EFFECTS OF DRIVER CHARACTERISTICS ON ACCIDENT INVOLVEMENT: A STUDY IN SAUDI ARABIA

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الخلاصة :

العوامل الإنسانية من المسببات الرئيسية لحوادث الطرق وبناء على ذلك فإن التفهم الواضح لعلاقة العوامل الإقتصادية — الإجتماعية وخصائص إتجاهات السائقين ، والمشاركة بالحوادث ضروريا .

إن الهدف الرئيسي من هذا البحث هو تقصي هذه العلاقة ووضع توصيات لتحسين سلامة القيادة . ولقد تم استقصاء المعلومات اللازمة بواسطة إجراء مسح ميداني على الطرقات بالمنطقة الشرقية من المملكة العربية السعودية حيث أجريت مقابلات على الطرق مع السائقين .

لقد إستخدمت بعض الطرق كلاحصائية مثل تحليل التباين وواسطة التباين ، تحليل التراجع ، تحليل التنسيق المتعدد لتقصي هذه العلاقة . ومن التحليل أمكن استنتاج ثلاثة عوامل مؤثرة وهي السن ، الوظيفة ، والدخل بينما بقيت العوامل الأخرى التي لا تؤثر عندما أدخلت العوامل السابقة الذكر بالمعادلة . وبناء على ذلك فالعوامل التي حددها التحليل يمكن التركيز عليها لعمل برامج لتحسين القيادة لهذه الفئة من الناس .

أما العوامل الخاصة بأوضاع السائقين فلقد وجد أنها لا ترتبط بصورة مباشرة بتفسير المشاركة بالحوادث . لأن هذه الدراسة تطرقت إلى هذه العوامل بصورة ضيقة فإنه لمن الضروري تقصي مثل هذه العوامل في دراسات أخرى مستقبلاً بصورة أكبر .

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ABSTRACT

Human factors are one of the major causes of highway accidents. Hence, a clear understanding of the relationships between socio-economic and attitudinal characteristics of drivers and accident involvement is essential.

The main goal of this research is to investigate this relationship and make recommendations for the improvement of driving safety. The relationships are investigated using a sample of roadside interviews carried out in the Eastern Province of Saudi Arabia.

Analysis of variance and covariance, multiple classification analysis, and regression analysis are used to analyze the relationships. The analysis using these techniques isolates three main variables as significant. These variables are age, occupation, and income. All other variables become insignificant when the effects of these variables are taken into account. The three significant variables are targetable, and driver improvement programs can be introduced for these specific targets.

Attitudinal variables are not found to contribute significantly to the explanation of accident involvement. However, it is too early to eliminate such variables from future studies because the study makes only a limited attempt to construct such variables. Further efforts are needed in the study of the effects of attitudinal variables.

EFFECTS OF DRIVER CHARACTERISTICS ON ACCIDENT INVOLVEMENT: A STUDY IN SAUDI ARABIA

1. INTRODUCTION

Traffic accidents can be attributed to human, vehicular, and environmental factors [1, 2]. When considered alone, human factors account for about 57% and together with the other factors (vehicular and environmental) about 92% of automobile accidents [1]. Therefore, it is very important that a clear understanding of the relationship between the socio-economic and attitudinal characteristics of drivers and accident involvement is obtained.

Although the relationship between accident involvement and various socio-economic characteristics has been investigated in other countries, this has not been done for the Kingdom of Saudi Arabia. Also, the results obtained for other countries may not be applicable to the Kingdom because of its unique nature. This uniqueness can be attributed to several factors.

First is the enormous growth in the number of registered vehicles. The number of registered vehicles was 144,768 in 1971; this figure reached 1,723,116 by the end of 1980 [2].

Second is the presence of expatriates from all over the world. These people come from different cultures with different habits, attitudes, and value systems. The wide differences in their backgrounds may create safety-related problems on the roads.

Third, the fast pace of motorization has not been paralleled by developments in driver education, law enforcement, and other safety related areas.

In this study, 758 drivers were interviewed. An analysis was made of the backgrounds of the drivers on Saudi Arabian Roads; attitudinal scales related to the driving environment were constructed; and the effects of various socio-economic and attitudinal characteristics on accident involvement were investigated.

2. GOALS AND OBJECTIVES

The main goal of the study was to examine the relationship between human characteristics (which are represented by some socio-economic characteristics and some attitudinal questions) and accident involvement, and through this understanding improve highway safety. The specific objectives are as follows:

(1) to examine the characteristics of the drivers in the selected pilot area;
(2) to construct attitudinal scales related to the driving environment;
(3) to determine the effects of various human characteristics on accident involvement;
(4) to make recommendations for the improvement of driving safety based upon the above findings;
(5) to make recommendations for further research.

3. BACKGROUND

Many researchers have looked into the relationships between socio-economic factors and accident involvement. Among these factors, age has been found to be one of the highest correlates of accident involvement [3, 4]. It has also been found that when kilometres driven are taken into account, both young and old drivers have poorer driving records than do middle-aged drivers.

Existing research indicates that accident involvement decreases as the driver's level of education increases [5, 6].

Significant correlations have been found between marital status and accident involvement [7, 8]. Single drivers, in general, have been found to be involved in more accidents than married ones.

Contradictory results have been derived for income. One study [9] found no relationship between income and accident involvement. However another study [10] reported that poor accident records and low income status are correlated.

It has been found that accidents are more frequent during the first three or four years of driving, regardless of age [11].

Forbes [4] and Harrington and Robin [7] reported that driver mileage is positively related to accident involvement. On the other hand, it has also been found that, when age is controlled, drivers with low annual mileage have higher accident rates per mile driven than those with higher annual mileage [11].

Drivers with formal driving training tend to have fewer accidents and convictions than those who learn to drive in other ways [11]. Another study, which surveyed American high school students [12], concluded that proper training would reduce the accident rate by half.

Harano and others [8] in summarizing the works of various authors and their own findings stated that age, marital status, mileage, traffic convictions, and education have been consistent predictors of accident involvement.

Many of the above studies analyzed the effects of the factors one by one. This may result in erroneous conclusions and may be one of the causes of the contradictory findings. To understand the true effects of one factor, the analysis should be done after the effects of other factors have been eliminated from the dependent variable. Only then is it possible to say confidently that the dependent variable is truly affected by that factor.

Several researchers have examined the relationships between psychological measures such as personality, attitudes, etc. and accident involvement or proxy variables for accident involvement such as traffic violations. For example, Loo [13] found significant correlations between the sensation-seeking personality dimension and traffic convictions. He also suggested that the use of primary personality dimensions such as impulsivity, sociability, and compliance may prove useful in studies of accident involvement. Mayer and Treat [14] were able to discriminate between a high-accident group, individuals in which were involved in three or more accidents, and a no-accident group using a lottery of personality scales.

An Eno Foundation study [12] has found differences between the attitudes of accident repeaters and accident-free drivers. The repeaters strongly agreed that driving is a competition, and that one can fix up anything in court if money is available.

Soliday [15] reports that individuals with no accidents or traffic violations for the last five years generally rated potentially dangerous driving situations as being more dangerous than those having had at least one accident during that time.

McMillan [16] studied the attitudes of drivers towards driving offenses. Young drivers rated driving offences as less serious than older drivers. Young drivers were also more inclined to take risks and drive in an aggressive manner.

Although these studies show some evidence that psychological variables would be useful in the prediction of accident involvement and possibly in the formulation of measures to correct driver behavior, most of the research findings in this area have not been conclusive. There are two main reasons for this. One is that previous investigations have lacked a theoretical basis for the measurement of this type of predictor. The other reason is that the measurement of these variables involves long and time-consuming efforts that force researchers to either reduce their sample size or simplify their measurement methods. Both of these actions could decrease the reliability and accuracy of the findings.

4. DATA COLLECTION

The data needed for this research were collected from roadside interviews carried out in Dammam and Al-Khobar (towns in a metropolitan area on the east coast of Saudi Arabia) in September through October 1981. Interview locations were randomly selected from a set of possible locations. A systematic sampling technique was employed for determining which drivers were to be interviewed, involving the selection of the driver of every n^{th} vehicle. This method randomizes the selection process, and assures an equal probability for each driver to be selected [17].

The questionnaire was designed in two parts. The first part consisted of personal information including age, nationality, education, occupation, driving experience, trip purpose, income, annual kilometers driven, familiarity with the region, number of accidents during the last two years and during the total driving life, and marital status. The second part of the questionnaire was designed to measure the attitudes of drivers towards road safety, road conditions, vehicle conditions, law enforcement, and drivers' education. This part contained 17 attitudinal statements. The responses to these statements were measured with a three point scale: agree, neutral, and disagree. These statements were about factors related to driving in the pilot area and are listed in Table 1. Because of the length of the questionnaire, approximately only half of the total sample was asked to complete the attitudinal questions.

The survey was carried out with the assistance of the police departments in the area, but the respondents were assured that the data were only collected for research purposes and would be kept strictly confidential. At the beginning of each interview, the purpose of

Table 1. Attitudinal Scales

Attitudinal item	Factor loadings in five factors				
	Regional safety	Official control	Law enforcement	Road conditions	Education
Driving in this area is safe	0.58	−0.01	−0.09	0.27	−0.24
Drivers in Saudi Arabia obey traffic rules in general	0.65	−0.03	−0.10	−0.05	−0.14
Traffic policemen are helpful in this area	0.65	−0.08	−0.05	−0.13	−0.02
Traffic signs and signals are well organized and maintained	0.68	−0.05	0.12	−0.13	0.03
Current drivers' licensing method is good	0.48	0.09	−0.09	0.13	0.16
Roads in this area are well organized and designed	0.55	−0.16	0.22	−0.35	0.12
Many accidents are caused mainly by poorly maintained vehicles	0.42	−0.10	−0.14	0.01	0.10
There should be more traffic control	−0.18	0.56	0.12	0.29	0.20
Vehicles are generally well maintained in this area	0.27	0.47	0.00	0.01	−0.30
Vehicles should be checked by a government agency	−0.09	0.76	0.01	−0.09	0.05
There are many speeding drivers in this area	−0.30	−0.21	0.54	0.01	0.30
Speeders should be penalized	0.08	0.10	0.72	−0.18	−0.20
There are many drivers without a driving license	−0.12	0.12	0.64	0.31	0.00
Roads need more and better maintenance	−0.21	0.13	0.12	0.55	−0.13
There are too many unnecessary traffic signs and signals	0.15	−0.11	−0.04	0.72	0.16
There should be special driving education before licenses are issued	0.07	0.35	0.06	−0.10	0.69
Persons below 18 years of age should not be allowed to drive	−0.04	0.10	0.08	−0.07	0.58

Note. Figures underlined indicate the group of attitudinal items forming the factor in each of the five factor columns.

the interview was explained to the respondent and he was assured that his answers would be kept confidential and that his name would not be recorded. The confidentiality was further assured before the interviewer asked such critical questions as number of accidents, driver's license availability, income, etc. These critical questions were asked towards the end of the interview, so that by the time the questions were asked a relaxed atmosphere had been created. It is felt these efforts eliminated most of the bias from the answers.

Cross-checking of the accidents reported with other statistics was not possible for the reasons given in **4.1** and **4.2** as follows.

4.1 During the research team's meeting with police officials, it was given to understand that accident reporting was incomplete. Police reports are prepared for two categories of accident. The first category involves fatalities and injuries, if and only if a liability issue is involved. For instance, if an accident involves one overturned vehicle resulting in the death of the driver, this would not be recorded in the first category because there is no liability at issue. The second category involves a few cases of property-damage-only type accidents where the dispute has not been resolved between the parties involved at the accident site. The available statistics that are published yearly by the Ministry of the Interior are a summary of the accidents in these two categories. Therefore, comparison of these statistics with the data collected for this research would have been meaningless. In fact, the main reason for collecting data was the incompleteness of existing data files.

4.2 Checking the accidents reported from the driver's files was not possible, firstly because, currently, driver's files do not contain accident histories. Secondly, even if driver's records with accident histories were available, checking the records would have required asking the respondent's name, drivers license number, etc. which would have jeopardized the claim of confidentiality made by the study team.

The high average numbers of accidents reported by all categories of respondent led the study team to believe that bias had been mostly eliminated. The relative ease of reporting non-availability of the driver's license during the interviews, which was cross-checked by asking the driver to show the license, is supportive of this belief. In short, every possible effort was made to remove bias from the answers and there are indications that this was achieved to a great extent.

The survey resulted in 758 questionnaires of which 372 contained attitudinal questions. After the elimination of cases containing missing values, sample sizes of 623 and 335, respectively, were obtained.

Table 2. Comparison of Some Characteristics of the Population as given by a 1978 Survey and by the Present Work

Variable	Percentage of population in	
	1978 survey*	Present sample (1981)
Nationality		
Saudis	55	63
Other Arabs	21	19
Asians	11	11
Others	13	7
Age		
15–34	66	80
35–64	34	23
Marital status		
Single	47	49
Married	53	51

*Taken from home interviews carried out by CH2M Hill International.

The sample characteristics were compared with information from a survey carried out in 1978 and found to be representative of the area without much deviation from the survey characteristics, as seen in Table 2. The highlights of the sample are given below.

The mean age of drivers was 27.9 years. Approximately 12% of drivers were less than or equal to 18 years old. Saudi drivers accounted for 63.5% of all drivers. The remaining 36.5% were drivers from 30 different countries. 35% of all drivers had been involved in at least one accident during the previous two years. 52% of all drivers had been involved in at least one accident during their driving life. Only 8% of all drivers reported that they did not own a car. 48% of all drivers were not married. 30% reported that their earnings were greater than SR 6,000 per month (US $1 = SR 3.42 in October 1981) and 11% reported that they did not earn income. All except one in this group were students. 15.6% did not have a driving license.

5. ATTITUDINAL SCALE CONSTRUCTION

Scale construction is a tedious job and should be done very carefully. This study only attempted to explore some hypothetical concepts and therefore can be taken as a first step in building reliable scales.

Scale development involves writing attitudinal items related to certain hypothetical concepts, and testing these concepts with factor analysis. Factor analysis combines items that are most closely correlated to each other and these groups of items form the factors. More information about factor analysis can be found elsewhere [18].

Common factor analysis without iterations and varimax rotation was used for two through six dimensions. The five factor solution was selected as the best because after this stage single item scales with low loadings started emerging and eigenvalues dropped below one; before this stage the factors were crowded with logically unrelated concepts. These five factors were named after the items that had high loadings and are presented in Table 1. The scores for these five factors were calculated and stored for data analysis.

6. ANALYSIS

Analysis of the data and tests of various hypotheses were carried out using three techniques: analysis of variance (ANOVA), multiple classification analysis, and regression analysis. The theoretical treatments of these techniques can be found in any statistics book dealing with multivariate analysis [19].

ANOVA is used to test the effects of a categorical variable on a dependent variable that is a continuous (metric) variable. The null hypothesis when there is one categorical variable (which is called one-way ANOVA) is that there is no difference between the means of any category of the independent variable and the grand mean. If one is interested in the simultaneous effects of n categorical variables, the analysis is referred to as n-way ANOVA. If one is interested in analyzing the effects of both nonmetric and metric independent variables, the analysis is referred to as an analysis of covariance. In this latter analysis the metric independent variable is referred to as a covariate. The statistical test of the null hypothesis is done using an F-test.

Although ANOVA provides the statistics necessary for testing the hypothesis, it does not provide information about the means of the categories of the categorical variable. Also, given two or more interrelated categorical variables, one may be interested to know the net effect of each variable when the effects of other factors are controlled. Multiple Classification Analysis (MCA) is used for these purposes. For all these analyses, the Statistical Package for the Social Sciences [20] has been employed.

The selection of the dependent variable was made as follows. First to be considered was 'total number of accidents per driver', without accounting for the years of driving experience. If this variable were to be used

as the dependent variable, two persons, each of whom had been involved in only one accident, would be treated the same regardless of their driving life (one month, 10 years, etc.). Therefore, this measure is not a good one because it does not compare drivers on equal grounds. Second to be considered was 'accident involvement during the last two years' (included as an item on the original questionnaire). This still has the same problem because it can compare drivers with less than two years experience with much more experienced drivers on an equal basis. Finally, the 'accident involvement rate', expressed as the total number of accidents per year of driving experience, was chosen as the best dependent variable. In spite of this, some analyses were carried out (but not reported due to space considerations) using each of the other above measures of accident involvement. As expected, the 'accident involvement rate' variable led to the most logical and significant relationships.

As a first test of the effects of single variables, one-way ANOVAs were performed using various categorical variables. The results of these one-way ANOVAs are given in Table 3, with and without covariates. Although some other covariates, 'distance driven' and 'number of cars in the family', were used, 'age' and 'familiarity with the area' (defined as the number of years lived in the area) were the only significant ones.

As can be seen in Table 3, when the covariates are not used all the independent variables have significant effects. But when covariates are introduced (column two) only 'occupation', 'marital status', and 'income' have significant effects. This is an important finding in terms of refuting various misconceptions. For instance, there is a common misconception that foreign workers are poor drivers and cause more accidents than Saudi drivers. If there are differences among the nationalities, this analysis shows that it is not because of the differences in their cultural backgrounds but simply because of their age structures and familiarity with the area. Table 3 gives a MCA table for 'nationality' as well as for those variables that have significant effects after the covariables are introduced. If the effects of 'age' and 'familiarity' are not considered, Saudi drivers appear to cause more accidents than non-Saudis. However, this is a very unfair comparison because the Saudi driver population contains many more young drivers compared with other nationalities. When the effects of 'age' and 'familiarity' are taken into account, there remain no significant differences among the nationalities—as can be seen from the deviations from the grand mean adjusted for covariates in Table 4.

Table 3. One-Way ANOVA Results (With and Without Covariates)

Variable	F-values (significance) for main effects	
	Without covariates	With covariates 'age' and 'familiarity'
Education	7.87 (0.00)	2.15 (0.07)
Occupation	28.07 (0.00)	9.84 (0.00)
Nationality	7.13 (0.00)	0.56 (0.64)
Driving school	4.84 (0.00)	0.25 (0.86)
Marital status	28.87 (0.00)	3.64 (0.03)
Ownership	2.82 (0.02)	0.63 (0.64)
Number of family cars	11.89 (0.00)	2.23 (0.08)
Income	18.49 (0.00)	6.03 (0.00)
Driver's license availability	3.08 (0.05)	2.77 (0.06)

*Covariates 'age' and 'familiarity' are significant at the 0.000 level.

Table 4 shows that when the covariates are introduced the categorical means come closer to the grand mean. Among the occupation categories, students caused the most accidents, followed by office workers, technical workers, and the category that consists of retired persons, army/police officers, and professional drivers.

'Marital status' also gave the expected result: the unmarried group caused the most accidents. The two married categories had almost the same deviations from the mean after the effects of 'age' and 'familiarity' had been taken into account. This shows that married people with children are not safer drivers than those married without children. It is just that the first group contains older people.

'Income' had an effect consistent with the a priori hypothesis: as his income increases, a driver becomes safer. It should be noted that there was just one driver who was not a student in the *not-earning* category. Therefore, the deviations from the mean of this category are the same as the *student* category in the 'occupation' variable.

The above one-way ANOVAs with covariates are still not sufficient for investigating the pure effects. For instance 'occupation' and 'income' variables may be interrelated. Therefore, to test the pure effects of these three variables, i.e. 'occupation', 'marital status', and 'income', two-way ANOVAs with covariates were run with all possible combinations. These are shown in Table 5. Two-way ANOVAs were also carried out with the factors that were found to be significant at the 0.5 to 0.10 level in one-way ANOVAs. But these

Table 4. Multiple Classification Analysis for One-Way ANOVAs

Variable	Category	Deviations from mean accident rate	
		Unadjusted for covariates	Adjusted for covariates
Occupation	Salesman/Buyer, Teacher/Professor, Professional/ Technician/Manager, Craftsman/Mechanic	−0.10	−0.07
	Clerk/Secretary/Office Worker	0.07	0.11
	Student	0.49	0.30
	Retired, Army/Police Officer, Professional Driver	−0.38	−0.26
Marital Status	Unmarried	0.23	0.10
	Married without children	−0.09	−0.07
	Married with children	−0.24	−0.09
Income	Not-earning (all except 1 are students)	0.52	0.29
	Less than SR3,000 per month	0.05	0.06
	Between SR3,000 and SR6,000 per month	−0.07	−0.06
	More than SR6,000 per month	−0.27	−0.17
Nationality*	Saudi	0.10	0.03
	Other Arab	−0.19	−0.08
	Asian and Far Eastern	−0.18	−0.02
	European and American	−0.33	−0.03

*Differences between nationalities become insignificant when covariates are introduced.

Table 5. Two-Way ANOVAs with Covariate Age

Variable	Sources of variation	F-values (significance)
Occupation and marital status	Main effects	
	Occupation	8.32 (0.00)
	Marital Status	1.45 (0.24)
	Two-way interactions	1.84 (0.09)
Occupation and income	Main effects	
	Occupation	7.79 (0.00)
	Income	5.14 (0.00)
	Two-way interactions	0.44 (0.85)
Marital status and income	Main effects	
	Marital Status	2.01 (0.14)
	Income	4.95 (0.00)
	Two-way interactions	1.08 (0.37)

factors remained insignificant at even lower levels and are not reported.

All the interactive effects were insignificant. Significant interaction implies that the effect of one variable is not uniform across different categories of another variable. If this is the case, then there is no compelling reason to test the significance of each main effect separately. Because this was not the case, the main effects were investigated separately.

In the two-way ANOVA between 'occupation' and 'marital status', the 'marital status' variable ceased to have significant main effects. This means that the effect is mainly explained by 'occupation'.

The two-way ANOVA between 'occupation' and 'income' resulted in significant main effects in both variables. However 'familiarity' became insignificant with a significance level of only 0.16.

In the analysis between 'marital status' and 'income', 'marital status' did not have significant main effects. This means that its effect is mainly explained by 'occupation'.

This analysis eliminated the 'marital status' variable, as its effects ceased to remain significant when either of the other two variables was introduced. Also eliminated was the covariate 'familiarity', as it became insignificant in the two-way ANOVA between 'occupation' and 'income'. This last finding was also supported by the regression analysis reported below.

To obtain specific information about the pattern of effects, the MCA table (Table 6) was prepared. It should be noted that the first income category (*not-earning*) was deleted because it is the same as the student category in the 'occupation' variable. In general, the pattern of accident involvement rates remained the same after the effects of the other independent variables and covariables had been taken into account. Two useful statistics, η and β, are also given here. η^2 for each factor indicates the proportion of variation in Y (the dependent variable) explained by each factor. β^2 indicates the same thing, but after first controlling for the other factors and covariates. In this

Table 6. Multiple Classification Analysis for Occupation and Income with Covariate Age

Independent variable	Category	Deviations from mean accident rate	
		Unadjusted	Adjusted for independent variables and covariate age
Occupation	Salesman/Buyer, Teacher/Professor, Professional/ Technician/Manager, Craftsman/Mechanic	−0.03	−0.00
	Clerk/Secretary/Office Worker	0.08	0.11
	Student	0.55	0.30
	Retired, Army/Police Officer, Professional Driver	−0.31	−0.29
		$\eta=0.27$	$\beta=0.19$
*Income	Less than SR3,000 per month	0.12	0.11
	Between SR3,000 and SR6,000 per month	−0.00	−0.01
	More than SR6,000 per month	−0.21	−0.17
		$\eta=0.16$	$\beta=0.14$

*The 'income' category *not-earning* was eliminated because all but one were students.

case, 'occupation' accounts for 7.3% ($0.27^2 \times 100$) unadjusted and 3.6% ($0.19^2 \times 100$) of the total variance when adjusted for the other variables. Similarly 'income' accounts for 2.6% and 2.0% of the total variance, respectively. The resulting R^2 from this analysis (the percentage of the variance explained by all the independent variables and covariates) was 0.13.

One final analysis was done to test the contribution, if any, of the attitudinal scales developed above to explain the variance in the dependent variable. This was done using regression analysis, a technique that expresses one dependent variable as a linear combination of some independent variables. Associated test statistics can be used in testing the contributions of single variables or a group of variables.

Because the attitudinal questions were only asked of approximately half of the total sample, it should be noted that the sample size used for regression analysis (335) is approximately half of the sample size (623) that was used in ANOVA.

Although various model specifications were tested, only the final two models containing socio-economic variables and socio-economic plus attitudinal variables are presented in Table 7. Socio-economic variables were introduced as dummy variables (taking the value 1 for that category, zero otherwise). 'Age' and dummy variables from the 'occupation' and 'income' categories remained as significant variables and were able to explain 10% of the total variance. The addition of attitudinal variables (factor scores) did not add significantly to the variance (as tested by a partial F-test). The Law Enforcement Factor, which is only significant at the 10% level, had the expected sign. (Note that the scale was built using 1 ≡ agree, 2 ≡ neutral, and 3 ≡ disagree.) In other words, drivers disagreeing with Law Enforcement tended to have more accidents. That 'familiarity' did not remain significant may be because of the decreased sample size. All other variables had the expected signs.

Table 7. Regression Analysis for Socio-economics and Attitudes

Variable	Coefficient estimates (t-values)	
	Socio-economics	Socio-economics and attitudes
Constant	1.629	1.645
Age	−0.023 (4.34)	−0.023 (4.24)
Dummy variable for occupation category 2	0.293 (2.36)	0.284 (2.18)
Dummy variable for high income category	−0.293 (2.29)	−0.283 (2.11)
Law Enforcement Factor	—	0.091 (1.87)
R^2	0.10	0.11
Overall F	13.77	10.26

7. CONCLUSIONS AND RECOMMENDATIONS

The major findings of this research can be outlined as detailed in **7.1** to **7.5** as follows.

7.1 The socio-economic factors found to be related to the accident involvement rate are 'age', 'occupation', and 'income'. All other variables that are significant in the simplistic one-way analysis become insignificant

once these variables are introduced. Also, each of these variables has the expected pattern of relationships with the accident involvement rate.

7.2 Although the percentage of the total variance explained by these variables is small (13%), this is expected because individual responses are used in the analysis. R^2 computed from individual data is often substantially lower than R^2 for the aggregate data, and small R^2 values as found above are acceptable for individual data (see [21] p. 61 and [22] p. 230). However, it is believed that these R^2 values could be improved with better measurement techniques—especially for measuring critical items such as accidents, income, etc. For instance, the use of driver records including all the accident history would have been much more reliable than the self-reporting of accidents. However, at the time this research was carried out, such data were not available.

7.3 Attitudinal variables were not found to contribute significantly to the explanation of the accident involvement rate. However, it is too early to eliminate these variables from further studies because, as mentioned above, the present work should be considered as only a first step in establishing reliable scales. In order not to exhaust the patience of the respondents, the number of attitudinal items was minimized and responses were asked on a three point scale during the survey. Both of these actions may have reduced the reliability of the scales considerably. Future work can improve the attitudinal factors developed here by establishing a better testing environment, such as home interviews or self-response questionaires that can be filled in at home.

7.4 The 'age' and 'income' variables are easily targetable ones. Programs to improve driver behavior can be formulated to target the critical categories of these variables. For instance, those drivers under 25 years of age should be given special attention. Driver education at schools will be the best place to institute these programs.

7.5 The low income category was found to be involved in more accidents than the high income category. This could be because of behaviorial differences between these two groups or might be caused by the physical constraints of the low income group. For instance, because of financial difficulties they may not be able to maintain their vehicles in a safe condition, which may result in higher accident involvement rates. This subject should be studied in further research. However, in either case, stricter vehicle inspection programs could help remedy the situation.

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REFERENCES

[1] J. R. Treat, 'Tri-Level Study for the Causes of Traffic Accidents, An Overview of Final Results', *American Association for Auto Medicine, Conference Proceedings*, September, 1977.

[2] 'An Analytical Study of the Traffic Statistics for 1400 Hijri (=1980)', *Ministry of Interior Publication*, Riyadh, 1980.

[3] F. L. McGuire, 'Personality Factors in Highway Accidents', *Human Factors*, **18** (1976), pp. 433–442.

[4] T. W. Forbes, *Human Factors in Highway Traffic Safety Research*. New York: Wiley, 1972.

[5] P. F. Waller and R. G. Hall, 'Literacy — a Human Factor in Driving Performance', in *Accident Causation*, SP-461. Warrendale, Penn.: Society of Automotive Engineers Publications, 1980, pp. 15–25.

[6] S. Hulbert, 'Driver and Pedestrian Characteristics', in *Transportation and Traffic Engineering Handbook*, ed. John E. Baerwald. New Jersey: Prentice–Hall, 1976.

[7] D. M. Harrington and S. M. Robin, 'Traffic Violations by Type, Age, Sex, and Marital Status', *Accident Analysis and Prevention*, **2** (1960), pp. 67–69.

[8] R. M. Harano, R. C. Peck, and R. S. McBride, 'The Prediction of Accident Liability Through Biographical Data and Psychometric Tests', *Journal of Safety Research*, **1** (1975), pp. 16–52.

[9] Herbert J. Stock, *Motor Driver: His Nature and Improvement*. Connecticut: Eno Foundation for Highway Traffic Control Publications, 1949.

[10] J. A. Saif, 'Defensive Driving Among a Selected Sample of Saudi Arabian Private Car Owners', Ph.D. Dissertation, Michigan State University, 1973, unpublished.

[11] R. A. McFarland, 'Psychological and Behavioral Aspects of Automobile Accidents', *Traffic Safety Research Review*, **12**, (1968), pp. 71–80.

[12] E. Allgaier, 'Some Road-User Characteristics in Traffic Problems', *Traffic Quarterly*, **IV** (1960), pp. 59–77.

[13] Robert Loo, 'Role of Primary Factors in the Perception of Traffic Signs and Driver Violations and Accidents', *Accident Analysis and Prevention*, **11** (1979), pp. 125–127.

[14] Richard E. Mayer, and John R. Treat, 'Psychological, Social, and Cognitive Characteristics of High-Risk Drivers: A Pilot Study', *Accident Analysis and Prevention*, **9** (1977), pp. 1–8.

[15] S. M. Soliday, 'Development and Preliminary Testing of a Driving Hazard Questionnaire', *Perceptual and Motor Skills*, **4** (1975), pp. 763–770.

[16] J. McMillan, *Deviant Drivers*. Lexington, Mass.: Lexington Books, 1975.

[17] Peter R. Stopher, and Arnim H. Meyburg, *Survey Sampling and Multivariate Analysis for Social Scientists and Engineers.* Lexington, Mass.: Lexington Books, 1979.

[18] R. J. Rummel, *Applied Factor Analysis.* Evanston, Ill.: Northwestern University Press, 1970.

[19] T. W. Anderson, *Introduction to Multivariate Statistical Analysis.* New York: Wiley, 1958.

[20] Norman H. Nie and others, *Statistical Package for the Social Sciences.* New York: McGraw-Hill, 1975.

[21] Gökmen Ergün and Peter R. Stopher, 'The Effects of Personality on Demand for Recreation Activities: Some Preliminary Findings', *Transportation Research,* **16A** (1982), pp. 55–63.

[22] J. Johnston, *Econometric Methods,* 2nd Edition. New York: McGraw-Hill, 1972.

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