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The impact of traffic violations on road accidents: Structural Equation Modeling

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Abstract

Background: With severe situation in road traffic safety, there is an urgent need to study the risk factors that determine driving violations and the severity of road accidents.

Objectives: The aim of the present study was to investigate the impact of driving violations and risky driving behaviors on the risk of accidents.

Methods: In this descriptive cross-sectional study, 320 professional drivers participated. Data of this study were collected from Occupational Medicine Center of Kashan, Truckers' Cooperative, and Aran and Bidgol Kavir Steel Company using the Persian version of the Driver Behavior Questionnaire (DBQ). Data were analyzed using structural equation modelling by IBM SPSS Statistics 22 and IBM AMOS 19.

Results: According to the results, the fit indices of the final model showed a good fit (X2/df=3.07, RMSEA=0.083, CFI=0.977, NFI=0.967, TLI=0.957). All three research hypotheses were confirmed in the final model. There was a positive and significant relationship between violating traffic laws and risky driving behaviors (β=0.56), and the risk of driving accidents (β=0.41). Moreover, there was a positive and significant relationship between risky driving behaviors and the risk of driving accidents (β=0.52, P>0.01).

Conclusion: The results of this study reveal that if the traffic violation rate could be reduced or controlled successfully by strict law enforcement and continuous monitoring, then the rate of serious injuries and fatalities would be reduced accordingly.

Keywords: Traffic violation law, Traffic accident, Dangerous driving behaviors, Heavy vehicle, Occupational driver.

Introduction

With the advancement of technology and the growth of societies, the need for greater order is felt more than before.[1] Hence, one of the factors that helps prevent chaos and confusion is the adherence to laws and regulations.[2] These laws apply in all areas and domains, including traffic laws, education laws, and other aspects.[3] In all countries, awareness of traffic laws is a crucial factor for driver safety and accident prevention, and it is naturally expected that awareness of traffic laws leads to fewer accidents as a direct result of regulations not being followed. However, the level of awareness of traffic laws is not at an acceptable level, but it can be increased by conducting educational courses for drivers.[4] Every year, many people suffer from physical problems caused by accidents.[5] It has also been identified that excessive or inappropriate speeding is the primary cause of deaths and serious injuries resulting from road accidents.[6] Violation of traffic laws is the second most important cause and the ninth main cause of mortality.[7] The damages caused by traffic accidents worldwide have been estimated at 518 billion dollars annually.[8] Each year, 1.35 million people lose their lives in traffic accidents and 20 to 50 million people suffer from non-fatal injuries.[9] Without taking fundamental actions, it is predicted that

road accidents will be the fifth leading cause of death by 2030[10] and the third main cause of adjusted life years lost due to disability.[11] In Iran, annual traffic accidents involve approximately 32 cases per 100,000 people, making it the second leading cause of death, the first cause of premature death, and the most common cause of injuries.[4,12] In Iran, factors such as human errors (65%), vehicle technical flaws (15%), road issues (13%), and weather conditions (7%) play a role in road accidents.[13] The results of the study of Fakharian et al. in 2019 in Kashan city, Iran showed that the most common traffic accidents were related to trauma (35.2%), and patients who were injured in traffic accidents were hospitalized for a longer period, with 2.63% of them suffering from spinal cord injuries and a 2.3% mortality rate.[14]

One of the key pillars for enhancing road safety in any country is a good understanding of the traffic safety culture and driving behavior of drivers.[15] In 90% of accidents, human factors have played a fundamental role, making it one of the major reasons for road accidents.[16] The most common aberrant behaviors that drivers engage in while driving, which lead to accidents, include drinking, eating, smoking, and talking on the phone.[14] As a result, various research institutions are currently investigating and offering various solutions to detect unsafe driving behaviors[18,19] because the safety of drivers and passengers in vehicles is a vital matter.[20] Monitoring abnormal driving behaviors is crucial for improving road safety, increasing driver awareness, examining their driving patterns, and minimizing future road accidents.[19,21] To prevent serious consequences, abnormal driving behaviors need to be identified and examined. A precise monitoring approach that can detect abnormal driving behaviors and identify them is essential to increase drivers' awareness of their driving behaviors and prevent potential accidents.[22]

Research Hypotheses

- There is a positive and significant relationship between violating traffic laws and risky driving behaviors.
- There is a positive and significant relationship between violating traffic laws and the risk of driving accidents.
- There is a positive and significant relationship between risky driving behaviors and the risk of driving accidents.

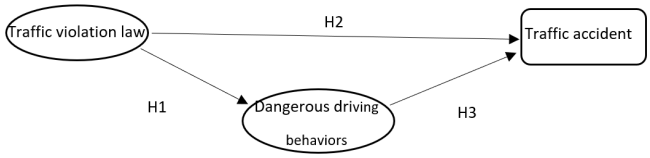

Figure 1. Conceptual Research Model

Objectives

The aim of the present study was to investigate the impact of driving violations and risky driving behaviors on the risk of accidents.

Methods

Population, Sample Characteristics, and Sampling Method

It is a cross-sectional descriptive study, which involves a comprehensive survey of all professional heavy vehicle drivers, including trailer trucks, trucks, minibuses, and intercity and intracity buses in the Kashan region (those whose primary occupation is driving and make a living from it). Heavy vehicles are defined as vehicles with a weight of more than 5.3 tons.

In structural equation modeling research, the sample size should be at least 5 to 10 times the number of observed variables in the study, as recommended by researchers.[23] In total, there are 18 observed variables in the present study. Therefore, a minimum of 300 samples is required. In this study, the number of individuals was increased to 320 to reduce sampling error and prevent the possibility of study dropout. After removing incomplete questionnaires, a total of 303 questionnaires were included in the final analysis.

To collect information, the convenience sampling method was used by visiting the Occupational Health Center for Drivers and the Heavy Vehicle Drivers' Cooperative. For this purpose, an anonymous questionnaire, consisting of two sections: demographic information and a history of driving accidents, violations, and risky driving behaviors, was provided to each professional heavy vehicle driver. They were given explanations about the study objectives and assured of the confidentiality of their information.

Research Instruments

All the drivers in the study completed two questionnaires. The first questionnaire included demographic information, the type of vehicle, driving speed, as well as a history of accidents (whether you have had an accident in the past three years, mention the result) and violations in the past three years. The second questionnaire was the Persian version of the DBQ (Driver Behavior Questionnaire), which was validated and its reliability was confirmed in the study by Mortazavi et al. The questionnaire included 15 items out of the initial 50-item DBQ presented by Rüssel et al. The items are scored on a Likert scale from 1 to 5 (Never=1, Rarely=2, Occasionally=3, Most of the time=4, and Always=5). To

obtain a score for each dimension, the total scores for all the questions in that dimension were added together. This questionnaire has four dimensions: Slip, with 4 questions and a score range of 4-20, Error, with 3 questions and a score range of 3-15, Violations on the highway, with 3 questions and a score range of 3-15. Dangerous violations, with 5 questions and a score range of 5-25. Additionally, it should be noted that the sum of the scores of the four dimensions in this questionnaire results in an overall score that represents the driving behavior of the drivers, which falls within the range of 15-75. The higher overall score for driving behavior indicates the higher the number of errors, mistakes, and violations committed by the driver. The results of Mortazavi et al. for the reliability and validity of the Driver Behavior Questionnaire showed that the Cronbach's alpha coefficient for the overall questionnaire items was 0.83, indicating good internal consistency among the questions. Furthermore, the results of the test-retest reliability assessment, based on the Spearman correlation coefficient, showed a value of 0.72 between the two studies, demonstrating acceptable stability of the scores over time. Based on the results obtained in this study, the validated Driver Behavior Questionnaire for self-reporting aberrant driving behavior demonstrates good reliability and validity.[24,25]

Statistical Analysis: Structural Equation Modeling (SEM)

Modeling Steps

Step 1: Validation and Reliability of Research Instruments

Before using measurement instruments, it is essential to ensure their scientific validity and reliability. In this study, Cronbach's alpha was used to calculate the reliability of the measurement instruments. This method is used to assess the internal consistency of measurement instruments, including questionnaires. If the obtained Cronbach's alpha coefficients for the entire questionnaire and each of the variables are greater than 0.70, it can be said that the questionnaire has the necessary and desirable reliability. Construct validity indicates the extent to which the results obtained from the use of indicators are compatible with the theories on which the test was designed. In this study, confirmatory factor analysis is used to ensure the validity of the model. Confirmatory factor analysis aims to determine whether the number of factors and the loadings of the measured and latent variables match what was expected based on theory and theoretical models. To confirm the validity of the measurement model in the study, factor loadings for manifest variables should be higher than 0.4, and all relationships between measurable and latent variables in the study should be significant at the 0.05 level of significance. Furthermore, the measurement model should have satisfactory fit indices. The reliability and validity of the DBQ questionnaire have been reported in a previous study (26). Based on the results of that study, the mentioned questionnaire had combined reliability ranging from 0.6 to 0.677 for each factor, and a Cronbach's alpha coefficient of 0.772, indicating the questionnaire's high reliability. This suggests that the questionnaire is very reliable and can be used for structural equation modeling. Additionally, based on the results of confirmatory factor analysis, the model fit indices are acceptable. These include a relative chi-square (χ^2/df) of 2.145, NFI=0.82, and CFI=0.89, which indicate that the fit is not very far from the recommended value of 0.90. Similarly, TLI=0.86, which is not significantly different from the recommended value of 0.90. The RMSEA value was less than 0.08.

Step 2: Testing Hypotheses Using Structural Equation Modeling

Structural Equation Modeling is a comprehensive multivariate analysis that belongs to the family of multivariate regression and allows researchers to simultaneously test a set of regression equations. Multivariate analysis refers to a set of analysis methods that focus on simultaneously analyzing several independent variables with multiple dependent variables. Structural Equation Modeling is a generalization of several multivariate analysis methods. Its main characteristic is the simultaneous analysis of multiple independent and dependent variables. Structural Equation Modeling allows for testing hypotheses about relationships between observed (manifest) and unobserved (latent) variables. It is sometimes referred to as covariance structure analysis or causal modeling. However, the common term used is Structural Equation Modeling, abbreviated as SEM. The research hypotheses are tested in this study with the help of AMOS19.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. Institutional Review Board approval (code: IR.KAUMS.NUHEPM.REC.1397.047) was obtained.

Results

After collecting the questionnaires, 320 drivers of heavy vehicles participated in the survey. After reviewing their responses, 303 questionnaires were included in the analyses. The first part of the questionnaire contained

questions about the drivers' socio-demographic information. Among the total number of participants, 61 (20.1%) were bus drivers, 95 (31.4%) were truck drivers, and 147 (48.5%) were trailer drivers. An examination of the drivers' personal characteristics revealed that their age ranged from 21 to 75 years (with a mean of 43.15 and a standard deviation of 10.29 years), and their driving experience ranged from 1 to 54 years (with a mean of 19.48 and a standard deviation of 11.34 years). Eighteen of the drivers were single (5.9%), while the rest were married.

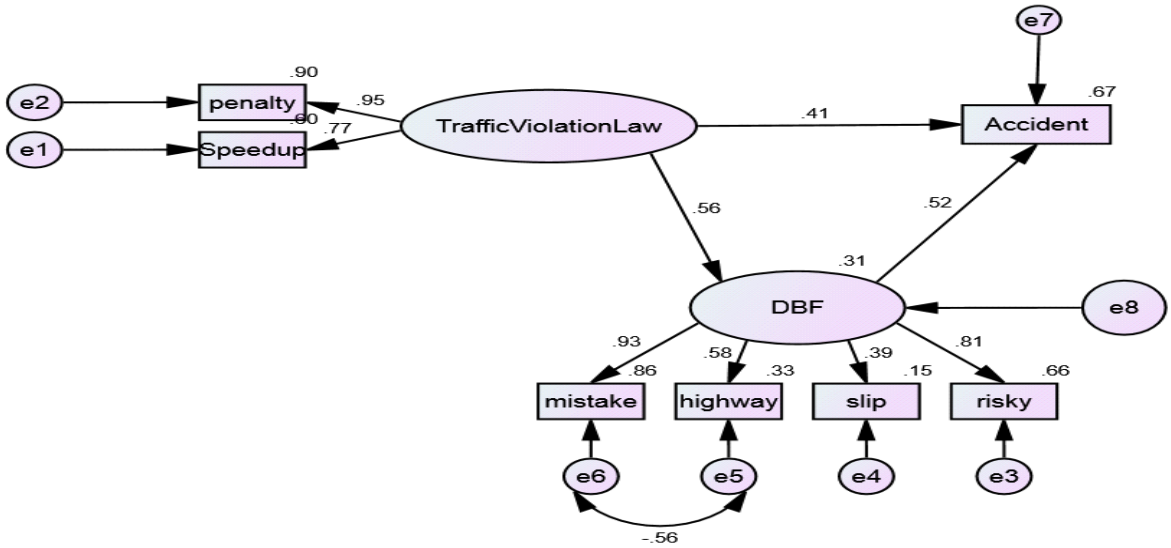

Figure 2. Final Research Model

Measurement Model Results

Initially, using SEM analysis, the model presented in Figure 1 was examined. After analyzing various models, Figure 2 illustrates the results of the final and ideal model. According to the results, the fit indices of the final model indicate a good fit (X2=33.869, X2/df=3.07, RMSEA= 0.083, CFI=0.977, NFI=0.967, TLI=0.957) [Table 1].

Furthermore, based on the final model, all three research hypotheses were confirmed. According to the final model, there is a positive and significant relationship between the violation of traffic laws and risky driving behaviors (β=0.56). Moreover, there is a positive and significant relationship between the violation of traffic laws and the risk of traffic accidents (β=0.41). Finally, there is a positive and significant relationship between risky driving behaviors and the risk of traffic accidents (β=0.52). All results are significant at the 0.01 level (P-value<0.01).

Table 1. Research Model Fit Indices

Fit Indicators	Recommended Amount	Structural Model
X^2		33.869
(X^2/df)	1-3	3.07
(CFI)	≥0.90	0.977
(NFI)	≥0.90	0.967
(LI)	≥ 0.90	0.957
(RMSEA)	>0.08	0.083

Discussion

The present study aims to investigate the impact of traffic violations and risky driving behaviors on the risk of traffic accidents. In this study, traffic violations refer to high-speed driving and not wearing safety belts, overtaking from the right, driving while drunk, using a mobile phone while driving, and other related factors. One of the major findings of this study is the statistically significant relationship between the violation of traffic laws, particularly related to speeding, and the risk of traffic accidents. Considering that studies considering speed variations as a contributing factor in predicting traffic accidents are relatively limited, and their results vary,[27-29] some studies consider speed variations to be positively associated with accidents,[30,31] while others did not find significant relationships between speed variations and accident risk.[27] The present study addresses this knowledge gap and offers useful insights. Furthermore, the variations in studies might be related to differences in the examined samples, which may include various age and gender groups, as well as different types of vehicles, both light and heavy, which have varying speed limits. Additionally, due to the high levels of illiteracy in low and middle-income countries, the associations between speed and risk, as well as traffic safety discussions, might be more pronounced in these countries compared to high-income countries. Hence, these findings may be related to

differences in traffic safety knowledge across various countries.

Vingilis and Wilk demonstrate that alcohol-impaired driving is a significant law violation that increases the likelihood of accidents, especially among young drivers.[32] Macdonald shows that drivers who receive treatment for addiction or alcohol misuse tend to commit more traffic violations than those who are not under treatment, suggesting that receiving treatment for substance addiction or alcohol misuse significantly reduces the likelihood of accidents.[33]

The study conducted by Zhang et al.,[33] demonstrates that cargo vehicles and passenger transport drivers have a higher risk of committing traffic violations in comparison to motorcycle riders. Improper safety conditions and overloading are also significant factors associated with traffic violations. Furthermore, among all traffic violations, speeding, driving under the influence, and talking on the phone all significantly increase the risk of severe and fatal accidents. In line with these findings, the present study revealed that drivers of heavy vehicles committed violations, including overloading, exceeding passenger capacity, speeding, and improper loading methods, which is consistent with results of the study by Zhang.[33] Moreover, the study by Ayuso et al., indicated that the most expensive traffic violation is excessive speed and exceeding the passenger or maximum weight limit. The expected cost ratio for this combination of traffic violations and driving is 2.78. This means that the cost of accidents in this case is almost three times the cost when no traffic violations occur.[34] The reasons behind committing traffic violations such as speeding and overtaking can be attributed to the competition for acquiring more passengers and carrying more loads, which is common among public and commercial transport drivers. This may lead to increased speeding and higher risk-taking, potentially posing a safety issue. These results highlight the significant role of traffic violations as a major threat to road safety.

Conclusions

The overall findings of this study suggest that if traffic violation rates can be reduced or effectively controlled, then the severity of accidents and casualties decreases accordingly. Furthermore, specific risk factors related to traffic violations and accident severity are identified. Therefore, in order to reduce the occurrence of traffic accidents and mortality rates, measures such as traffic regulations - with the aim of categorizing different types of vehicles/groups of drivers based on various human, vehicle, and environmental factors - are necessary. These measures can include safety programs targeting specific groups of drivers, the enforcement of traffic regulations, and improvements to road/transportation facilities.

Acknowledgment

None.

Competing interests

The authors declare that they have no competing interests.

Abbreviations

Driver Behavior Questionnaire: DBQ;
Structural Equation Modeling: SEM.

Authors' contributions

FK and MM: concept, design, definition of intellectual content, manuscript editing and manuscript review. FK, PKHD and MHN: literature search, data acquisition, data analysis, manuscript preparation, manuscript editing and manuscript review HA: data analysis, statistical analysis, manuscript preparation, manuscript editing and manuscript review FK and HA: manuscript editing and manuscript review. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Role of the funding source

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Institutional Review Board approval (code: IR.KAUMS.NUHEPM.REC.1397.047) was obtained.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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