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Research Paper

Drivers' speed choice behavior considering drivers' demographic characteristics: A driving simulator study

Mehdi Zolali [1], Babak Mirbaha [2,*], Arman Saffarzadeh [3]

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Abstract

The present study investigates the Iranian drivers' characteristics and tries to determine which factors can affect the drivers' speed selection behavior. Therefore, drivers' who choose speeds higher than the 85th percentile speed were examined, mainly because of the importance and effectiveness of higher speeds in crash occurrence in Iranian roads. For this purpose, a driving simulator was used to conduct the research and gathering the drivers' selected speed while driving in scenarios. Six scenarios were used in the driving simulator based on the visibility conditions, and 70 participants were evaluated through the driving simulator. Using the t-test, speed data differences in six scenarios have proved. Results showed that age, education level, and gender affect drivers' perception of speed and speed selection. The age of the participants affected the selected speed negatively, which means that increases in the drivers' age can cause selecting speeds lower than the 85th percentile of speed. The higher education level in the present study was the PhD, and results indicated that participants who were categorized in the higher level of education tried to decrease their speed more than others. Also, results indicated that drivers who selected speeds higher than the 85th percentile of speed experienced at least one accident during the driving task in the driving simulator.

Keywords: speed selection; drivers' behavior; driving simulator; weather conditions

* Corresponding author. E-mail: bmirbaha@gmail.com
1 Civil Engineering Department, Faculty of Engineering, Imam Khomeini International University, Qazvin, Iran.
2 Civil Engineering Department, Faculty of Engineering, Imam Khomeini International University, Qazvin, Iran.
3 Civil Engineering Department, Faculty of Engineering, Shahid Beheshti University, Tehran, Iran.

1. Introduction

All of us live in a world with various types of threats to humans, which causes their death and injuries. One of the most severe issues which endanger human life is driving. Every year thousands of people die or injure on roads, which has an important effect on the economy and world health. Typically, governments spend a considerable amount of money supporting and nurturing people from born to adulthood. However, when people die in an accident, especially at their young ages, the governments' investigation vanishes in a second, which is a severe failure for each government. From the statistics point of view, according to a published report of the National Highway Traffic Safety Administration (NHTSA), 1,830 drivers in age between 15 and 20 died in motor vehicle crashes in 2017, and according to the National Center for Health Statistics, vehicle crashes are the main reason of 15-to-20-year-olds drivers' death [NHTSA, 2019]. In this respect, the statistics relevant to the death rates in crashes are noticeably higher in Iran. According to the last statistics of the Iranian Legal Medicine Organization, in the first ten months (March 2019 to January 2020) of the recent year in Iran, about 14,500 people have died in road crashes, and about 300,000 people have injured [ILMO, 2019](Anon 2019). The first step to decreasing death rates is finding the factors associated with the crash occurrence and studying them. During the driving task, drivers have to interact with three main factors. The first two factors are the road and vehicle. The third factor in the driving task is the driver or human who controls the vehicle and chooses a driving method. Drivers can choose their speed, braking time, maneuver, passing time, and other factors considered driving behavior. Thus, it is essential to study the drivers' behavior, especially behaviors that can increase the potential of collision and crash by making wrong decisions on the roads.

Among the different factors that involve in motor vehicle crashes, speeding has a high frequency. In 2017 studies showed that young male and female drivers were more likely to be accompanied by speeding than other age groups at the time of the fatal crashes. In this respect, males in comparison to females were more speeding in these crashes. Statistics demonstrated that in 2017, there were 37,133 traffic fatalities in the United States of America, which 9,717 (26%) were in crashes where at least one driver was speeding (violation of speed limit) [NHTSA, 2019].

In addition to speed factors, roadway and weather conditions have a significant impact on drivers' behavior and crash rates, too. Therefore, drivers must pay attention to the weather conditions while driving and adequately evaluate the driving conditions. According to the statistics in 2017, speeding was a factor for 16% of fatal crashes on dry roads and 84% of fatal crashes in other roadway surface conditions like wet, snow, and ice [NHTSA, 2019]. This data shows that drivers should be more careful and choose the proper driving speed at wet conditions.

This study analyzes the Iranian drivers' behavior in different weather conditions to determine the drivers' characteristics that enhance crash probability. Participants in this study had unique characteristics such as age, gender, driving experience, and education level. Based on these characteristics, we tried to find the plausible relationship between participants' characteristics and tendency to higher speed selection, enhancing the crash occurrence potential. Also, participants were examined in various weather conditions such as night and foggy conditions to evaluate the effect of weather conditions on

higher speed selection behavior. For this purpose, using a driving simulator, a two-lane driving path with six different scenarios (with varying conditions of visibility) is simulated for assessing the drivers' speed choice behavior. Drivers' personal information and their characteristics such as gender, age, driving experience, education level, and accident information were collected through the questionnaire. In order to achieve the goal of this study, two foggy conditions scenarios as the light fog and heavy fog were simulated which both were simulated in daylight and nighttime scenarios. Previous studies have analyzed the drivers' behavior in various weather conditions. However, the focus of the current study was to analyze the drivers' behavior in all possible lighting and visibility conditions. Analyzing has been conducted based on various characteristics factors that influenced drivers' behavior. Moreover, the driving performance examination has been performed in many countries except Iran. Since the participant from different countries probably had different characteristics, we designed the presented research for Iranian people to examine their characteristics' effects on the driving behaviors.

The rest of this paper's structure can be summarized as follows. In the second section, Previous studies have been examined. In the third section, the methodology description, including participants, driving simulator, scenarios, and modeling procedure, is presented. The fourth section explained the collection of data and analyzing them. Then, in the next section, the results of the statistical data analysis are presented, and the effect of different factors on the speed choice of drivers is discussed. The conclusion of the paper and recommendations for future research is presented in the last section.

2. Background

Driving is a complex act in which every one based on his or her characteristics, has specific behavior in various roadway or weather conditions. As a researcher, studying the drivers' behavior and recognizing their manners in different situations could enhance safety and, consequently, save lives. In this respect, several studies have concentrated on driving behaviors influenced by drivers' age, gender, experience, and so forth. [Broughton et al. 2007; Cai et al. 2020; Fu et al. 2020; Konstantopoulos et al. 2010; Lee et al. 2020; Li et al. 2015; Mueller and Trick, 2012; Ni et al. 2010; Pan et al. 2020; Zhang et al. 2018]. Also, some of them have studied the impact of weather condition, like foggy condition, and visibility on drivers' behavior and speed selection [Bella et al. 2014; Brooks et al. 2011; Calvi and Bella, 2014; Hamdar et al. 2016; Hoogendoorn et al. 2011; Liu et al. 2020; Rahman and Lownes, 2012; Yan et al. 2014; Yang et al. 2019].

In a study aiming to recognize the crash risk factors that can affect the severity of teenage drivers' injuries, researchers found that "age" considerably affects teenage drivers' injury severity. Results revealed that teenage drivers who were between 15 to 18 years are more likely involved in severe crashes than 19-year-old drivers. This result illustrates that drivers are less prone to severe injuries by increasing the driving experience. Moreover, when young drivers (16 to 19 years old) drive with occupants, they experience a relatively higher number of crashes rather than when they drive alone. The reason is probably careless driving or without paying attention to driving due to talking with occupants. Additionally, female teen drivers are less prone to sustain severe injuries compared to males teen driver [Duddu et al. 2019].

Papantoniou et al. (2019) have experimented and have found that drivers' characteristics, including gender, age, education, and driving experience, are the critical factors in the occurrence of driving errors. Results show that older drivers, similar to female drivers, are more likely to commit errors during driving. Since young drivers possess better physical and mental conditions when compared to older drivers, they are less likely to commit errors even in distraction situations. On the other hand, experience and education reduce both young and old drivers' likelihood of committing driving errors [Papantoniou et al. 2019]. Another study that has proved these findings say that training can improve the hazard anticipation and attention maintenance performance of careful drivers [Zhang et al. 2018]; this means that higher experience, maybe through training, can improve driving skills and decrease errors.

For surveying the lighting effect conditions on driver's behavior, a study by Gilandeh et al. revealed that drivers choose the higher speed in daylight conditions compared to dark lighting conditions [Gilandeh et al. 2018]. This result confirms previous studies' results [Bella et al. 2014; Jafari Anarkooli and Hadji Hosseinlou, 2016; Rumar 1998], which illustrated that in darkness, the limited visibility of drivers could significantly impact their perception and expectations for road alignment. Consequently, drivers' behavior will be different in daytime and nighttime, particularly in speed choice [Gilandeh et al. 2018].

In another research to study younger and older drivers' behavior, Shuo Li et al. (2019) analyzed drivers' behavior. They concluded that younger drivers need less time to do their tasks; conversely, older drivers require a longer time to control the vehicle. Besides, older drivers need more time to change their driving lanes to avoid collisions with stationary cars [Li et al. 2019]. All of these results show that younger drivers are agile than older drivers.

3. Method

In every study, researchers using some instruments collect and obtain data to analyze and get results. Typically, there are three main parts in a driving simulator study to conduct the experiment and collect data. These parts are a human as a driver, a driving simulator, and a scenario with some unique features based on the researchers' aims and type. In this study, like previous studies, we used a driving simulator with a designed scenario to investigate the drivers' behavior and collecting data. Further information about the participants, the driving simulator, and the experiment procedure will be described in the following sections.

3.1. Participants

In this experiment, 75 persons (including 47 men and 28 women) participated in performing the driving tests in the traffic lab. The drivers' selection for the driving tests and the whole experiment procedures were performed at the traffic safety lab in Tabriz city, Iran. Figure 1 shows the statistics of the drivers' characteristics descriptively. Four men and one woman had difficulty finishing the experiment (feeling tired or dizzy), so their data were excluded from the entire database. The speed data relevant to the remaining 70 participants were then collected and analyzed to get the results.

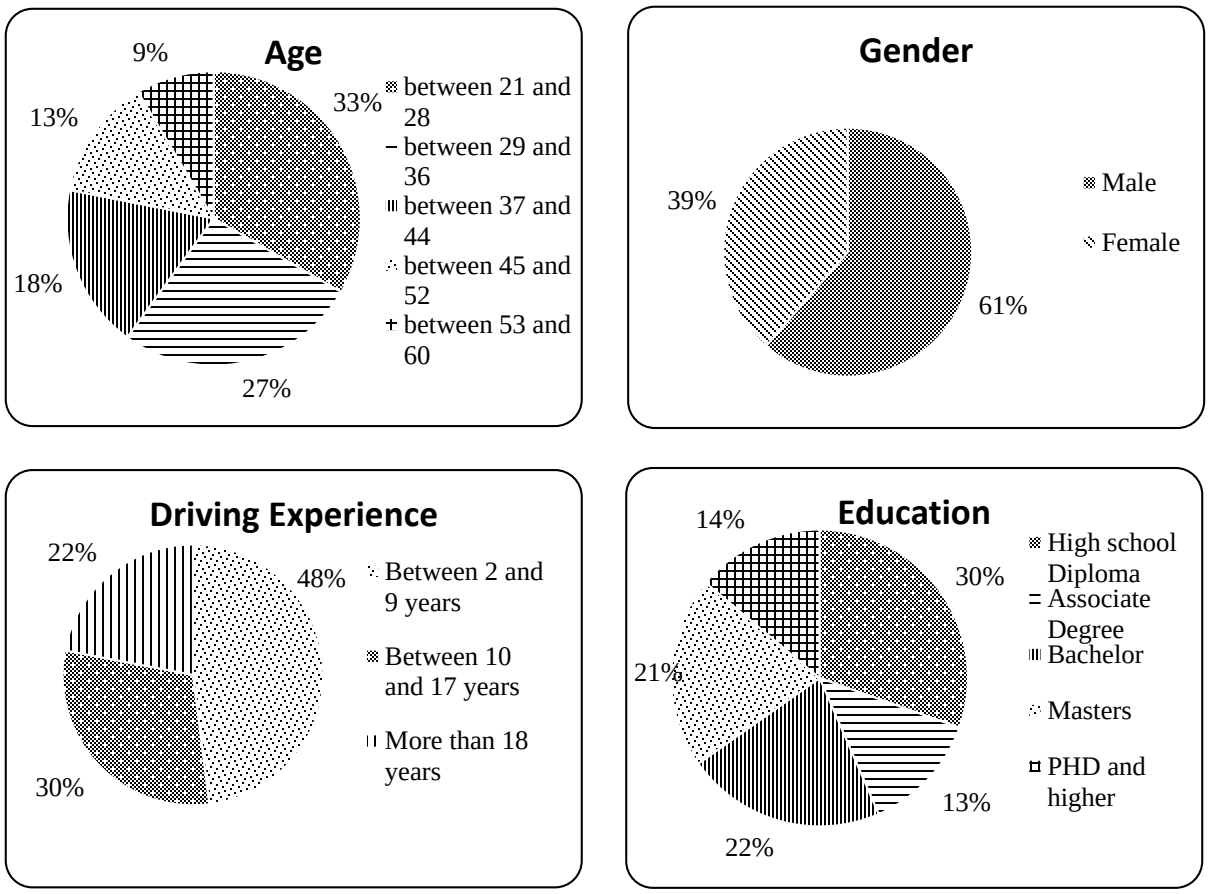

Figure 1. Participants' characteristics information

3.2. Driving Simulator

In the present study, a designed driving simulator was used to conduct the driving tests (Figure 2). The driving simulator had an unfixed platform and features typical in many cars, such as a steering system, accelerator, brake pedals, shock absorbers, and a manual gearshift. Therefore, all of the means used during the driving were installed on the driving simulator like a typical car. This similarity caused participants' familiarity with the simulator working. As it is mentioned, the driving simulator was created on an unfixed platform. The platform was moving in the vertical direction when the drivers passed a speed bump. Moving in the vertical direction was considered a shock absorber to convey the true feelings from the road bumps.

Besides this equipment, the driving simulator had an audio system. The audio system played the driving simulator engine sound and sounded from other vehicles on the simulated road. All of these facilities were installed on the driving simulator to improve the reality of driving. Moreover, the driving simulator interior was very similar to the actual cars used by most of the participants in their daily driving. For displaying the simulated road environment and scenarios, three large LED screens were used. One of these monitors installed in front of the driving simulator and the other two monitors were placed on each side of the first monitor to

display the car's side view. These screens provided a 120° field of view to drivers. There were three mirrors, like typical cars, to see what happens on the road. The central mirror appeared on top of the front screen to show the behind scene of the car. Also, two side mirrors existed on the side screens to show the lateral view of the road. Also, one computer system was connected to the simulator that performed some tasks like rendering the scenarios, processing drivers' behavior, and collecting ordered data. The data-recording system had recorded the parameters related to the driving performance like speed, mean speed, and vehicle positions in the 0.06 seconds period during the experiment. All the recorded positions of the vehicle (x, y, and z) were collected in the virtual environment.

It should be mentioned that the relative validity of the driving simulator was proven in previous studies [Zolali et al. 2021, Zolali and Mirbaha, 2020].

Figure 2. Driving simulator

3.3. Scenario

In order to reach the goal of this study, a two-lane rural road was simulated in the driving simulator. The width of the simulated road was 7 meters with a total length of 12 kilometers, including a 3 kilometers training road and 9 kilometers main scenarios (each scenario had 1.5 kilometers length). The simulated road had no barrier or guardrail; instead, it had a shoulder on each side of the road to help safe driving. There was milepost sign designed to give information about the remaining distance to the end of the scenario. Drivers saw roadside features such as gas stations and markets while driving. At some points, the simulated road had connections to other routes where traffic was flowing. The simulated road had horizontal and vertical markings to inform the drivers about the road situations. In this respect, markings such as cross walking, speed bump, stop sign, speed limit sign, and so forth were shown to the drivers during the driving tasks. Drivers who drive the scenario Horizontal and vertical alignments have been provided to challenge the drivers and their behavior in these situations. In the scenarios, the rural road was simulated with distinctive geometry characteristics, including the horizontal curves (with a length of 212 meters), vertical curves (with a length of 300 meters), and a combination of the horizontal and vertical curves. The geometric characteristics of the simulated road plan are shown in Figure 3. The 90 km/h speed limit sign was installed in the simulated road path on the screen to inform the drivers about the speed limits.

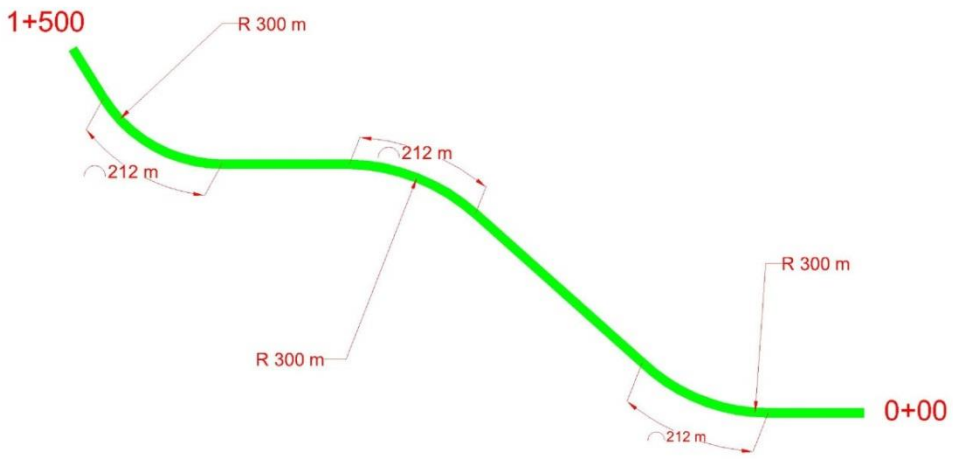

Figure 3. Geometric features of the simulated road

In order to accomplish this study, six scenarios were simulated, and the weather conditions in all of these scenarios were the only variable parameters. The sequential orders of the scenarios were day and clear weather, night and clear weather, day and light fog, day and heavy fog, night and light fog, and night and heavy fog, respectively (Figure 4). Table 1 shows the characteristics and weather conditions of six simulated scenarios.

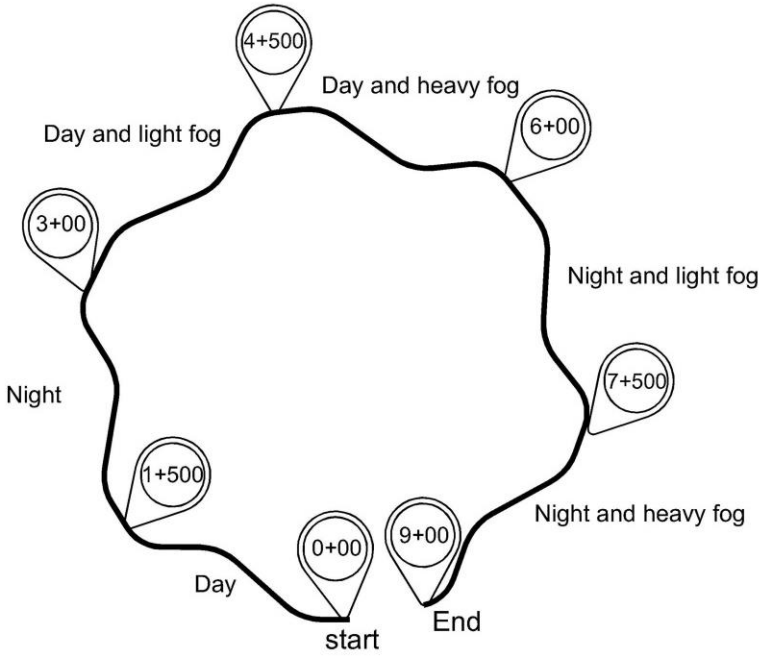

Figure 4. The overall plan of simulated scenarios

Table 1. Characteristics and weather conditions of simulated scenarios

Order of Scenarios	Name of Scenarios	Light of the Ambient	Visibility Conditions
1	Day and Clear Weather	Bright	Without limitation in the visibility
2	Day and Light Fog	Dark	Limited visibility due to darkness
3	Day and Heavy Fog	Bright	Limited visibility due to light fog (light fog's sight distance is about 250 meters)
4	Night and Clear Weather	Bright	Limited visibility due to heavy fog (heavy fog's sight distance is about 50 meters)
5	Night and Light Fog	Dark	Limited visibility due to both darkness and light fog (sight distance in light fog is about 250 meters)
6	Night and Heavy Fog	Dark	Limited visibility due to both darkness and heavy fog (sight distance in heavy fog is about 50 meters)

The type of fog (light fog and heavy fog) was chosen in the present study based on the visibility gap and sight distance. In this respect, Li et al. (2015) and Yan et al. (2014) had chosen 50 meters for simulating light fog conditions and 250 meters for simulating heavy fog conditions as a sight distance [Li et al. 2015; Yan et al. 2014]. In other words, a sight distance limitation of 250 meters means that drivers who drive in the light fog weather condition could not see the pathway beyond the 250 meters distance. Thus, drivers can see a blurred simulated road image at a distance of fewer than 250 meters. The smaller the distance, the better the driver's vision was due to more details in the road environment. Similar to the light fog conditions, heavy fog conditions limited the driver's sight distance, too. Under heavy fog conditions, the sight distance limitation was 50 meters so that drivers could see the road environment at a distance of fewer than 50 meters. Figure 5 shows the simulated environment under light and heavy fog conditions.

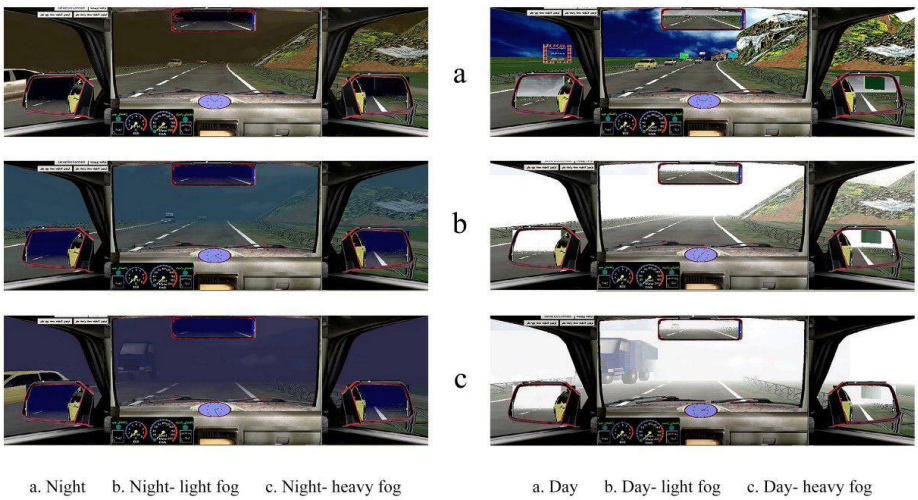

Figure 5. Example screenshots to demonstrate simulated conditions

In the present study, researchers tried to simulate scenarios that allow drivers to drive and select speed based on their preferences without any other variables that may affect their choices. Since traffic congestion has an important effect on speed choice, the simulated scenarios had a good traffic quality that allowed drivers to choose their desired speeds. In other words, the traffic quality in simulated scenarios did not pass the Level of Service C. Therefore; it will give an assurance that traffic conditions or platooning will not have any effect on speed choice behavior.

3.4. Procedure

To collect the research data needed and obtain the desired research results, participants filled out one questionnaire before starting the test. This questionnaire consisted of personal information such as gender, age, education, and participants' driving background, such as years of driving experience, accident rate, license, etc. After completing the questionnaire by the participants, drivers got ready to drive in the driving simulator by receiving a short verbal explanation about the driving simulator and experiment procedures.

The simulation scenario consisted of two main stages, in which the second stage started immediately after the first stage. The first stage was "training drive," and the second stage was "main scenarios." The first stage was simulated to give information about the working process of the simulator to the drivers and make them familiar with the way of simulator controlling. In this way, the drivers could interact with the environment of the driving simulator. During the first stage (training drive), participants had full visibility conditions. They were able to distinguish the characteristics of the road, such as tangents, curves, and signs. The second stage was the "main scenarios," and it started after the first stage. In this stage, any instructions about driving in the scenarios were not given to the participants. It was emphasized that they drove like their normal and actual driving behavior. All the drivers conducted the six scenarios of driving tests in the same sequence to avoid any biased data.

4. Data

Data collection is the most critical part of each research. This study tried to collect the required data from the simulator output in an appropriate and useful way. The output file was in excel (*.xls) format for each participant that provided the location and speed details in every fracture of time. Also, a questionnaire contained characteristics data, and each driver had filled out before starting the test. Both data sets had merged in one excel file that contained simulator and questionnaire data.

4.1. Data Analysis

As a first step, to select the most appropriate statistical test for data analysis, it should be proven that speed data in each of the scenarios has a normal distribution. Therefore, to evaluate the normal dispersion of the data set, the normality test was applied. There are two interrelated approaches to determine normality. The first approach is to calculate summary statistics that measure skewness and kurtosis. The acceptable skewness and kurtosis values to prove normal univariate distribution is between -2 and +2 [George and Paul, 2010]. In Table 2, the results of the skewness and kurtosis calculation are shown. The results demonstrate that speed data in each scenario has a normal distribution.

Table 2. Skewness and kurtosis values

Scenario	N	Skewness		Kurtosis	
	Statistic	Statistic	Standard Error	Statistic	Standard Error
Day and Clear Weather	70	0.321	0.287	-0.294	0.566
Day and Light Fog	70	0.306	0.287	-0.380	0.566
Day and Heavy Fog	70	0.295	0.287	-0.319	0.566
Night and Clear Weather	70	0.852	0.287	0.419	0.566
Night and Light Fog	70	0.426	0.287	0.242	0.566
Night and Heavy Fog	70	0.565	0.287	0.475	0.566

In the second approach and for determining the normality, the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) test results were considered. These two tests compare the data with a normal distribution, which has the same mean and standard deviation of the sample, to determine the normality. If the test result is "NOT significant," the value is above 0.05, and so data are non-normal. Conversely, if the test is "significant," the value is less than 0.05, indicating the non-normality of data [Thode, 2002]. Table 3 shows the results of the Kolmogorov-Smirnov test (K-S) and Shapiro-Wilk (S-W) test. The results indicate that data sets have a normal distribution.

Table 3. Kolmogorov-Smirnov test (K-S) and Shapiro-Wilk (S-W) test results

Scenario	Kolmogorov-Smirnova		Shapiro-Wilk	
	Statistic	Significance	Statistic	Significance
Day and Clear Weather	0.100	0.083	0.982	0.391
Day and Light Fog	0.076	0.200	0.980	0.341
Day and Heavy Fog	0.088	0.200	0.981	0.353
Night and Clear Weather	0.102	0.075	0.971	0.129
Night and Light Fog	0.104	0.061	0.974	0.153
Night and Heavy Fog	0.088	0.200	0.970	0.090

After obtaining assurance about the normality of the data distribution, the data were analyzed to prove the differences between recorded speed data in various environmental conditions. Since each data set had a normal distribution, the t-test analysis was used to show the differences between recorded speed data [Kanji, 2006]. Table 4 illustrates the t-test results in different environmental conditions by showing the P-value parameter. According to these results, the P-value in all scenarios is less than 0.05; therefore, the effect of the various weather conditions on the drivers' speed-choice behavior is significant. In other words, the speeds that the drivers would choose in each weather condition were different from speed-choice behavior in other weather conditions.

Table 4. Results of t-test analysis

Scenario	Day and Clear Weather	Day and Light Fog	Day and Heavy Fog	Night and Clear Weather	Night and Light Fog	Night and Heavy Fog
Day and Clear Weather	-	0.000	0.000	0.001	0.000	0.000
Day and Light Fog	0.000	-	0.000	0.002	0.002	0.000
Day and Heavy Fog	0.000	0.000	-	0.000	0.000	0.000
Night and Clear Weather	0.001	0.002	0.000	-	0.000	0.000
Night and Light Fog	0.000	0.002	0.000	0.000	-	0.000
Night and Heavy Fog	0.000	0.000	0.000	0.000	0.000	-

5. Results and Discussion

5.1. Speed Statistics

The descriptive statistics of the collected speed data from the driving simulator are shown in Table 5. According to the results, the selected speed by drivers in adverse weather conditions' scenarios in which drivers have lower visibility than other scenarios was reduced. For example, at night and in heavy fog conditions, the mean selected speed was 43 km/h, showing more caution of the drivers in lower visibility conditions. In previous studies accomplished by Edwards (1999, 2002), it was indicated that under low-visibility conditions like wet and foggy weather conditions, the drivers' mean speed was decreased [Edwards, 1999; Edwards, 2002]. According to Mueller and Trick (2012), drivers' speed-choice in foggy conditions reduced compared with the clear weather condition [Mueller and Trick, 2012]. In another study, Peng et al. (2018) found out that the mean speeds of drivers in foggy conditions are significantly less than clear visibility conditions. This result showed that speed, the mean of headways, and the standard deviation of headways selected by the drivers in various situations are significantly different [Peng et al. 2018]. These results were in line with the findings of the present study.

Table 5. Speed statistics in each scenario

Scenario	Minimum Speed (Km/h)	Maximum Speed (Km/h)	Mean Speed (Km/h)	Standard Deviation
Day and Clear Weather	39	110	72	15.27
Day and Light Fog	34	96	61	13.22
Day and Heavy Fog	24	80	48	12.35
Night and Clear Weather	40	100	65	13.52
Night and Light Fog	32	88	56	12.28
Night and Heavy Fog	25	73	43	9.99

On the other hand, with decreasing visibility conditions in the road environment, the standard deviation of observed speeds in the scenarios was reduced (see Table 5). The lower standard deviation showed less dispersion of selected speeds by the drivers (for example, at night and heavy fog conditions, the standard deviation is equal to 10). The drivers' inclination to choose speeds in the range of the mean speed of traffic in lower visibility conditions causes this

behavior to enhance safe driving. Figure 6 shows the speed dispersal in the "day" (high visibility) and "night and heavy fog" conditions (low visibility) for better understanding. Drivers' speed-choice behavior was varied by visibility condition. In low visibility conditions, drivers had tried to drive in the vicinity of average speed, with a minimum dispersal range. This result was in contrast with Peng et al. They indicated that speed differential was increased with an increase in the sight distance limitation in both rainy and foggy conditions. But, as they stated in the paper, their results were not significant [Peng, Jiang, et al. 2018].

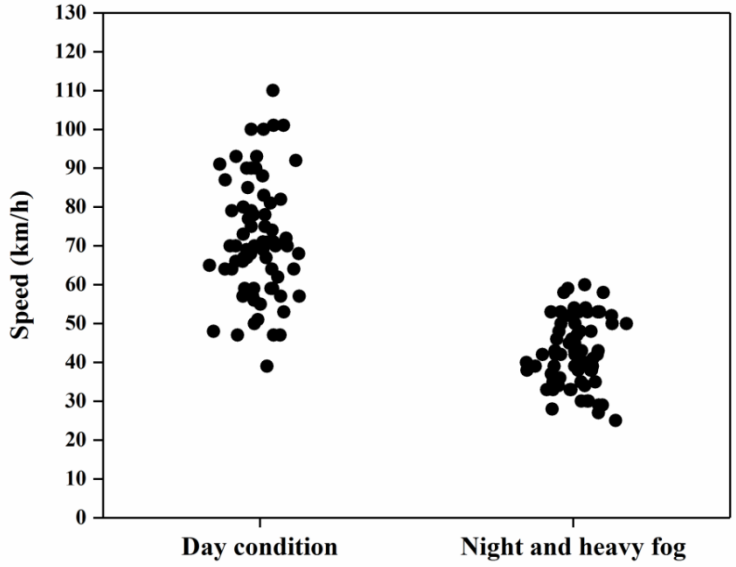

Figure 6. Speed dispersal in two weather conditions

5.2. Gender Effect on Speed Choice

Based on the aim of this study, which investigates the characteristics of drivers and their speed-choice behavior, researchers had analyzed the gender effect on speed selection. As expected, the average speed selected by men in different weather conditions is higher than women. The graphical result is shown in Figure 7. As shown in all of the scenarios, the selected speed by men is higher than women; however, the average speed was decreased by increasing the visibility restriction. Although in a study by Yan et al. (2014), results declared that gender did not affect the drivers' speed-choice behaviors in foggy weather conditions [Yan et al. 2014], Other studies' results indicated that women drive slower than men shows the direct effect of gender on the speed-choice behavior. It is in line with current study results [Butters et al. 2012; Harré et al. 2000; Harré et al. 1996; Oltedal and Rundmo, 2006; Zolali and Mirbaha, 2020]. Another statistic revealed the effectiveness of gender on the speed control behaviors of drivers in the present study. Among the participants who choose the speeds higher than the 85th percentile of speed, men have a higher proportion than women. The exact percentage of men and women who choose speeds higher than the 85th percentile of speed in all scenarios is shown in Figure 8. Based on Figure 8, 77% of men had selected higher speed and were driving faster; however, only 23% of women had decided to choose high speeds.

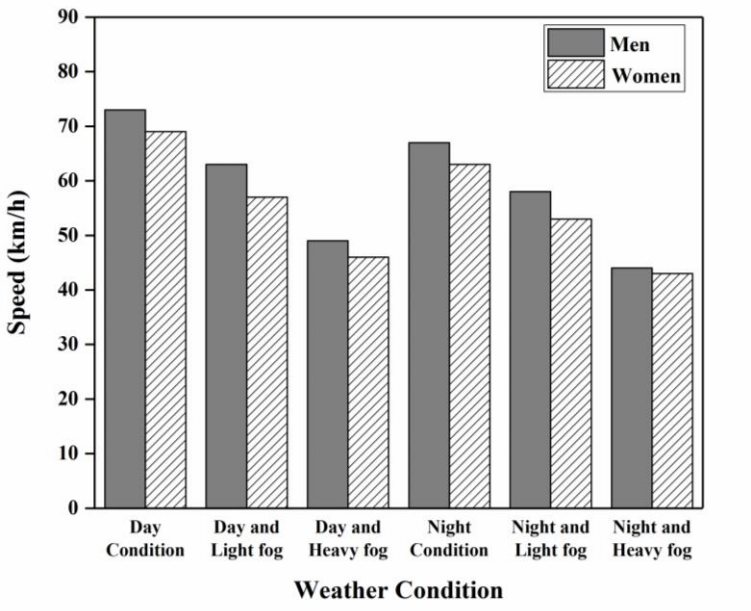

Figure 7. Speed choice differences between men and women

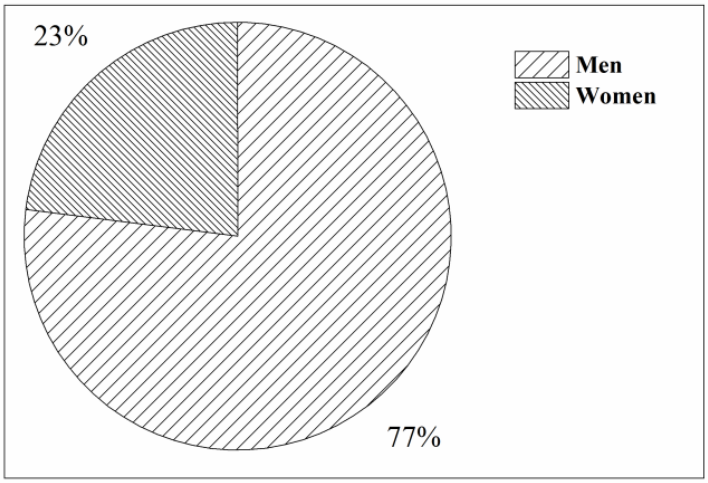

Figure 8. The proportion of men and women that choose speeds higher than the 85th percentile of speed

5.3. Age Effect on Speed Choice

In order to study the participants' behavior and their speed selections during the study, they arranged into five age groups. The age of participants in groups 1, 2, 3, 4, and 5 were 21 to 28 years old, 29 to 36 years old, 37 to 44 years old, 45 to 52 years old, and 53 to 60 years old, respectively. Researchers analyzed age groups based on the chosen speeds higher than the 85th percentile of speed, so the following results were obtained. Among the groups, group 1 had a higher percentage, which means that the drivers between 21 and 28 are more interested in selecting a higher speed than other groups. By increasing the drivers' age, selecting the speed higher than the 85th percentile of speed has decreased among participants. For example, groups 4 and 5 have the lowest percentages equal to 3% and 4%. This result has shown in Figure 9. Previous studies confirm these

findings. Hakamies-Blomqvist and Wahlström, in a study, proved that driving performance is affected by age in various aspects. For example, they indicated that age could affect drivers' caution behind the wheel, which means that the younger drivers are usually less cautious than older drivers [Hakamies-blomqvist, 1998]. Also, Wu et al. (2018) showed that younger people during the driving test have less tendency to reduce their speeds and to have a more rigid brake [Wu et al. 2018].

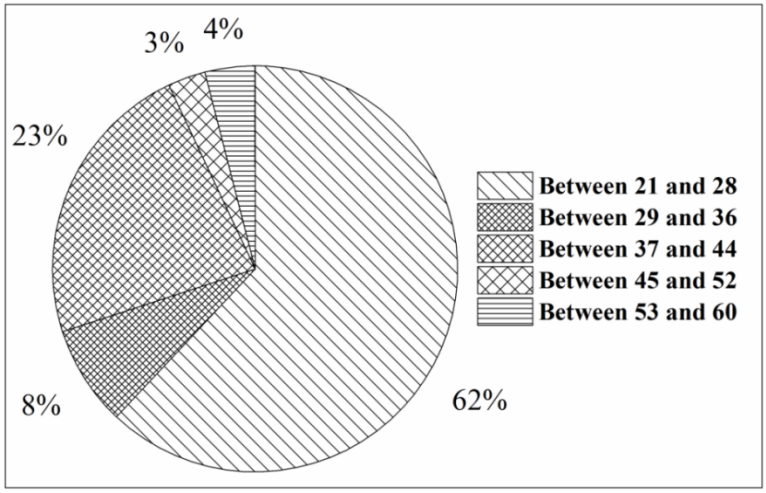

Figure 9. The proportion of drivers who choose speeds higher than the 85th percentile of speed based on age groups

5.4. Education Effect on Speed Choice

One another variable that affect the speed choice behavior was education level. The mean speed and standard deviation of all scenarios in terms of the drivers' education are shown in Table 6. In this study, participant drivers have been divided into five groups concerning the educational level. These levels include Education 1: diploma and lower; Education 2: Associate degree; Education 3: Bachelor; Education 4: Masters; and Education 5: Ph.D. and higher. As shown in all of the scenarios, the groups with higher education levels have chosen lower speeds than groups with lower education levels. Also, the selected mean speed was decreased in all five groups by reducing pure visibility conditions. About the impact of education level on drivers' behavior, some studies like a paper by the Wu et al. indicated that education level have no effect on drivers' speed selection behavior [Wu, et al. 2018]. But other studies have investigated the relation between driving behavior and education level. In an study done by Papantoniou et al. they indicated that drivers who have more education years than others was less likely to perform driving errors [Papantoniou, et al. 2019].

Researchers also analyzed the drivers who had selected speed higher than the 85th percentile of speed from the education level of viewpoint. The results of this analysis are shown in Figure 10. According to the obtained results, only 4% of drivers categorized into the Education 5 group (Ph.D. and higher) have selected higher speed. The higher percent corresponds to Education 1 group, which indicates that drivers with a diploma and lower education levels have more tendencies to select higher speeds.

Table 6. Mean speed in each scenario with respect to drivers' education level

	Education 1 (21 drivers)	Education 2 (7 drivers)	Education 3 (14 drivers)	Education 4 (17 drivers)	Education 5 (11 drivers)
Day and Clear Weather					
Mean Speed	74	80	74	67	64
Standard Deviation	13	19	16	14	14
Night and Clear Weather					
Mean Speed	67	74	69	60	51
Standard Deviation	11	19	15	11	13
Day and Light Fog					
Mean Speed	61	74	62	58	55
Standard Deviation	11	16	14	11	12
Day and Heavy Fog					
Mean Speed	52	54	50	43	43
Standard Deviation	11	14	13	11	12
Night and Light Fog					
Mean Speed	58	68	57	52	49
Standard Deviation	10	15	11	12	11
Night and Heavy Fog					
Mean Speed	46	45	45	42	38
Standard Deviation	12	8	10	9	7

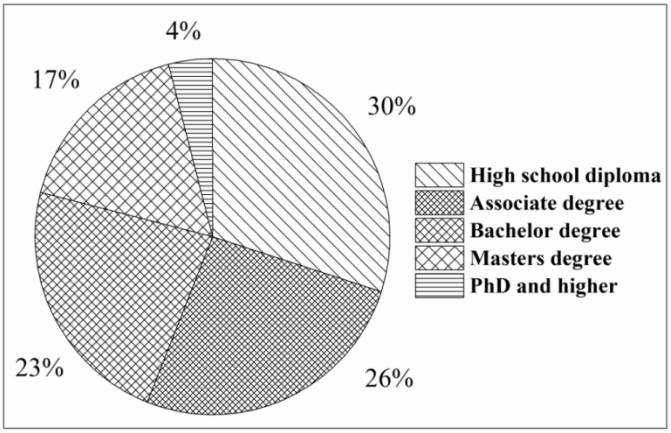

Figure 10. The proportion of drivers who choose speed higher than the 85th percentile of speed based on education level

5.5. Experience Effect on Speed Choice

In order to analyze the effect of experience on drivers' behaviors, all drivers have classified it into three different levels concerning their driving experience. These levels include Experience 1: 2 to 9 years of driving experience; Experience 2: 10 to 25 years of driving

experience; Experience 3: 26 to 41 years of driving experience. According to the results, at all experience levels, the lower visibility conditions lead to the lowest mean speed compared to other weather conditions (see Table 7). The mean speeds of groups based on the driving experience have indicated that the mean speed of the Experience 3 group and the Experience 1 group is not significantly different from each other. However, both are higher than the mean speed of drivers in the Experience 2 group. The previous studies' results illustrate that the young drivers, compared with old and experienced drivers, probably choose a higher speed [Mueller and Trick, 2012; Zolali et al. 2021], Professional drivers such as taxi drivers choose lower speed rather than naive drivers [Li et al. 2015]. Also, experienced drivers have a lower driving errors compared to others [Papantoniou et al. 2019]. Similar to other characteristics of drivers, experience also has analyzed in terms of speed selection. In this study, all drivers had declared their driving experience, and researchers have divided the drivers into three groups. The results show that drivers with lower driving experience (Experience 1 group) have more tendency to choose speeds higher than the 85th percentile of speed. This value is 67% for this group. On the other hand, drivers categorized into Experience 3 have a lower tendency to select higher speed, only 14% of drivers. These results show that drivers with high driving experience are more cautious than other drivers. Figure 11 shows drivers' tendency to choose speeds higher than the 85th percentile speed based on the driving experience.

Table 7. Mean speed in each scenario with respect to the driving experience

	Experience 1 (34 drivers)	Experience 2 (21 drivers)	Experience 3 (15 drivers)
Day and Clear Weather			
Mean Speed	72	70	71
Standard Deviation	17	13	13
Night and Clear Weather			
Mean Speed	67	63	64
Standard Deviation	14	12	14
Day and Light Fog			
Mean Speed	63	58	60
Standard Deviation	15	9	13
Day and Heavy Fog			
Mean Speed	50	44	49
Standard Deviation	13	12	11
Night and Light Fog			
Mean Speed	58	53	54
Standard Deviation	14	9	13
Night and Heavy Fog			
Mean Speed	44	40	45
Standard Deviation	10	9	10

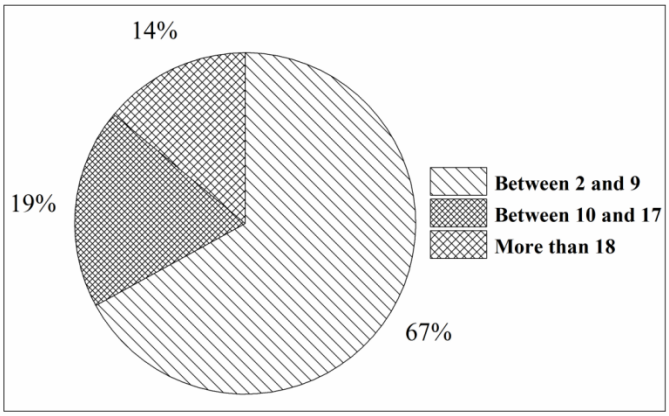

Figure 11. The proportion of drivers who choose speed higher than the 85th percentile of speed based on the driving experience

5.6. Accident and Speed Selection Behavior

In this study, some of the drivers had an accident during the driving task. According to the study's aim and to investigate the speed selection behavior, the drivers who had an accident during the test were examined. The speed data of these drivers were analyzed separately. Among 70 participants, 13 drivers had at least one accident during the test. Speed data has shown that these drivers had selected speeds higher than other drivers that they did not have an accident during the test. Figure 12 shows the mean speed of drivers who had an accident and did not have an accident during the driving test. As shown, the mean speed of drivers with an accident during the experiment is higher than other drivers, and this difference has the maximum value in the day and clear weather conditions (maximum visibility). These results also show that drivers who choose higher speeds are more likely to have an accident because they cannot control their vehicle at high speed.

A review of past articles confirms these results. In an article published by Parishad et al., participants' driving behavior was assessed using a DBQ. One of the items of the questionnaire measures the violation item in drivers' behavior. Based on the results, it has been observed that drivers who have been involved in accidents in the past three years have had higher violation scores, and one of the components for measuring the violation item is selecting a speed higher than the allowable limit [Parishad et al. 2020].

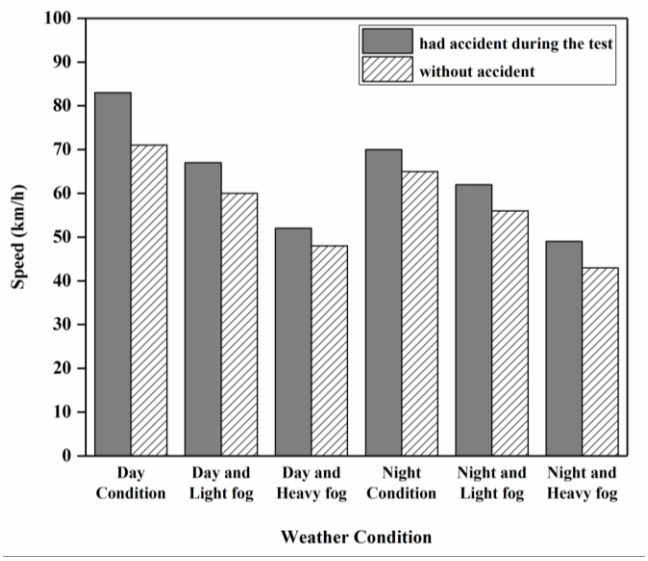

Figure 12. The mean speed of drivers who had an accident and who did not have an accident during the test

6. Conclusion

In the present study, using statistical analysis, drivers' characteristics effects on the speed-choice behavior of drivers on a simulated two-lane rural road were investigated. The data was collected through revealed (simulator) and stated (questionnaire) methods. By using these data and statistical analysis, the results were obtained and discussed.

According to the obtained results, generally foggy weather conditions and low visibility conditions due to lack of daylight decrease the drivers' inclination to select a higher speed. Some of the drivers with distinct characteristics had chosen speeds higher than the 85th percentile of speed. Drivers' characteristics that affected their high-speed selection were gender, age, driving experience level, and education level. Based on findings in this study, novice drivers tend to drive faster and select higher speeds than other age groups. Due to their numerous experiences in different driving incidents, experienced drivers are less likely to select the speed higher than the 85th percentile of speed. Drivers who have higher education levels tried to choose a lower speed in the vicinity of mean speed than drivers who have a lower education level. Accident analysis has revealed that drivers who selected higher speed than other drivers experienced at least one accident during the test. This is a significant result that induces drivers to be more careful about their speed choice. Governments or decision-makers should pay more attention to such drivers with specific characteristics that stimulate them to select a higher speed.

For future study directions, to find other factors associated with speed choice behavior, investigation of the family members to study the similarity in driving behaviors in the family such as father and his child can be considered. Also, participants can be trained and receive information about safe driving first and then be tested by the driving simulator. By doing so, it can be studied which training how much effective in terms of accident prevention.

For future studies, it recommends finding an appropriate way to control the potential drivers (controlling their speed and enhancing safety) and studying other characteristics that can affect

the speed selection and accident occurrence like the stress level in drivers.

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