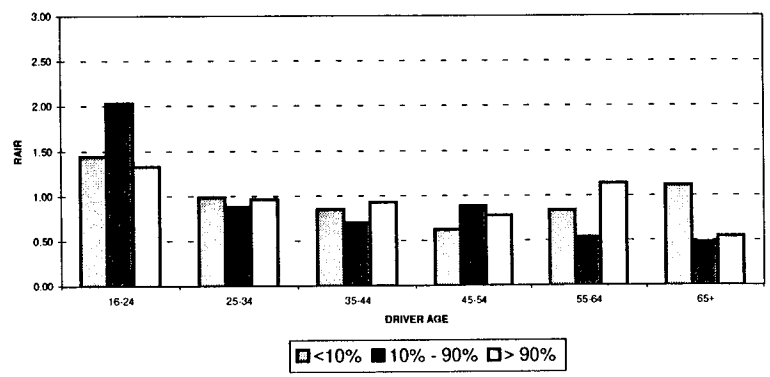
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



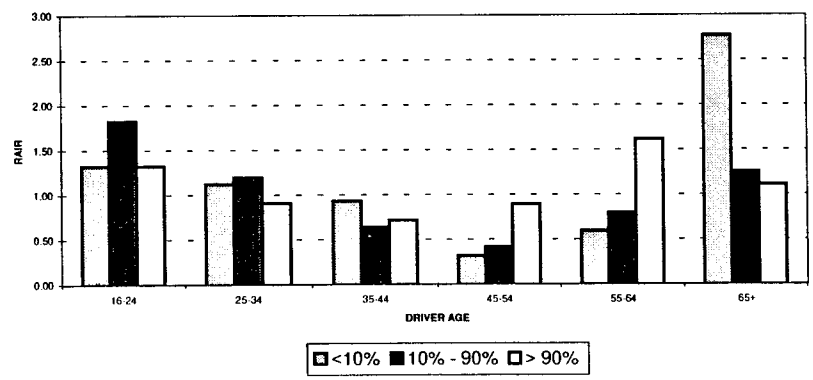
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in single vehicle accidents



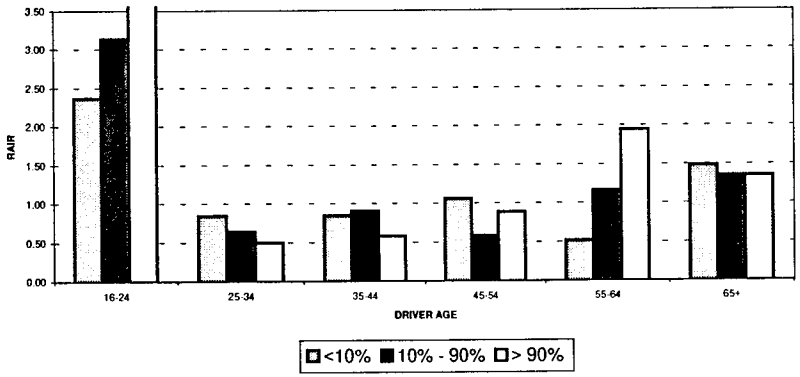
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



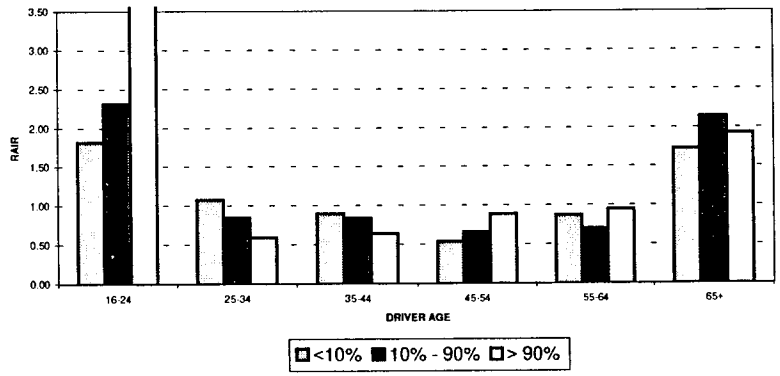
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in single vehicle accidents



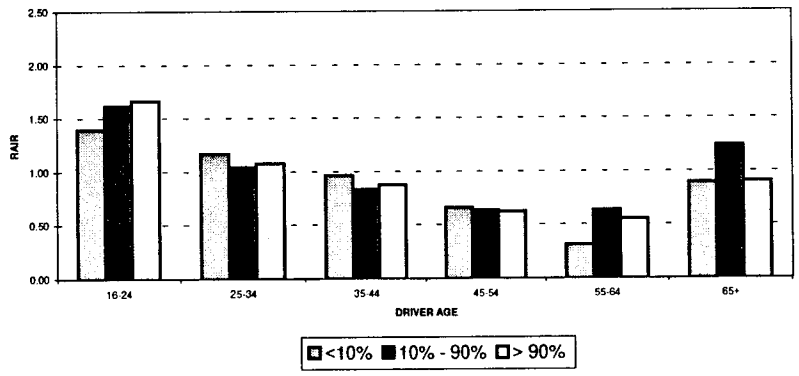
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in multiple vehicle accidents



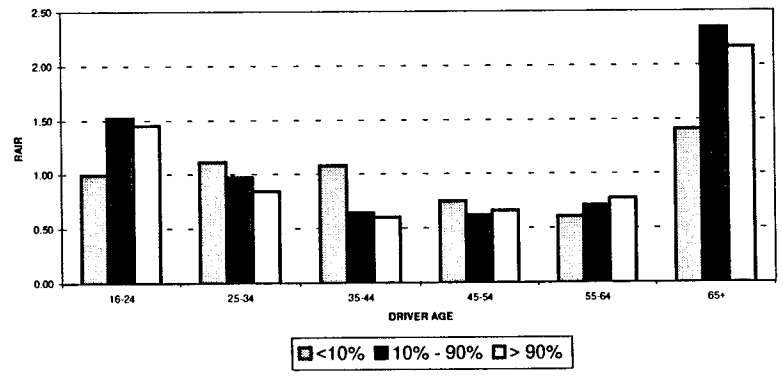
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



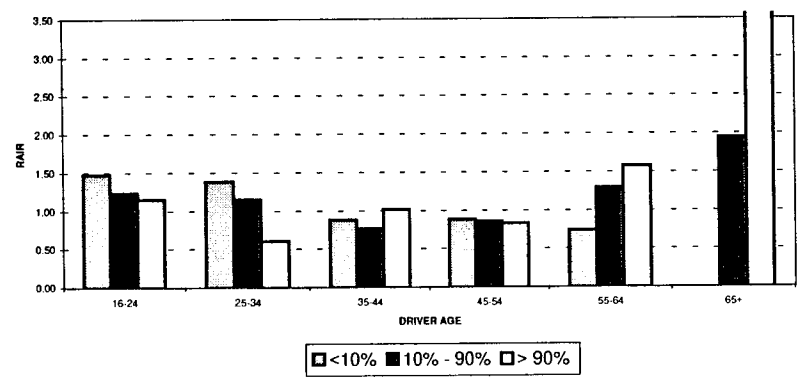
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



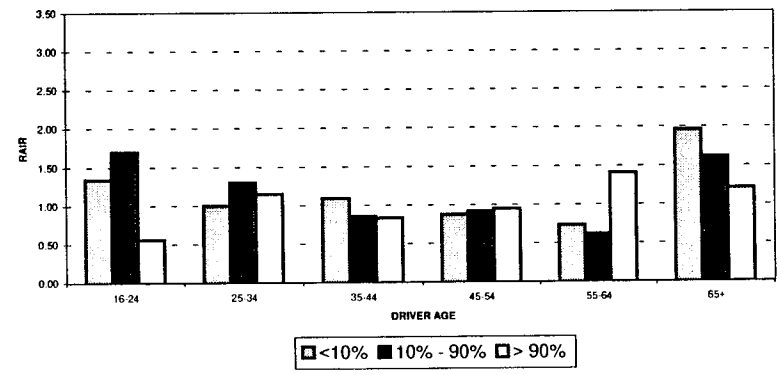
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in single vehicle accidents



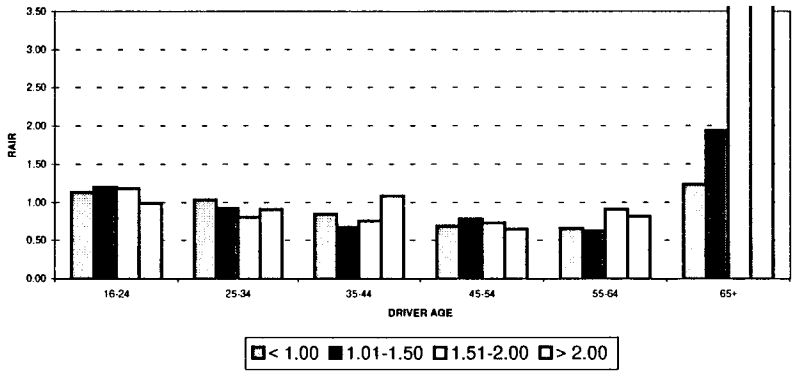
Accident exposure by Rural population, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in multiple vehicle accidents



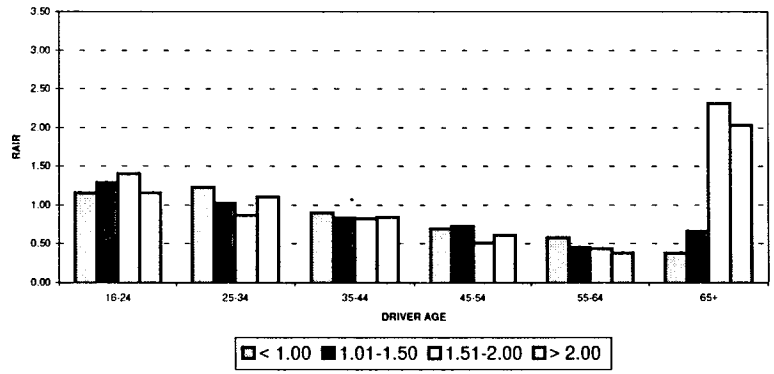
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



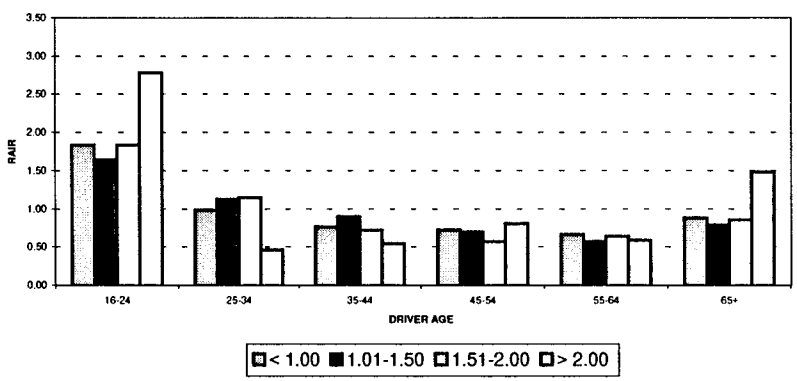
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



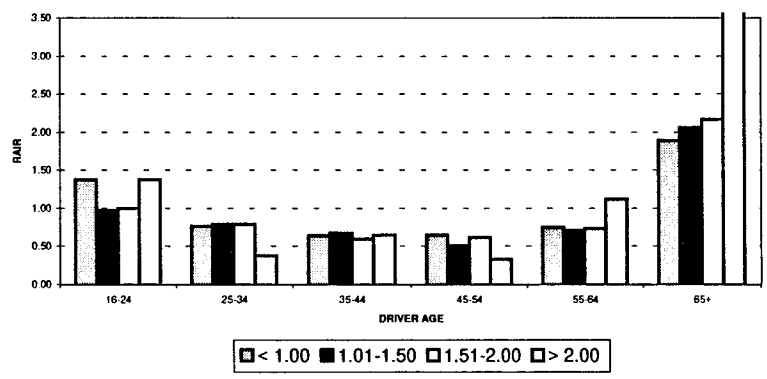
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



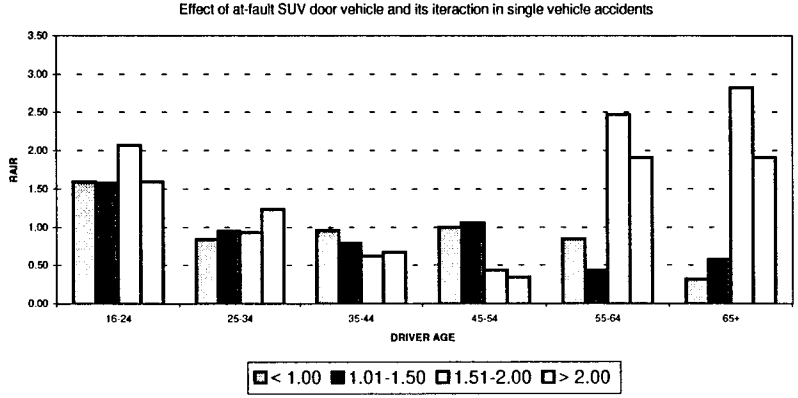
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



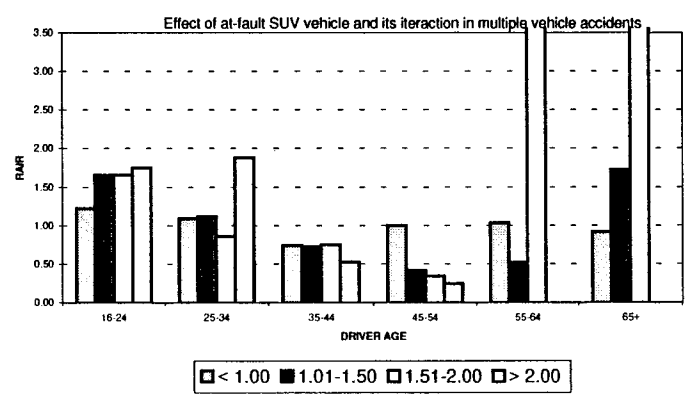
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault SUV door vehicle and its iteraction in single vehicle accidents



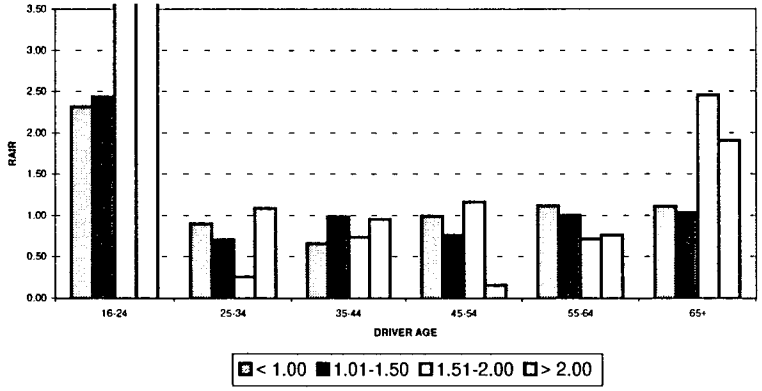
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



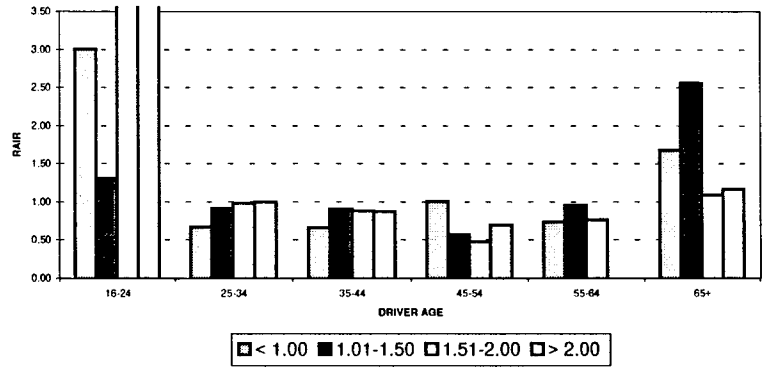
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in single vehicle accidents



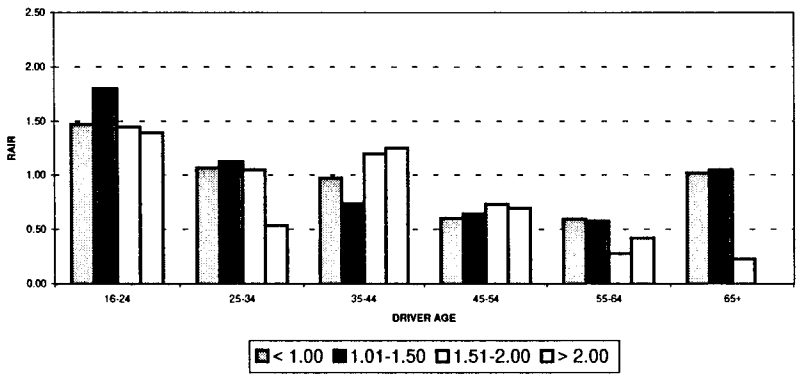
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in multiple vehicle accidents



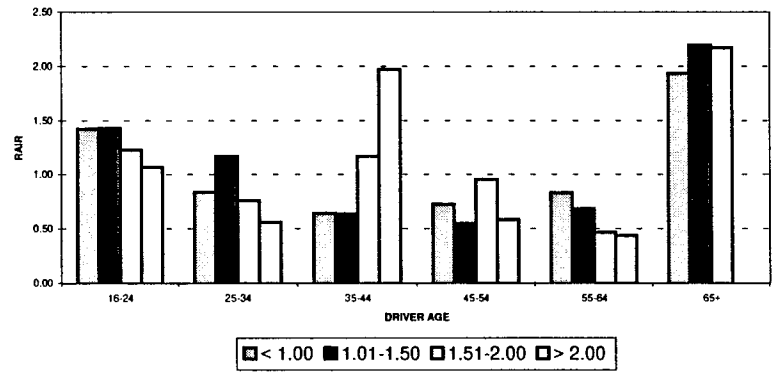
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



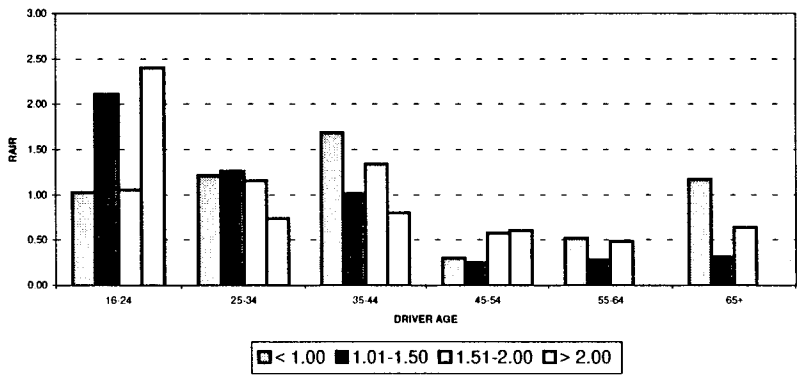
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



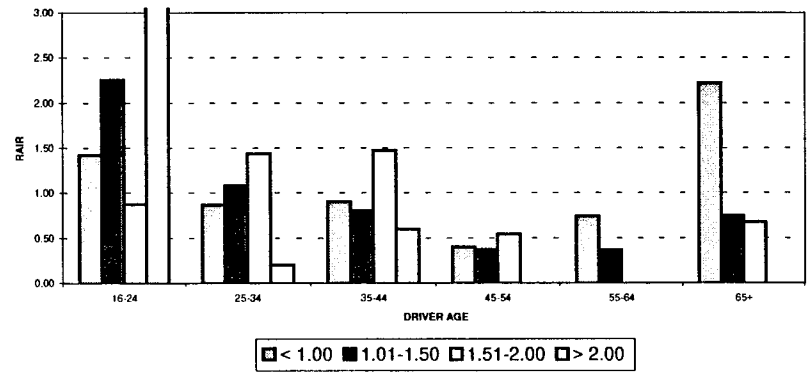
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Motorcycle door vehicle and its iteraction in single vehicle accidents



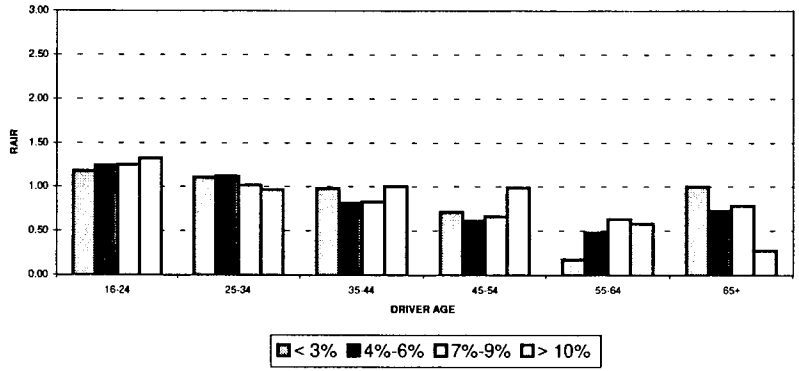
Accident exposure by Educational level, vehicle type and driver age

Effect of at-fault Motorcycle vehicle and its iteraction in multiple vehicle accidents



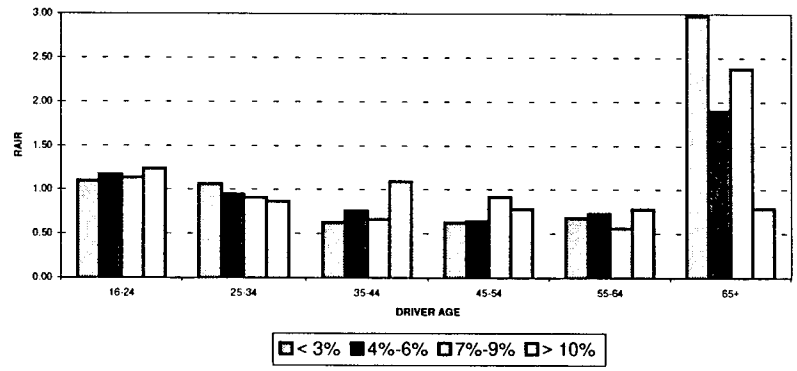
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



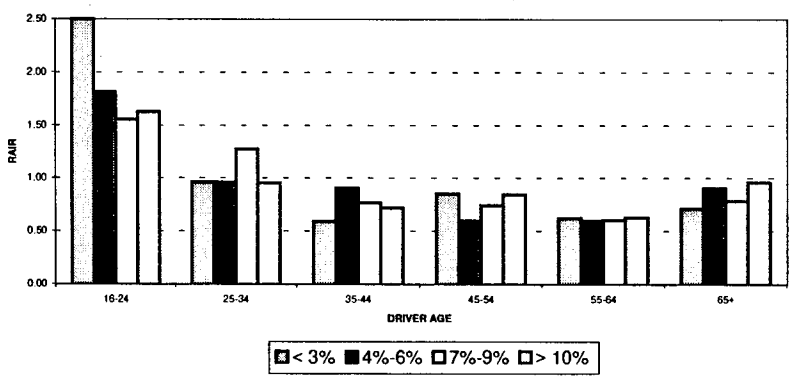
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



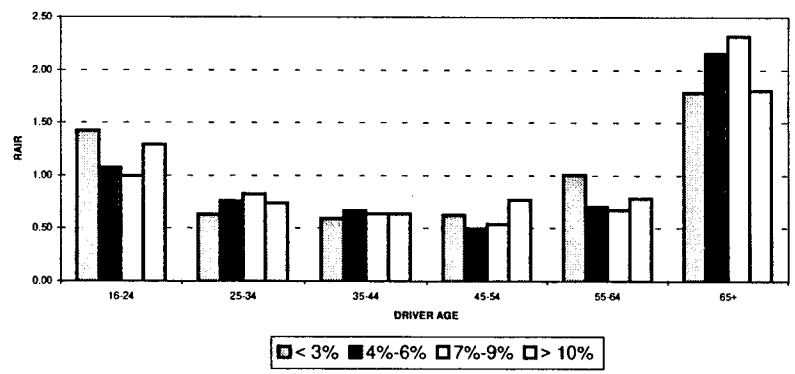
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



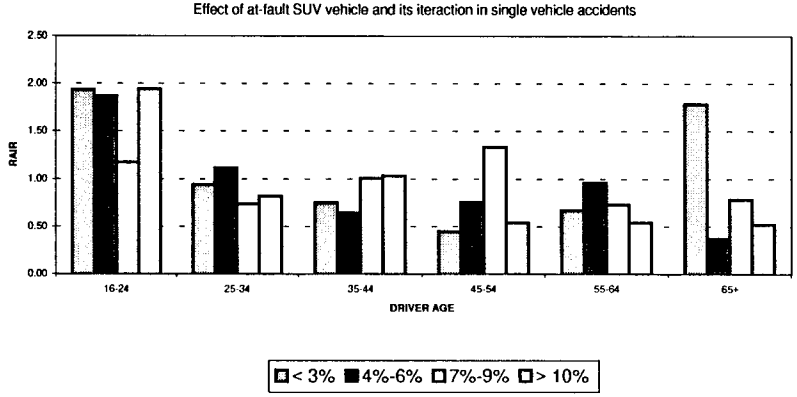
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



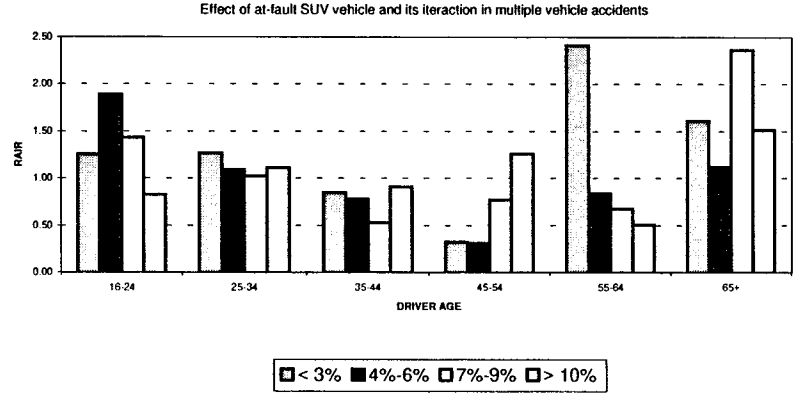
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in single vehicle accidents



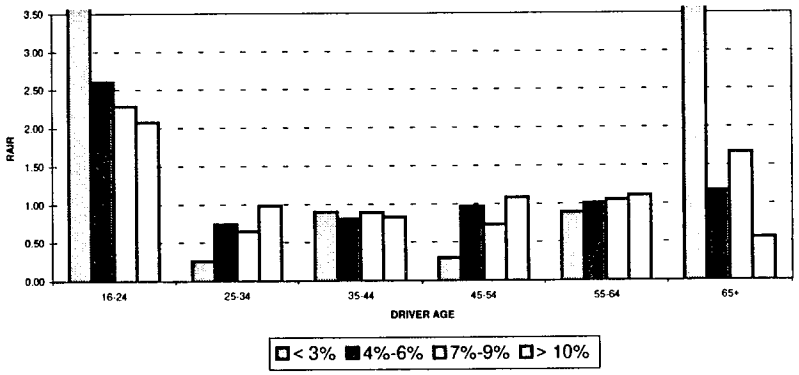
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



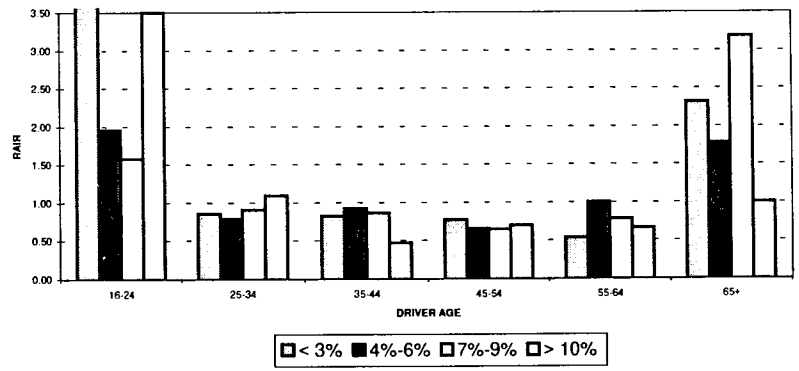
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in single vehicle accidents



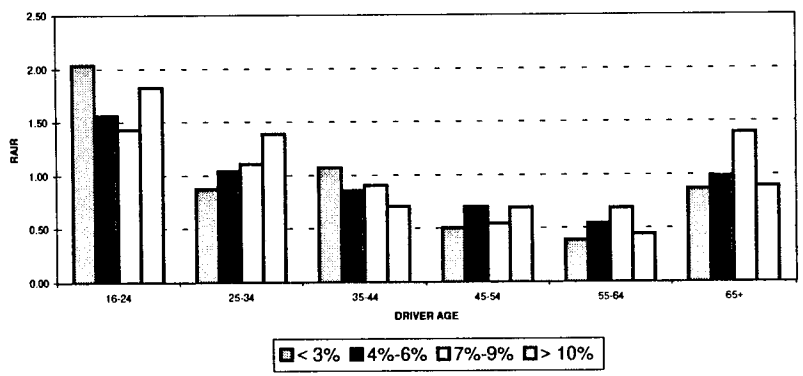
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in multiple vehicle accidents



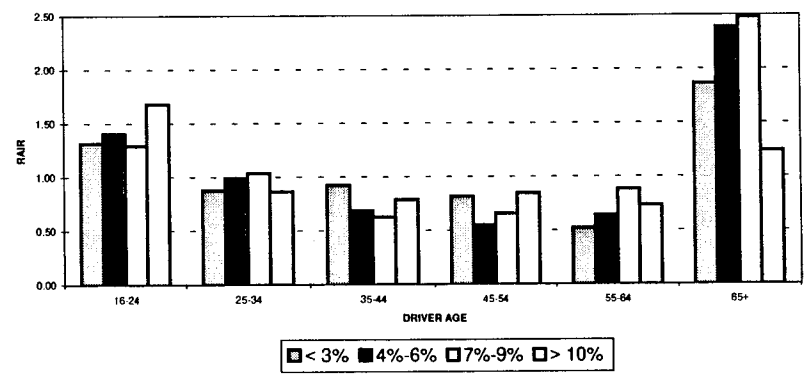
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



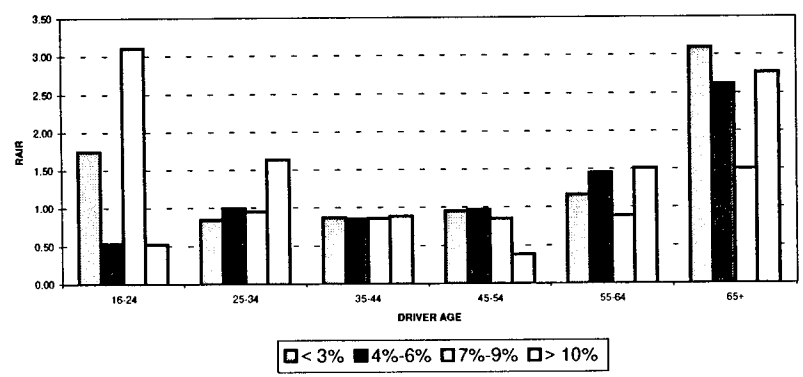
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



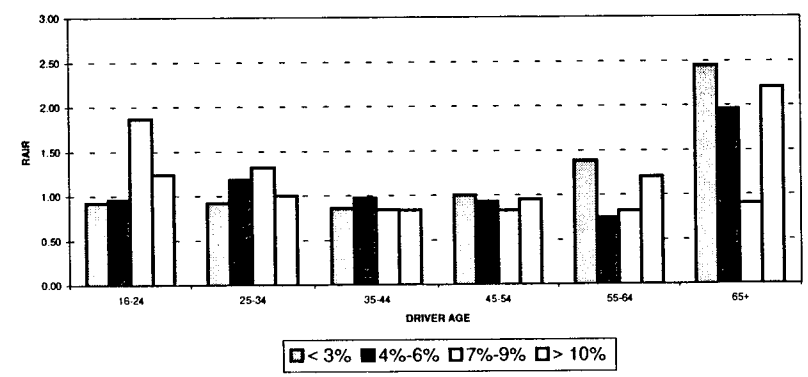
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in single vehicle accidents



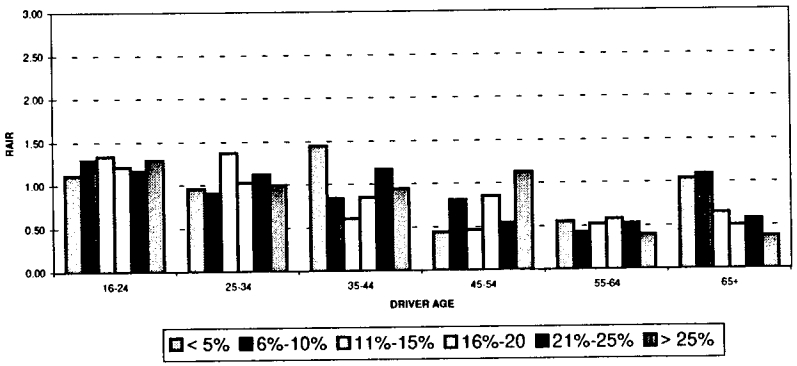
Accident exposure by Unemployment, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in multiple vehicle accidents



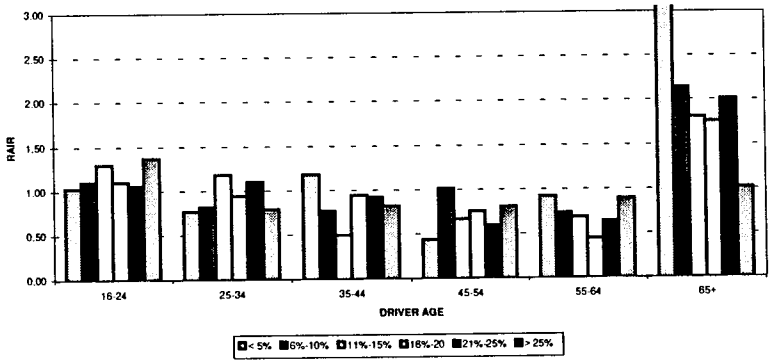
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in single vehicle accidents



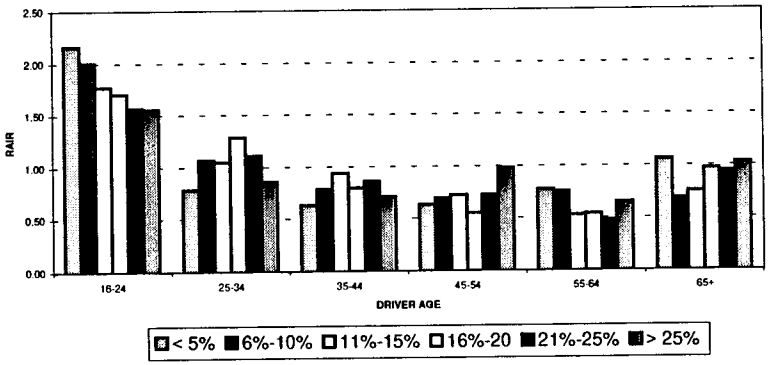
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault 2 door vehicle and its iteraction in multiple vehicle accidents



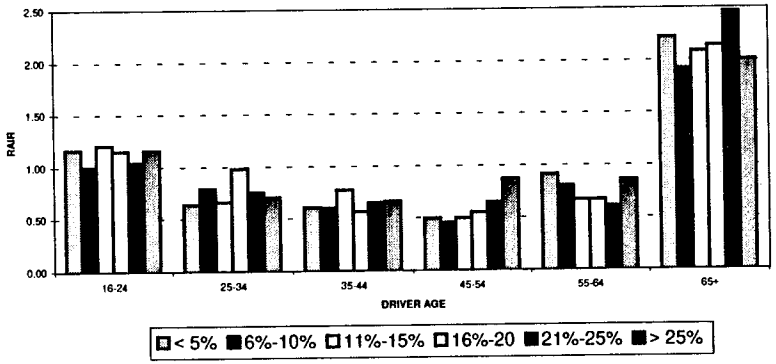
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in single vehicle accidents



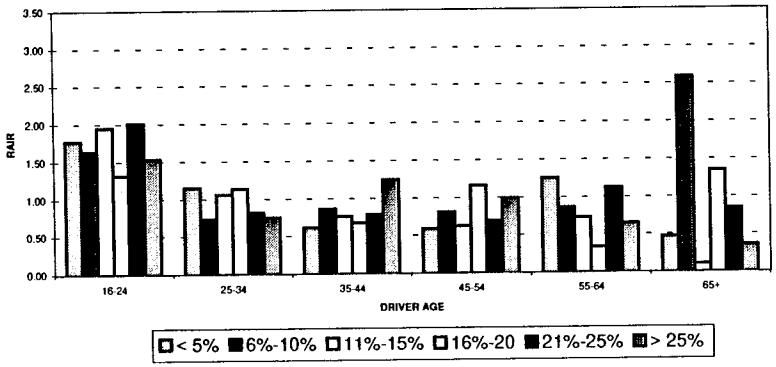
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault 4 door vehicle and its iteraction in multiple vehicle accidents



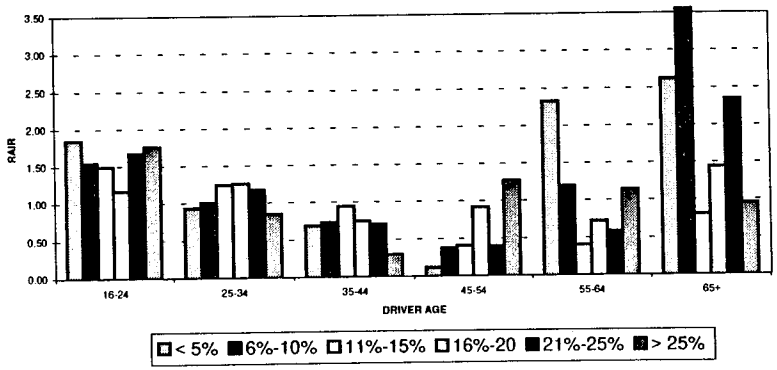
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in single vehicle accidents



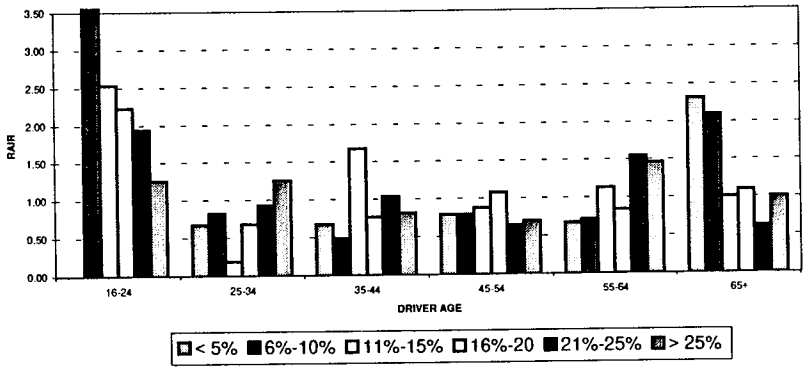
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault SUV vehicle and its iteraction in multiple vehicle accidents



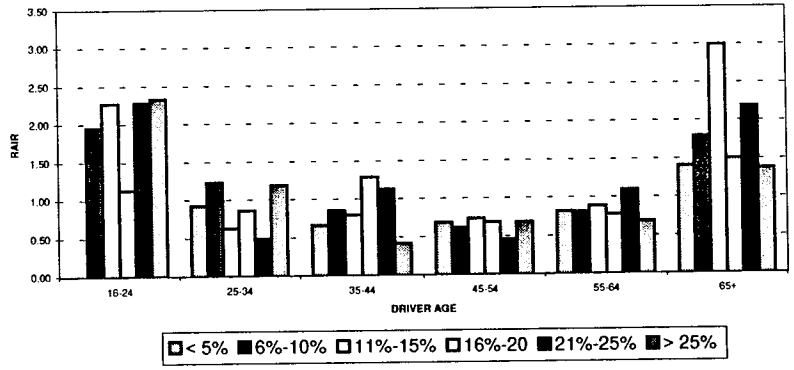
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in single vehicle accidents



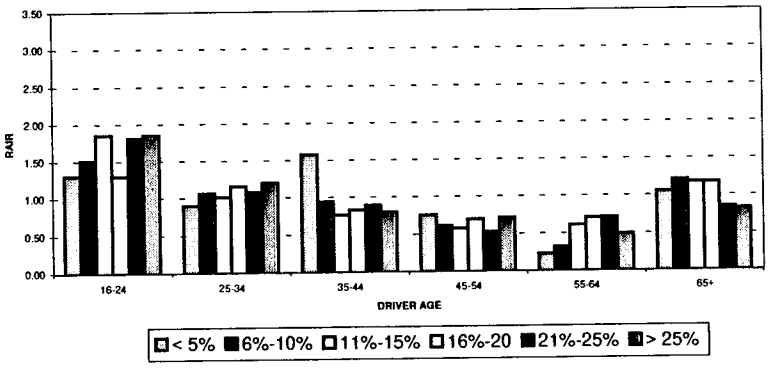
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Van vehicle and its iteraction in multiple vehicle accidents



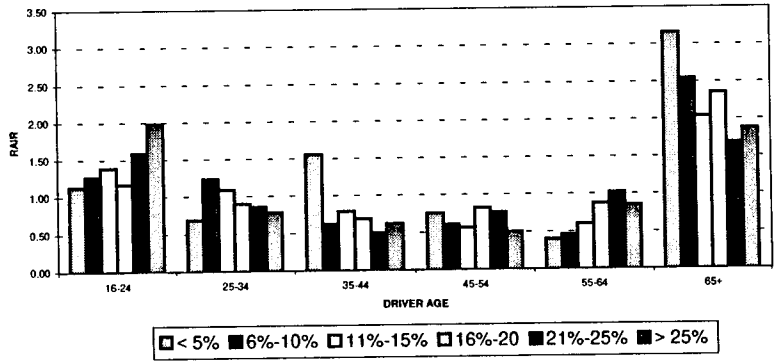
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in single vehicle accidents



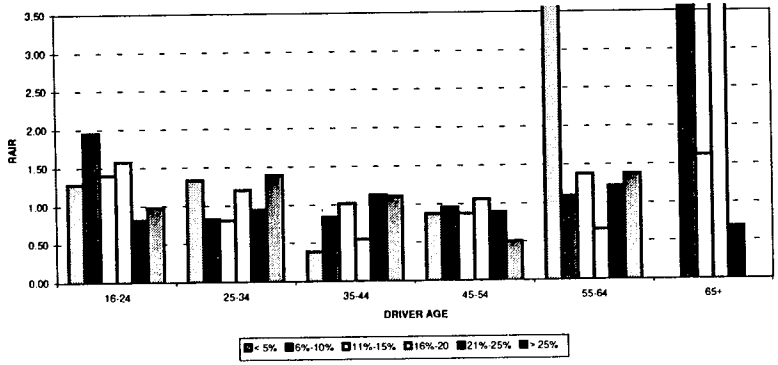
Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Pickup vehicle and its iteraction in multiple vehicle accidents



Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in single vehicle accidents



Accident exposure by Population below poverty, vehicle type and driver age

Effect of at-fault Truck vehicle and its iteraction in multiple vehicle accidents