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Association between Visual Acuity and Road Accidents among Heavy Vehicle Drivers in Tehran, Iran (2019)

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Abstract

Background: Poor vision in drivers may represent an important cause of risk for car accidents. The purpose of this study was to analyze the Association between visual acuity in heavy vehicle drivers and the occurrence of road accidents.

Materials and Methods: This cross-sectional study was carried out on 200 drivers of heavy motor vehicles (trunks) in Tehran province in 2019. Data were gathered using a checklist of demographic and background features, a standardized driver safety questionnaire, and drivers' driving records obtained from occupational health centers. In addition, drivers' visual acuity status was assessed using Snellen chart. Descriptive statistics, Spearman's correlation, and Chi-square were utilized to analyze the data using SPSS version 21 and Microsoft Excel 2016.

Results: Visual acuity scores for the right and left eyes were 9.16 ± 1.04 and 9.20 ± 1.08, respectively. All drivers with no prior experience with crashes on roads had normal vision acuity. The visual acuity scores in both eyes were not related to occurrence of accidents or near miss accidents ($P>0.05$), while drivers who had higher visual acuity score experienced fewer numbers of near miss accidents and accidents ($p<0.001$). The most common accidents involved collisions between vehicles (60%), which had negative correlations with the right visual acuity ($p<0.001$, $r = - 0.24$) and the left one ($p<0.05$, $r = - 0.21$).

Conclusion: There was a high rate of road accidents among the studied heavy vehicle drivers. Also, impaired visual acuity can contribute to high accident and near miss rates among drivers.

Keywords: Accident, Drivers, Motor Vehicles, Safety, Visual Acuity.

Introduction

Road accidents are one of the leading causes of death in developing countries [1], accounting for more than half of all vehicle as well as road traffic fatalities worldwide, based on the World Health Organization [2]. Thus, improving road transportation is a critical issue, as reducing road traffic fatalities and injuries by 50% by 2030 is part of the United Nations Sustainable Development Goals [3].

According to a cohort study conducted in Iran in 2015, vehicle crashes are the second cause of leading death [4]. Road accidents can be caused by a variety of human, environmental, road, and vehicle factors [5]. According to research, human factors are responsible for 93% of collisions, whereas environmental and vehicle factors are responsible for 34% and 13%, respectively [6]. This emphasizes the significance of human factors in the occurrence of crashes in traffic and the need to pay special attention to this factor [5]. According to a literature review, human factors that affect the occurrence of traffic accidents include driving behaviors (such as driving slips (lapses), errors, and violations), sleep quality (drowsiness, tiredness), socioeconomic characteristics (such as age, gender,

education, occupation), and so on [5, 6]. For example, a study by Useche (2014) found that an increase in the number of high driving speed violations increased the possibility of traffic collisions in truck drivers [7]. In another study that concentrated on elderly drivers, only driving errors, which are mistakes that result from a misjudgment and an inability to see, had a significant Association with the total number of collisions [8].

Driving is a significant visual activity so that vision alone accounts for about 95% of driving-related information input [9]. Some studies have investigated visual acuity among drivers [10-12]. Additionally, high number of accidents have been disclosed among drivers with poor vision [13, 14]. Given that heavy vehicles contribute to more than 8% of total vehicles in Iran [15] which can subject the drivers to particular risks, and Snellen chart is a basis for visual examinations, so it can be suitably used for determining the status of visual acuity on heavy vehicle drivers. Different countries and studies have considered various traffic regulations for assessing drivers' visual acuity. For example, according to visual standards for driving safety proposed by the International Council of Ophthalmology (ICO), the threshold of 20/40 (0.5, 6/12) has been introduced as acceptable visual acuity [16], whereas in a study in Nigeria, commercial drivers' visual acuity was evaluated using criteria of 6/12 and 6/18 [17]. Furthermore, in another study in Iran, at least visual acuity of 8/10 was deemed normal for public transportation drivers [18]. Thus, in the present study, the binocular visual acuity threshold of 14/10 (with present glasses, if they had any) was considered as normal for drivers' heavy vehicle in Tehran Province, with no study yet published in this geographical area [1]. Studies have reported the status of visual acuity in drivers, especially heavy vehicle drivers in Iran. for example, a study in Kerman province revealed that approximately 18% of public vehicle drivers with a mean age of around 40 years had less vision than required on the road [18]. Furthermore, in another study, collisions of Iranian drivers were studied using Bayesian networks to detect driver factors affecting at-fault collisions of heavy vehicles [5].

In our previous study, we looked into high-risk behaviors such as cell phone use, texting, snacking, and drowsiness that could have affected the occurrence of road accidents among heavy vehicle drivers in Tehran province [20]. Given that vision is the most important factor in vehicle control and accident prevention, the purpose of this study is to examine the Association between visual acuity using the national traffic regulations and road accidents among heavy vehicle drivers in Tehran Province.

Materials and Methods

This descriptive-analytical research was conducted over one year among trucks drivers in Tehran Province. A two-stage cluster random sampling technique was used to select 200 heavy vehicle drivers. In the initial stage, each occupational health center was treated as a cluster. Overall, this study included six clusters. The second stage involved randomly selecting 40 drivers from each cluster. A total of 240 drivers were initially chosen for the research, and medical histories were reviewed. The inclusion criteria for drivers in this study were: having a health certificate, a valid driver's license (with at least two years of experience driving heavy vehicles), relevant driving history data, and voluntary participation in the study. Note that 40 drivers who could not fulfill the eligibility requirements were excluded from the study.

This study used a checklist of demographic and background characteristics, a standardized driver safety questionnaire, and drivers' medical histories from occupational health centers. Following the identification of eligible individuals, sessions were set up to clarify how to respond to the checklist and questionnaire, assure individuals of the confidentiality of their information, and obtain written permission from all study participants. To facilitate data protection and analysis, each participant's data was assigned a unique code.

The researcher-developed checklist included data on individual lifestyle (age, weight, height, body mass index (BMI), smoking status, and exercise) as well as drivers' occupational information such as driving hours per 24 h, continuous driving hours, as well as rest and sleeping hours during the day (rating scale of 0 to 10). This questionnaire, based on studies of human factors and factors related to driving accidents, included an assessment of safety and occupational health training, as well as the number and type of road accidents reported by drivers over the last 5 years (car accidents, pedestrian collisions, hitting obstacles, and overturning). Furthermore, the drivers were questioned about their role in road accidents. A test-retest correlation test was employed to assess the questionnaire's validity, with responses from 15 participants in two weeks. Based on the findings, 82% of the responses given were similar. As a result, four experts confirmed the questionnaire's validity [20].

To assess drivers' vision status, medical records from occupational health centers were reviewed. Accordingly, the visual health status of drivers on the visual acuity of each driver's right and left eyes was assessed through Snellen chart. As previously stated, according to Iranian traffic rules, if the sum of visual acuity scores in both eyes is 14/10 or higher, the driver's vision is regarded as normal; otherwise, the individual has a visual impairment.

The Kolmogorov-Smirnov test was utilized to assess data distribution, and since not all data were normally distributed, Spearman's correlation and Chi-square tests were used for data analysis. Descriptive analyses were

carried out on the variables as mean and standard deviation (SD). All tests were considered significant at the 0.05 level. The data were analyzed using SPSS version 21 and Microsoft Excel 2016.

Results

In this study, 200 drivers (bus and truck) participated. Table 1 reports drivers' general characteristics. The drivers had an average age of 47.51 ± 9.05 years. In addition, 67.5% of the drivers smoked, and 2.5% received safety and occupational health training. Drivers' visual acuity average scores in their right eyes and left ones were 9.16 ± 1.04 and 9.20 ± 1.08, respectively. The combined visual acuity for both eyes was 18.36 ± 1.90 (Table 1).

Table 1. The general characteristics of the studied drivers

Variables	Mean±SD	Min.	Max.
Age (year)	47.51±9.05	30	70
BMI (Kg m^{-2})	27.90±2.99	21.85	40.74
Driving hours	10.67±2.52	5	16
Rest hours	8.70±1.13	6	12
Continuous driving hours	5.82±1.87	3	10
Exercise hours per week	1.14±0.92	0	5
Visual acuity of the right eye	9.16±1.04	6	10
Visual acuity of the left eye	9.20±1.08	5	10
Total visual acuity	18.36±1.90	11	20

Fig. 1 depicts the distribution of participants' visual acuity scores. The highest and lowest vision acuity scores in drivers' eyes were 10, and 5, respectively. Also, 50% of the drivers had a full vision acuity score (10) in their right eye and 54% in their left eye.

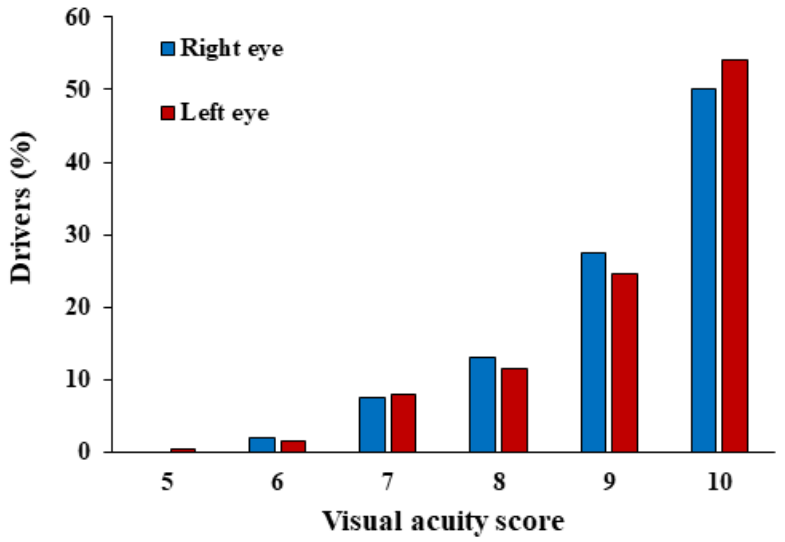

Fig. 1. The frequency distribution of the visual acuity scores of the right and left eyes among the examined drivers (n=200)

Furthermore, our results revealed that 97.5% (195 out of 200) possessed normal binocular vision acuity (vision acuity score of at least 14/10), while 2.5% (5 out of 200) suffered from impaired vision acuity (vision acuity score of less than 14/10). Our study found that the drivers who had normal visual acuity exercised more hours per week (Table 2), and weekly exercising was positively linked to the visual acuity of the drivers ($p<0.05$).

Table 2. Status of visual acuity of the drivers and physical activity

Status of visual acuity	Exercising hour(s) per week			
	0	1	2-3	4-5
Normal	87	57	48	3
Impaired	2	3	0	0

Based on the participants' driving records, an assessment of accident and near miss occurrence over the previous five years revealed a total of 221 accidents and 852 near misses. In addition, the average number of accidents and near misses was 1.11 ± 1.20 and 4.26 ± 2.29, respectively (Table 3). Accidents and near miss accidents ranges were 0-6 and 0-10, respectively. The findings reveal that near misses were higher than accidents among the surveyed drivers. Further, 26% of drivers did not have previous accident experience. Among the drivers who were involved in an accident, 59.5% disclosed only one accident, while 13% and

1.5% reported two to six or more accidents, respectively (Table 3). Also, among the drivers experienced accidents, 96.62% had normal visual acuity, while all of the drivers who had no prior experience with road accidents had normal vision acuity (52 drivers).

Table 3. Number of accidents and near misses over the last five years for the examined drivers

Variables	Mean±SD	Range	Total sum	Number of accident(s)			
				0	1	2-5	≥ 6
Accidents	1.11±1.20	0-6	221	26%	59.5%	13%	1.5%
Near misses	4.26±2.29	0-10	852	2%	7%	61%	30%

As outlined in Table 4, 60% and 11.5% of drivers had collisions with other cars in one or more accidents, respectively, where 44% of the drivers with collision a vehicle believed they were to blame or responsible for this accident. Specifically, 3.5% and 1.5% of drivers reported colliding with a pedestrian or overturning their vehicle, respectively. Furthermore, 5.5% and 3% of the drivers experienced hitting an obstacle in one or more accidents, respectively, with 3.5% of the drivers blaming themselves for this accident.

Table 4. Frequency of the accidents over the last 5 years and the types of the accidents experienced by the examined drivers

Experiences of the studied drivers	Without accident	1 accident	>1 accident	At-fault accident
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Collision a vehicle	57 (28.5)	120 (60)	23 (11.5)	88 (44)
Collision a pedestrian	193 (96.5)	7 (3.5)	-	2 (1)
Hitting an obstacle	183 (91.5)	11 (5.5)	6 (3)	7 (3.5)
Overturning the vehicle	194 (97)	6 (3)	-	3 (1.5)

The Association between driver vision acuity and the occurrence of accidents or near misses was investigated using the Chi-square test, with the results presented in Table 5. According to the findings, the participants' vision acuity in their right and left eyes had no significant Association with the occurrence of accidents or near misses (P>0.05). Furthermore, no significant statistical relationships were found between total vision acuity score and the occurrence of accidents or near misses (P>0.05) (Table 5).

Table 5. Mean and SD of drivers' visual acuity with occurrence of accidents and near misses

Variables	Accident		P-value	Near miss		P-value
	With experience	Without experience		With experience	Without experience	
Visual acuity of the right eye	9.10±1.08	9.30±0.92	0.49	9.14±1.04	9.75±0.5	0.84
Visual acuity of the left eye	9.12±1.13	9.42±0.85	0.59	9.18±1.07	10	0.63
Visual acuity of both eyes	18.22±2	18.73±1.53	0.8	18.33±1.91	19.75±0.5	0.92

The Chi-square test revealed a significant Association between drivers' vision acuity in both eyes and the number of the near misses and the accidents, including collisions with other cars and obstacles (P<0.05) (Table 6).

Spearman correlation test was carried out to determine a correlation between the studied variables and drivers' visual acuity and the studied variables (Table 7). There was a significant and negative correlation between drivers' visual acuity in both eyes as well as the total number of near misses (p<0.001) and accidents (p<0.05). The study found significant negative correlations between the number of collisions with other vehicles and visual acuity in the right eye (p<0.001, r = - 0.24) and left eye (p<0.05, r = - 0.21). Also, significant negative correlations were found between the number of collisions with obstacles and visual acuity in the right eye (p<0.05, r = - 0.24) and left eye (p<0.001, r = - 0.29). There was no significant Association between the number of overturning the vehicle and visual acuity in both eyes of drivers (p>0.05). Moreover, the present study found no significant Association between pedestrian accidents and visual acuity in the right eye (p>0.05), but a negative correlation in the left eye (p<0.05, r = - 0.17) (Table 7).

Table 6. Association between drivers' visual acuity and the number of near misses, accidents, and their types

Variables \ Visual acuity	Right eye		Left eye	
	X^2	P value	X^2	P value
Near misses	87.27	< 0.001	100.45	< 0.001
Accidents	105	< 0.001	178.79	< 0.001
Collision with a vehicle	77.17	< 0.001	90.46	< 0.001
Collision with a pedestrian	9.84	0.043	24.73	< 0.001
Hitting an obstacle	44.19	< 0.001	67.96	< 0.001
Overturning the vehicle	9.69	0.046	5.06	0.41

Table 7. Correlation between the visual acuity of the drivers and the studied variables

Variables	Visual acuity	Right eye		Left eye	
		r	P value	r	P value
Demographic and background	Age (year)	-0.67	<0.001	-0.55	<0.001
	BMI (Kg m^{-2})	0.20	0.005	0.18	0.012
	Weekly exercise (hour)	0.16	0.022	0.18	0.010
Road accidents	Number of near misses	-0.45	<0.001	-0.35	<0.001
	Number of accidents	-0.23	0.001	-0.26	<0.001
	Number of collisions with a vehicle	-0.24	<0.001	-0.21	0.003
	Number of collisions with a pedestrian	-0.14	0.055	-0.17	0.016
	Number of collisions with an obstacle	-0.24	0.001	-0.29	<0.001
	Number of overturning the vehicle	-0.09	0.21	-0.14	0.054

Discussion

The present study examined the link between visual acuity and the occurrence of road accidents among heavy vehicle drivers in Tehran province. In our study, about 59% of the drivers had at least one accident over the previous five years (Table 3). This finding points to a high accident rate among study participants. In Australia, research results indicated that the incidence of at least one accident in the past year among young and elderly drivers was 38% and 19%, respectively [21]. This finding differs from the accident rates discovered in our study, which could be attributed to differences in the drivers studied, their geographical location, and the length of the accident investigation.

More than half of the study's participants (61%) reported 2-5 near misses (Table 3). Furthermore, the near miss rate was higher than the accident rate among the studied drivers. Near miss road traffic accidents are events with potential safety-related impacts that were ultimately prevented from evolving into actual crash accidents [22]. In the current study, the higher near miss rate could be due to risk factors in the road safety system, such as weather, road condition, sleeping status, and driving hours [23].

Our study discovered a negative Association between drivers' visual acuity and accidents that involve collisions with obstacles or vehicle crashes ($p<0.001$, Table 6). In other words, the drivers who had higher visual acuity score experienced fewer vehicle accidents and collisions with obstacles. It reveals that visual health could affect the accident rates. In another study, drivers with poor vision were more susceptible to accidents and they had a greater average number of accidents over the previous ten years [24]. There was no significant Association between the visual acuity score of both eyes and the number of vehicle overturns reported by participants ($p>0.05$, Table 6). This type of accident may be influenced by other factors. The other findings from our study demonstrated no statistically significant Association between drivers' visual acuity and the occurrence or non-occurrence of accidents as well as near misses (Table 6). The result is similar to another study [25], in which impaired vision among commercial drivers did not significantly increase the risk of road traffic accidents ($p>0.05$, $X^2= 0.3$, RR= 0.62).

The average age of the drivers was 47.51 years, which was consistent with other studies [24, 26], though drivers were younger in other countries than the present study [10, 25]. Among the age groups studied, the middle-aged (under 45 years) and elderly (over 55 years) had the most and least participants. In other words, the majority of heavy vehicle drivers in this study were middle-aged, and there were fewer elderly participants. In one study, the majority of drivers were between the ages of 36 and 59 years [10]. Also, another study found that most drivers were between the ages of 31 and 40 [24]. Note that age can influence visual acuity. Our findings revealed a negative correlation between drivers' ages and visual acuity. In other words, older drivers had less wealthy eyesight. This issue could be due to changes in the structure of the eyes with ageing [27].

Our study found that weekly exercising was positively related to the visual acuity of the drivers ($p<0.05$). It reveals that physical activity, as the most significant indicator of health and well-being, benefits the nervous system as well as the visual system [28]. A systematic review found that physical activity can improve cognitive, perceptual, physical, and health-related factors linked to driving performance [28].

BMI is a useful tool for determining obesity [29]. Our study found a high prevalence of obesity among the drivers, with 69% of them being overweight. There were also significant positive correlations observed between visual acuity in both eyes and BMI (Table 7). Few studies have looked into this issue. A biological study found a direct correlation between visual acuity and BMI [30]. Meanwhile, a highly significant positive Association was observed between BMI and visual impairment in school students (adjusted OR = 1.20, 95% CI: 1.15-1.25, $p<0.001$) [29].

The prevalence of visual impairment among the drivers in this study was relatively low (2.5%), which is consistent with some other studies [10, 25]. For example, Pepple et al. (2014) examined the visual status of commercial drivers using the minimum visual acuity of 6/9 as the better eye. According to the findings,

approximately 2% of Nigerian drivers had impaired vision [25]. Another study found that 2.5% of drivers were visually impaired based on 6/9 Snellen acuity [10]. More than 97% of drivers in this study received occupational health and safety training. Our previous study found that training could play an essential role in road accidents and near miss accidents [20]. So, training and raising awareness about risk factors in accidents may assist in preventing them; this issue appears to warrant further investigation.

We used driving variables extracted from related studies to provide a comprehensive analysis of participants' driving status. Also, this study determined the Association between the variables and visual status of the drivers evaluated using the valid method and threshold confirmed by the national traffic regulations. Our study had some specific limitations. First, we used a cross-sectional study design. Further, driving datasets were collected using a self-reported approach that relied on participants' recall levels. This may result in underestimating or overestimating the outcomes (accidents or near misses). In addition, drivers' visual acuity is typically assessed under high contrast and brightness conditions using the Snellen chart method, whereas actual driving occurs under low light conditions such as cloudy weather or at night. Also, this study assessed visual acuity and road accidents among heavy vehicle drivers in Tehran province, which may not be reflective of the different types of vehicle drivers and for other areas of Iran, and thus further research is recommended.

Conclusion

This study discovered a high rate of road accidents among the studied heavy vehicle drivers. Furthermore, since drivers with normal vision are less likely to be responsible for accidents, visual acuity is regarded as an important factor in accident control and prevention. The results of the present research can be summarized as follows:

- Occurrence of accidents and near miss accidents did not relate significantly to the binocular visual acuity scores.
- Higher binocular visual acuity score experienced positively correlated with fewer accident rates of collisions with other vehicles and obstacles.
- Physical activity and age were found to significantly impact drivers' vision.
- Participants had a wide age range and increased susceptibility to visual acuity as they aged.
- Many drivers lacked occupational health and safety training.

It is hoped that the study's findings will help policymakers and planners of transportation improve drivers' safety performance.

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Conflict of interest

None declared.

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Ethical Considerations

This research was carried out in line with the Declaration of Helsinki. Before taking part, all participants gave their informed consent. They were guaranteed that their responses would remain confidential, and their identities were kept anonymous in all data analyses. They were also made aware of their right to withdraw from the study at any point without facing any repercussions.

Code of Ethics

This manuscript is an excerpt from a research project with the ethics code IR.TUMS.MEDICINE.REC.1397.491.

Authors' Contributions

Sepideh Keyvani: Drafted the manuscript, and wrote the conceptual framework and methodology; Farzaneh Mehri: Coordinated the data collection process; Fatemeh Fasih-Ramandi: Conducted the data analysis; Ali Karimi: Supervised the study, facilitated communication among team members, and helped finalize the manuscript for submission.

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