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Blood Parameters of Drivers and Road Accidents: A Study of Heavy Vehicle Drivers in Tehran, Iran, 2018

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Abstract

Background: Taking the drivers' health into account from different perspectives is important. This study aimed to examine how heavy vehicle drivers' blood parameters are related to their road accident risk.
Materials & Methods: A descriptive study was conducted among 200 drivers of heavy vehicles. The blood parameters were determined based on the medical records of drivers, as well as data on accidents, demographics, and occupational factors reported in a standardized questionnaire assessing the safety of drivers. The examined drivers' blood parameters included markers for white and red blood cells, platelets, hemoglobin, fasting blood sugar, cholesterol, and triglyceride. Nonparametric statistical tests and logistic regression were used to analyze the data by SPSS-v.21.
Results: Mean and standard deviation of age, BMI, and daily working hours of drivers were 47.5±9, 27.9±2.99, and 10.66±2.52, respectively. Most drivers were normal in terms of white and red blood cells, hemoglobin, and platelet, while 22.5%, 29%, and 26% were suffering from abnormal conditions in terms of fasting blood sugar, total cholesterol, and triglyceride, respectively. A study of the impact of blood parameters on accidents revealed that red blood cells, fasting blood sugar, and triglyceride levels were significantly different in three groups of drivers with different numbers of accidents and near-misses. Based on the logistic regression analysis, the number of cigarettes per day, age, exercise hours, and blood hemoglobin contributed to accidents.
Conclusion: This study supports the concept that blood parameters, such as hemoglobin, fasting blood sugar, total cholesterol, and triglyceride, can influence the safe performance of drivers and road accidents.

Keywords: Blood, Accidents, Traffic, Occupational Health, Safety Management.

Introduction

Nowadays, road accidents are known as one of the most important safety and health problems globally. Based on the statistics, over 1.3 million people worldwide are losing their lives per year in road accidents, and according to the predictions, if no basic changes are made, road accidents will be the 7th cause of death in the world in 2030 [1, 2]. In contrast, the conditions are more complicated in Iran since the frequency of road accidents is five times as much as the number of industrialized countries despite the fact that its population is equivalent to less than 1% of the total world population. On the other hand, since the death rate from road accidents is globally 8.2% of the total number of deaths, this is 38% in Iran [3]. Therefore, it is necessary to investigate the causes and factors affecting road accidents in Iran.

Various factors affect road accidents, including inappropriate roads, adverse environmental conditions, unsafe vehicles, human factors, and non-observance of the rules and regulations, as well as the managerial inefficiency in controlling road traffic properly; however, what is seen as the most practical solution for reducing the risks is to focus on the human factors [1, 2]. Driving-related occupations, especially heavy vehicle driving, are among the most stressful and risky jobs. Thus far, different studies have been conducted on the risk factors of accidents in this occupation. Based on results, conditions such as vision impairment, loss of hearing, epilepsy, arthritis, cardiovascular, diabetes, anxiety, stress, depression, fatigue, drowsiness, obesity, older age, anger, and distraction can cause accidents [4-6]. In Iran, the relationship between road accidents and drivers' fatigue, drowsiness, and accident proneness, as well as psychological, environmental, and ergonomic characteristics, has been confirmed in many studies [7-11]. There are few studies on drivers' blood parameters and their relationship with accidents [12].

The assessment of the blood parameters is among the most valid methods to identify and detect many problems and diseases [13], affecting mood, habits, and behavior. For example, due to long working hours, shift or night working, irregular diet, and inactivity, drivers are more exposed to changes in parameters such as obesity, blood pressure, and increased blood lipid. Long working hours, particularly among older drivers, can be highly boring. Shift work may interfere with the health rhythms and activity levels of many organs, including the heart, stomach, and brain. Obesity and lipid can affect the drivers' quality of sleep and activity, leading to fatigue and drowsiness during the day and while driving. Overall, these factors can decrease consciousness and increase the risk of accidents and injuries to drivers and people around while driving [14]. Hence, it is extremely important to pay close attention to another aspect of the person's health (the blood parameters) and how they relate to accidents, as Jahangiri et al. rightly pointed out [12]. This study aims to discover the correlation between accidents and drivers' blood parameters. Once this is discovered, a simple and easy methodology will be used to identify those with a higher accident potential and assist them accordingly.

Given the above, this study is conducted to investigate the blood parameters (counting the white and red blood cells, platelets, hemoglobin, fasting blood sugar, cholesterol, and triglyceride) of drivers of heavy vehicles and their relationship with road accidents. This study offers a novel approach encompassing many blood parameters of drivers and their relationship with road accidents

Materials and Methods

This descriptive study was conducted in a cross-sectional form among the drivers of heavy vehicles in Tehran Province from April to December 2018; heavy vehicles refer to the autobuses, trucks, and mini-trucks. This study was confirmed by the Ethics Committee of Tehran University of Medical Sciences (Ethics Code: IR.TUMS.MEDICINE.REC.1397.491).

Samples were selected by a two-stage cluster random sampling method; each occupational medicine center (located in Tehran) with the drivers' information was taken as a cluster, and the sampling was also made randomly from each cluster. Those occupational medicine centers that did not cooperate sufficiently or whose samples participated voluntarily with less than the permissible limit were replaced by the samples from the neighboring centers to which more persons were referring. Using a random number table, 40 samples were selected randomly from each cluster, and the size of the initial sample (240 persons) was equal to the outcome of the total number of selected clusters (6 clusters) to several samples in each cluster. Following the criteria for inclusion and exclusion, 226 drivers met the inclusion and exclusion criteria, thus being included in the study. Of those, 26 people abandoned the study, and finally, 200 drivers' information was evaluated. The inclusion criteria were male drivers with health cards, over 2 years passing from driving certificate validity, complete information on laboratory quantities, and contact information in records. Those drivers whose information in the medical records was incomplete or who did not cooperate properly in filling the questionnaires were excluded from the study. Subjects participated voluntarily in the study, and in case of any unwillingness, they were excluded. Written informed consent was obtained from all participants; drivers and occupational medicine centers were ensured that their information would be kept confidential and used only for the present study.

Occupational medicine centers and the standardized safety questionnaire were used to collect the data. Information already registered in drivers' medical records was also collected.

The safety questionnaire is designed based on specialized information and previous studies [12, 15]. To determine the validity of the questionnaire, before starting the study, 15 participants were selected and completed the questionnaire. After two weeks, the same questionnaire was filled out by the same participants, and their answers were compared. Then, the correlation test was performed based on the test-retest method. The correlation coefficient (reliability) was set at 0.75, indicating that 75% of the participants responded the same. The validity of the questionnaire was also confirmed by 5 experts after the necessary corrections. This questionnaire was composed of several parts assessing the data on demographics (age, height, weight, BMI), lifestyle (exercise and smoking), factors related to the occupation (driving hours round the clock, continuous driving, and rest hours), and accidents within the past five years (accident number and types and if drivers blame themselves or not). Further, the incidents were differentiated by whether they were accidents or near-misses; they were categorized into four categories: car collisions, collisions with passengers, collisions with barriers, and vehicle rollovers. In the occupational medicine centers, the scholars supervised the completion of the questionnaires by the drivers, and appointments were scheduled in person. Medical records were also used to extract data on the blood parameters of the drivers. These parameters, i.e., white blood cells (WBC), red blood cells (RBC), platelets (per ml of blood), hemoglobin (gr per blood dl), fasting blood sugar, total cholesterol, and triglyceride (mg per blood dl), were measured in the same year in the credible laboratories confirmed by occupational medicine centers.

Data were statistically analyzed by SPSS v.21, and the figures were drawn by Microsoft Excel 2016. The descriptive statistics were used to examine the frequency distribution and measures of central tendency (mean, SD, median, interquartile range, percentiles, and skewness), demographic characteristics, blood parameters, and occupational factors. The Kolmogorov-Smirnov test was applied to investigate the normality of research data distribution. The nonparametric tests, i.e., Mann-Whitney U and Kruskal-Wallis, were used for dichotomous variables (age, smoking, driving hours, and experienced accidents) and continuous variables (BMI and number of accidents), respectively, with the drivers' blood parameters. The Tukey post hoc test was also applied for pairwise comparisons among the continuous groups. The Spearman correlation test was also used to investigate the correlation among the blood parameters. The logistic regression model was used to predict the accidents based on the study variables. The significance value was set at 0.05 for all tests.

Results

Results of demographics and factors related to the occupation of the studied drivers are presented in Table 1. As seen, the mean and SD of the age of drivers with and without accident experience were 48.28±9.1 and 45.30±8.6, respectively, based on which the relationship between age and driving accident was significant (P-value = 0.05). BMI of 88.5% of drivers was in the overweight and obese classes. The relationship between the accidents and continuous driving hours was also significant ($P \leq 0.05$). The average rest time of driving in 24 hours was 8.7, and over half of the studied population (58.5%) rested less than 8 hours. The average exercise time per week was highly trivial and less than 1 hour. The relationship between the exercise hours per week and accidents was also significant ($P \leq 0.05$). According to the smoking status investigation, over two-thirds of drivers (67.5%) were smokers, and the connection between smoking and accident was statistically significant ($P \leq 0.05$).

Investigation of accidents and near-misses showed that 74% and 98% of the studied drivers had experienced at least one accident and near-miss during their working time within the past 5 years. The descriptive statistics on such accidents are provided in Table 2. As observed, the total number of accidents and near-misses was 1071, out of which 291 (20.45%) and 852 (76.55%) were accidents and near-misses, respectively.

Based on investigations of various kinds of accidents, the most frequent type was a collision with a car, followed by a collision with a barrier. Collision with passenger and car rollover was responsible only for a few road accidents. In terms of the accident cause from the drivers' viewpoint, 44% blamed themselves for the collision with another car, while 27.5% considered themselves innocent. In total, most drivers left the question unanswered whether they were guilty or not (Table 2).

Table 1. Demographic and job-related characteristics of the drivers in the study (n=200)

	Variable	Mean ± SD: No Accident	Mean ± SD: Accident	Mean ± SD: Total	Min-Max	Category (%)				P-value
Demographic	Age (year)	45.30±8.6	48.28±9.1	47.5 ± 9	30 - 70	<40	40-50	50-60	60<	0.05
						23.5	34	36	6.5	
	Height (cm)	173.6±6.5	172.7±6.6	173 ± 6.6	157 - 189					0.484
	Weight (Kg)	84.7±11.4	83.36±11.8	83.7 ± 11.7	58 - 132					0.426
	BMI (Kg/m²)	28.02±2.9	27.86±3.01	27.9 ± 2.9	21.85 - 40.74	<18.5*	18.5-24.9*	25-29.9*	30<*	0.717
						0	11.5	69	19.5	
Job-related	Driving hours (in 24 hours)	11.07±2.5	10.52±2.5	10.66 ± 2.5	5- 16	<8	8-10	10-12	12<	0.201
						22	33.5	20.5	24	
	Continuous driving hours	5.62±1.7	6.38±2.06	5.82 ± 1.8	3-10	<4	4-6	6-8	8<	0.020
						24.5	43.5	22	10	
	Rest hours (in 24 hours)	8.71±1.05	8.69±1.1	8.7 ± 1.12	6-12	<8	8-10	10-12	12<	0.934
						58.5	36	5.5	0	
Exercise hours (in a week)		1.15±1.03	0.84±1.04	0.92 ± 1.04	0-5	None	1&2	3&4	5≤	0.030

The status of each blood parameter among the drivers against the reference values is shown in Fig. 1. As seen, most drivers were normal in terms of WBC, RBC, hemoglobin, and platelets, while 22.5%, 29%, and 26% of drivers were abnormal in terms of fasting blood sugar, total cholesterol, and triglyceride, respectively. There was no significant difference between the blood parameters among the drivers with and without accident experience (P > 0.05).

Table 2. Descriptive statistics of the incident during the last 5 years in the study (n=200)

Incident	Number	Percent	The driver's fault? Yes (%)	No (%)	None (%)
Car crash with another vehicle	183	83.56 □	44	27.5	28.5
Pedestrian accident	7	3.20 □	1	2.5	96.5
Collision with barriers	23	10.50 □	3.5	5	91.5
Vehicle overturning	6	2.74 □	1.5	1.5	97
Total accidents	219	20.45 □□	12.5 †	9.1 †	78.4 †
Near-miss accidents	852	79.55 □□			
Total	1071	100			

□ Percentage of total accidents
□□ Percentage of total incidents
† The average response

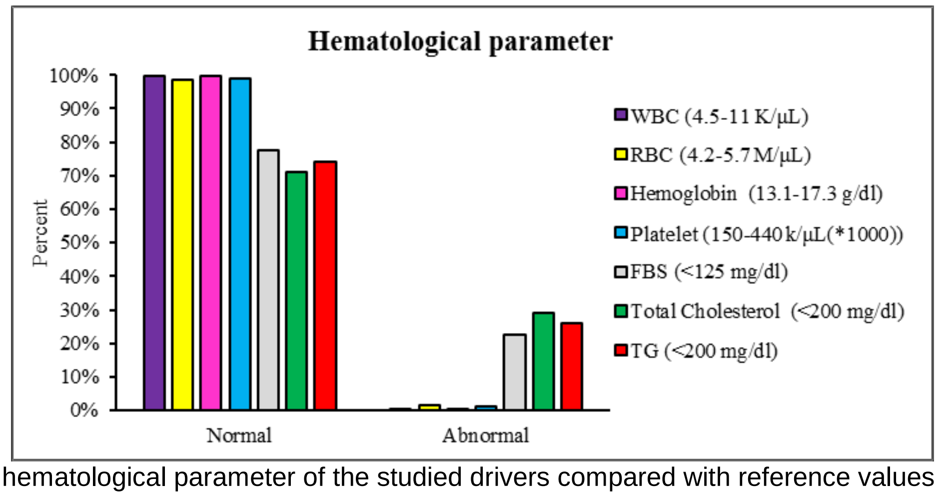

Fig. 1. Status of the hematological parameter of the studied drivers compared with reference values

Table 3. Descriptive statistics of the hematological parameter in the study

Hematological parameter	Mean (95% CI)	Median±IQR†	Percentile					Normality parameter ‡	
			5	25	50	75	95		
WBC□ (10^3/μL)	6.52 (6.32-6.72)	6.2 ± 2.17	4.80	5.32	6.20	7.50	9.39	0.75	-0.26
RBC□ (10^6/ μL)	4.97 (4.92-5.02)	4.95 ± 0.60	4.36	4.69	4.95	5.30	5.50	0.07	-0.60
Hemoglobin (g/dl)	15.53 (15.38-15.68)	15.50 ± 1.67	13.7	14.7	15.5	16.4	17.1	-0.09	-0.93
Platelet* (10^3/μL)	274.4 (262.9-285.9)	260 ± 145	165	200	260	345	420	0.34	-0.94
FBS□ (*mg/dl*)	107.9 (105.5-110.4)	107 ± 27.75	81.1	94.2	107	122	136.9	0.56	0.23
Total Cholesterol (*mg/dl*)	185.6 (179.1-192.1)	165 ± 67	140	153	165	220	288.9	1.11	-0.06
Triglycerides (*mg/dl*)	160.31 (153.9-166.7)	137 ± 72	120	128	137	200	250	1.05	-0.33

□ WBC: White Blood Cells; RBC: Red Blood Cells; FBS: Fasting Blood Sugar;
† IQR: Inter-quarter range;
‡ Amount of skewness and kurtosis for each hematological parameter

The descriptive statistics for blood parameters, including mean (confidence interval of 95%), median, interquartile range, percentiles of 5, 25, 50, 75, and 90, as well as the values of skewness and kurtosis, are presented in Table 3. Based on this table, mean (95% CI) for indices of WBC, RBC, hemoglobin, platelets, fasting blood sugar, total cholesterol, and triglyceride were 6.52 (6.32-6.72), 4.97 (4.92-5.02), 15.53 (15.38-15.68), 274.4 (262.9-285.9), 107.9 (105.5-110.4), 185.6(179.1-192.1), and 160.31 (153.9-166.7), respectively.

According to the Kolmogorov-Smirnov test, none of the blood parameters had normal distribution ($P < 0.05$). Hence, the Kruskal-Wallis and Mann-Whitney U tests were used to investigate the connection between the research variables and blood parameters, as provided in Tables 4 and 5. The investigation of the age impact on the blood parameters in two groups of drivers aged less and more than 50 years old showed a significant difference between the averages of these two groups for FBS, cholesterol, and triglyceride (Table 4). In other words, age affected the increase or decrease in these three blood indices, while it had no significant impact on the others. Regarding the impact of BMI (in three groups of normal, overweight, and obese) on the blood parameters, a significant difference was observed between three levels of BMI, FBS, cholesterol, and triglyceride. $P < 0.001$ for these variables showed that at least one BMI group differed significantly from others. Hence, to more accurately assess the impact of BMI on FBS, cholesterol, and triglyceride and find the group/groups with significant differences, the Tukey post hoc test was used. According to the test results, a significant difference was observed among normal, overweight, and obese groups in terms of blood sugar ($P < 0.05$). The mean of the normal group was less than the overweight and obese groups, and it was the same for the obese group than the overweight. While normal and overweight groups were the same in terms of cholesterol ($P > 0.05$), the normal and overweight groups were significantly different from the obese group in terms of cholesterol ($P < 0.001$). Based on a pairwise comparison of BMI groups in terms of triglyceride values, the assumption of equal means between two normal and overweight groups and the obese group was rejected ($P < 0.001$), while this assumption was conformed between the normal and overweight groups ($P = 0.099$).

Table 4. Effect of age and BMI on the value of the hematological parameter in the studied drivers

Hematological parameter	Age effect		P-value	BMI effect			P-value
	≤50	50<		Normal †	Overweight †	Obese †	
WBC□ (10^3/μL)	6.44±1.37	6.61±1.49	0.471	6.36±1.26	6.59±1.42	6.38±1.58	0.397
RBC□ (10^6/ μL)	4.93±0.34	5.02±0.36	0.123	4.95±0.39	4.97±0.35	4.98±0.33	0.951
Hemoglobin (g/dl)	15.59±1.06	15.45±1.10	0.398	15.50±1.34	15.55±0.99	15.48±1.19	0.925
Platelet (10^3/μL)	275.8±79.5	272.7±86.4	0.532	291.1±96.8	266.9±79.8	289.1±79.1	0.217
FBS□ (*mg/dl*)	112.3±16.8	102.7±17.6	<0.001	95.6±9.8	104.3±15.5	129.5±13.3	<0.001
Total Cholesterol (*mg/dl*)	196.0±52.8	172.9±33.2	0.007	158.6±10.1	175.0±39.7	242.2±39.7	<0.001
Triglycerides *(mg/dl)*	170.0±51.1	148.4±35.2	0.002	131.7±8.2	149.7±39.2	218.2±35.3	<0.001

□ WBC: White Blood Cells; RBC: Red Blood Cells; FBS: Fasting Blood Sugar;
† Normal: 18.5≤BMI≤24.9; Overweight: 25≤BMI≤29.9; Obese:30≤BMI, Ref:[16]

Table 5. Effect of driving hours and smoking on the value of the hematological parameter in the studied drivers

Hematological parameter	Driving hours effect †		P-value	Smoking effect		P-value
	≤10 hr	10 hr<		Yes	No	
WBC□ (10^3/µL)	6.49±1.37	6.56±1.50	0.950	6.54±1.50	6.48±1.27	0.928
RBC□ (10^6/ µL)	5.01±0.36	4.92±0.33	0.116	4.99±0.36	4.93±0.34	0.350
Hemoglobin (g/dl)	15.50±1.12	15.57±1.02	0.662	15.47±1.09	15.65±1.04	0.234
Platelet (10^3/µL)	278.3±84.2	269.4±80.4	0.579	276.8±80.2	269.2±87.3	0.399
FBS□ (*mg/dl*)	102.7±16.7	114.4±16.9	<0.001	109.3±19.3	105.2±13.5	0.281
Total Cholesterol (*mg/dl*)	174.1±35.5	199.9±54.1	0.003	189.7±47.0	177.0±44.3	0.037
Triglycerides (*mg/dl*)	149.8±36	173.3±53.1	0.003	165.3±46.4	149.8±43.0	0.011

□ WBC: White Blood Cells; RBC: Red Blood Cells; FBS: Fasting Blood Sugar;
† Driving Hours in the 24 Hours

Based on results in Table 5, driving hours and smoking affected both values of cholesterol and triglyceride, such that their mean values for the drivers who were driving 10 hours and less round the clock and did not use cigarettes were significantly less than those smoking and driving over 10 hours round the clock. Another parameter influenced by the driving hours round the clock was FBS, the mean of which increased by this element ($P \leq 0.001$). Concerning the rest hours (less and more than 8 hours per day), this variable did not impact the blood parameters.

Fig. 2 shows the outcomes of the accident and near-miss statistics for each blood parameter for drivers. In this diagram, the frequency percentage of drivers who were abnormal in terms of each blood parameter is given per the number of accidents (i.e., without accident, one case, more cases, and more) and near-misses (without near-miss or one case, 2-5 cases, 6 cases, and more). The groups with a significant difference, including RBC, FBS, and TG, are shown in hatched. The level of significance for RBD with several accidents is 0.043 and for FBS and TG with some near-misses is 0.011 and 0.017, respectively.

To investigate the relationship and dependence of blood parameters on each other, the Spearman correlation coefficient was used. Results (Table 6) showed a positive correlation between the blood hemoglobin & WBS, FBS and cholesterol & TG, and cholesterol & TG. Also, a negative correlation was also observed between the hemoglobin and blood platelet, which was statistically significant ($P < 0.05$). It was found that the normal and abnormal status of FBS and cholesterol correlated positively with that of TG, with a larger correlation coefficient than the quantities of these parameters.

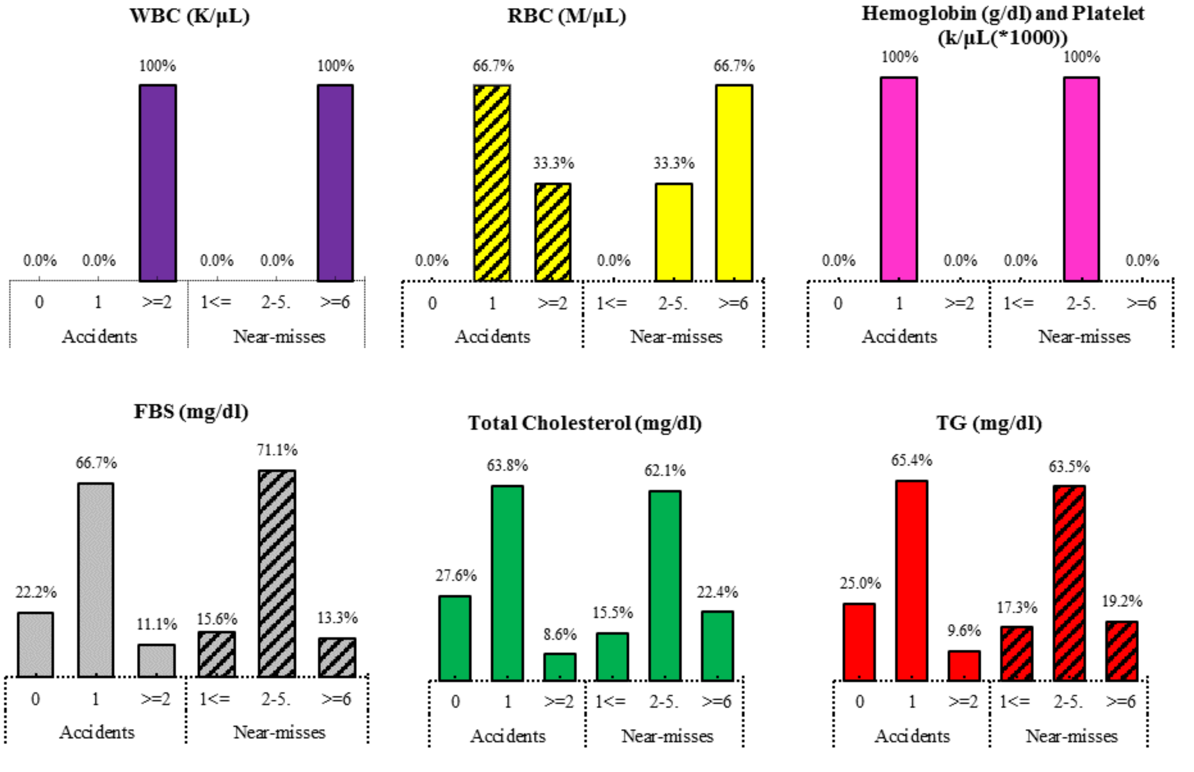

Fig. 2. Frequency distribution (%) of drivers with abnormal blood parameters according to number of experienced accidents and near-misses accidents (hatchings: P-value<0.05)

Table 6. Correlation between hematological parameters in the study (n=200)

Correlation between variables		R	P-value
Hemoglobin (*g/dl*)	WBC* (*10³/µL*)	0.186	0.008
	Platelet (*10³/µL*)	-0.139	0.050
FBS* (*mg/dl*)	Total Cholesterol (*mg/dl*)	0.690	<0.001
	Triglycerides (*mg/dl*)	0.711	<0.001
Total Cholesterol (*mg/dl*)	Triglycerides (*mg/dl*)	0.896	<0.001
FBS* (*mg/dl*) (N/Ab)	Total Cholesterol (*mg/dl*) (N/Ab)	0.764	<0.001
	Triglycerides (*mg/dl*) (N/Ab)	0.800	<0.001
Total Cholesterol (*mg/dl*) (N/Ab)	Triglycerides (*mg/dl*) (N/Ab)	0.927	<0.001

* WBC: White blood cells; FBS: Fasting blood sugar; N/Ab: Normal or Abnormal

The logistic regression model was used to investigate the predicting effect of road accidents based on the research variables, the results of which are given in Table 7. As seen, the inclusion of variables of age, exercise hours, number of cigarettes, and blood hemoglobin (the only one among the blood parameters) affected the accidents. The beta coefficient of age, number of cigarettes per day, and hemoglobin with road accidents were positive, i.e., 0.037, 0.111, and 0.312, respectively. It was negative for exercise hours per week, i.e., -0.462.

Table 7. Logistic regression model for variables affecting the occurrence of accidents in the study

Variables	β	P-value	ODDS	95% CI for ODDS
Age	0.037	0.043	1.038	1.001-1.076
Exercise hours	-0.462	0.050	0.630	0.393-1.010
Number of cigarettes	0.111	0.043	1.118	1.004-1.245
Hemoglobin (*g/dl*)	0.312	0.035	1.367	1.022-1.829

Discussion

In recent decades, scholars have been interested in studying the blood parameters of drivers. However, most studies have intended to investigate the impact of air pollutants and personal–environmental stresses on the blood parameters and their connection to cardiovascular diseases among the drivers [17-19]. The present study has directly assessed the connection and impact of blood parameters on accidents. Traffic accidents, as predictable and preventable events, are considered among the most important problems with health in the current era, particularly in developing countries [20, 21]. As a result, the characteristics and accidents of drivers are first described, and then each parameter's relationship and odds ratio to the accident is analyzed.

Based on the results, over half of the studied drivers were less than 50 years old, and most had BMI over 25 kg/m2 (Table 1). The relationship between the drivers' age and possible accidents was significant, such that most accidents had occurred among the drivers with a higher age average; this finding is consistent with that of Seyed-Mahdi et al., who found out that age over 60 years old increased the risk of road accidents significantly [22]. However, no significant relationship was found between BMI and accidents. The reason was possibly the high BMI among most drivers, such that 88.5% were categorized in overweight and obese classes. In contrast, based on Stoohs et al., the risk of accidents increased among obese people [23]. Similar to the current study, higher values of BMI among the drivers have been confirmed in many studies [24-27]. Investigating the demographics of autobus drivers in Tehran, Soori et al. reported the mean and SD of BMI as 26.38 and 2.1, respectively, and prevalence of overweight and obesity as 78% and 3.85%, respectively, which were highly consistent with the present research [28].

Continuous driving hours, using cigarettes, and exercising were confirmed as the factors affecting the accidents. Similar to Jahangiri et al. [12], the average driving hours among the drivers with accident experience were significantly higher than those without (6.38 hours vs. 5.62 hours). On the other hand, many studies conducted on the drivers of heavy vehicles have reported smoking as a factor with high frequency [28-30]. In this study, it was also found that 67.5% of drivers were smoking, which was higher than in Hedber et al. (36.3%) [31], Bigert et al. (49% for truck drivers and 32% for autobus drivers) [29], and in public populations, while it was similar to Yazdi et el. (69.8%) [32]. In the present study, the impact of smoking on the accident was significant, possibly due to its impact on the nervous system and the intervention in understanding and perception, judgment, and reaction time of driver to other environmental stimuli and others' behaviors [33]. Similar to other studies [29], a low percentage of participants had regular physical activity and exercise. However, it became clear that the exercising hours per week affected the accident; 46% and 9.5% of drivers exercised up to 2 hours and 3-5 hours per week. Despite the low hours of exercise among the drivers, a significant relationship was observed between the occurrence of accidents and exercise hours; those drivers who were exercising experienced fewer accidents than those with no exercise per week.

In the recent 5 years, drivers (200 persons) experienced a relatively high number of accidents and near-misses (1070 cases), of which 219 cases were accidents and 852 near misses, being higher than other studies. In a study among the heavy vehicle drivers referred to the credible centers of drivers examination, Seyed-Mahdi et al. reported that 88 accidents had happened within a year for 1136 drivers [22]. In another study in Iran, the number of accidents was similar for the drivers of heavy vehicles [34]. According to the comparison of the present study and the studies above, the number of accidents per driver in the former was much higher, while the number of near-misses of the same extent increased. Further, it was revealed that car collisions and collisions with barriers were more common than collisions with passengers and rollovers. Drivers mostly encountered heavy vehicles and fewer passengers, explaining why car collisions and barriers were more likely to occur.

In this study, normal limits for blood parameters of drivers were taken as below: 4.5-11 k/µL for WBC; 4.2-5.7 M/µL for RBC; 13.1-17.3 g/dl for HG; 150-440 k/µL (*1000) for Ptl; <125 mg/dl for FBS; <200 mg/dl for cholesterol and TG. The mean and SD values for the parameters of WBC, RBC, HG, Plt, FBS, cholesterol, and TG were obtained as 6.52±1.4, 4.97±3.5, 15.53±1.08, 274.4±82.5, 107.9±17.7, 185.6±46.4, and 160.3±45.8, respectively. Comparing the mean of each parameter with the normal limits showed the average of all blood parameters to be normal among the drivers. Ansari-Moghaddam et al. (2016) reported the mean and SD of blood parameters among the non-smoking drivers for RBC, FBS, cholesterol, and TG as 5.63±2.3, 96.04±35.2, 198.47±58.9, and 157.78±29.5 mg/dl, respectively [35]. Jahangiri et al. (2017) reported the mean and SD of FBS, cholesterol, and TG as 109±15.7, 210±39, and 205±8 mg/dl, respectively [12], being higher than the normal values compared to the present study. On the other hand, based on this study, over one-third of the studied drivers had values higher than the normal limits in the most important parameters, i.e., FBS, cholesterol, and TG, while in other parameters, drivers had normal status in more than 98% of cases. Wang and Lin reported a prevalence of 34% and 69.4% for cholesterol and triglyceride, respectively [26]; from this perspective, the status of drivers in the present study is better than in their study.

In some studies, poor diet (high-fat and high-calorie foods during travel), inactivity, sleep problems, shift work, psycho-social issues, driving stress, smoking, and environmental pollution (carbon monoxide, lead, and noise) were mentioned as factors that contribute to the prevalence of high values of FBS, cholesterol, and triglyceride among the drivers [24, 36]. In contrast, the prevalence of hypertriglyceridemia, diabetes, and high cholesterol among the drivers was reported in other studies [25, 35, 37]. Disorder in body circadian rhythm due to the shift work and sleep disorder in derivers' stratum per se, in turn, leads to the disorder in body lipid profile and metabolic process; hence, it can be discussed as a reason for the high value of some blood parameters among the drivers than other occupational groups [32].

In connection to demographic and occupational factors, the impact of age over 50 years old, three levels of BMI (normal, overweight, and obese), driving hours more than 10 hours per day, and smoking were significant on FBS, cholesterol, and TG. Ansari-Moghaddam et al. stated that the variables of age (over 40 years old) and smoking affected FBS and cholesterol synergistically [38]. In other studies, smoking by itself was expressed as an effective factor in increasing the rate of FBS, cholesterol, and TG among the drivers [25, 39]. No significant difference was observed between normality or abnormality of blood parameters and the occurrence or non-occurrence of accidents. However, there was a significant relationship between the accident and near-miss number and some blood parameters. According to these findings, although it is impossible to claim that the abnormal status of blood parameters is a reason for potential accidents, exceeded conditions in blood parameters, particularly in RBC, FBS, and TG, can increase the frequency of accidents and near-misses among the drivers significantly. Based on results (Diagram 2), almost in most blood parameters, a higher percentage of drivers experienced 1 accident and 2-5 near-misses. All drivers in the abnormal situation of WBC, RBC, HG, and Plt indices, had over one accident and two near-misses.

Meanwhile, for FBS, cholesterol, and TG, the percentage of drivers with one accident and 2-5 near-misses was much more than the drivers without accidents and one near-miss and less. Generally speaking, most drivers with an abnormal state have experienced at least one accident and near-miss in terms of blood parameters. High rates of parameters, especially FBS, can disturb the skills needed for safe performance and guidance of vehicles, such as the reaction time and visual acuity, thus likely increasing the risk of accidents [40]. While Jahangiri et al. showed no significant relationship between the drivers' blood parameters and road accidents, it was determined that the drivers with road accident experience had higher TG rates [12]. At last, in addition to affecting the frequency of accidents, abnormal blood parameters can be very worrying because it increases the risk of cardiovascular diseases among drivers.

Spearman correlation analysis showed a strong and positive association of FBS rate with cholesterol and TG, such that an increase or decrease in FBS directly affected the cholesterol rate (r = 0.690) and TG (r = 0.711). Thus, the impact of normal/abnormal FBS on the status of cholesterol and TG was higher than its numerical values, with r = 0.764 and r = 0.800, respectively. A strong and positive correlation was observed between the numerical values and the normal/abnormal status of cholesterol and TG (r = 0.896 and r = 0.927, respectively).

Logistic regression analysis showed the presence of variables of age, exercise hours, smoking, and hemoglobin in the regression model to be statistically significant. The older the drivers, the more cigarettes they use per day, and the more their blood hemoglobin values, the more likely the accidents are to occur. While the more hours are devoted to exercise per week, the less likely the accidents are to occur. The highest predicted rate of the model was related to the blood hemoglobin, 1.367 (1.022 – 1.829), followed by the number of cigarettes per day, 1.118 (1.004 – 1.245). In other studies (e.g., Borucka et al. [41] and Batouli et al. [42]), the numerical value of ODDS for the driver's age was reported as 1.02 and 1.02-1.07, respectively, being highly close to the present research results. In comparing the results of the logistic regression model to other variables affecting accidents, no similarly designed study was found.

The study's strength is its innovative nature, based on which it directly examines the relationships between many blood parameters and accidents, as well as using actual accident data and information about drivers with prior accidents. However, due to being cross-sectional, this study may come with limitations of such studies, i.e., the impossibility of proving the cause and effect relationship.

Conclusion

The present study supports the proposition that the status of drivers' health in terms of blood parameters, particularly indices of HB, FBS, cholesterol, and TG, can influence their safe performance and road accidents. Therefore, close attention to the physical health and welfare of drivers through encouraging them to exercise, maintain an appropriate diet, quit smoking, control sleep, as well as their shift work, stress management, mental tension, and fatigue, can play a critical role in improving the status of blood parameters and reducing the number of road accidents. In future studies, the effects of such cases on blood parameters and traffic accidents are suggested to be addressed.

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