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Research Article

Evaluating Rainy Weather Effects on Driving Behaviour Dimensions of Driving Behaviour Questionnaire

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This study aims to develop a modified version of the existing driving behaviour questionnaire (DBQ) by including items related to driving behaviour under rainy conditions to evaluate driving behaviour changes and their implications. A survey of 680 drivers in Iran was conducted with the modified DBQ considering rainy conditions. Exploratory and confirmatory factor analysis concluded a four-factor solution (high velocity with a law violation, slips, positive and cautious behaviours, and aggressive driving behaviours) with a 52% explanation of variance. One of the most affected driving behaviours during rainfall is the tendency of high velocity with law violation behaviours. Compared to male drivers, female drivers showed lower high-velocity behaviours with law violation when driving in dry weather and in rainy weather. Married drivers have not only less tendency to drive fast or violate the law compared to single drivers but are also less susceptible to these actions during rain. It was observed that young drivers under 25 did not change their aggressive driving behaviours in rainy conditions. The results from this study are valuable resources to help transportation agencies to understand drivers' likely behaviour in rainy conditions and develop appropriate countermeasures to minimize the risky behaviours. Also, since aggressive driving, high acceleration, and speed variance have been reported to result in high fuel consumption and emissions, the findings from this study are valuable resources to understand the relationship between weather, driver behaviour, and emissions in future studies.

1. Introduction

Environment, transport infrastructure, human, and vehicle are important elements of the transportation system. It can only operate safely and efficiently when these elements are compatible. The environment element, especially weather, could impact not only the safety and performance but also the fuel consumption of the vehicles [1]. Adverse weather conditions such as rainfall are among the most significant reasons for decreasing road safety [2]. According to the National Highway Traffic Safety Administration report in 2013, weather conditions caused 22% of total traffic crashes. A considerable amount of these crashes has occurred during rainfall (43%) and wet surfaces (73%) [3]. Based on the evidence, the weather change is one of the most significant reasons for driving behaviour changes as drivers adapt to the changing driving environment [4].

According to the literature, vehicles' speed and distance are affected by the weather [5]. It has been found that average driving speed during heavy and light rainfall would decrease by 22 and 13%, respectively, suggesting a change in driving behavioural patterns. This is also consistent with the acceleration change with the reduction in average positive and negative acceleration as 8 and 11%, respectively. In addition, the percentage of time spent on hard braking or hard acceleration also decreases compared to dry weather [6].

As a noteworthy point, even the fuel efficiency differs between drivers, depending on their driving behaviours [7]. Driver's characteristics besides traffic environment are among four influential fuel efficiency features [1]. A

comprehensive analysis of driving style and fuel efficiency by Tzirakis et al. [8] found that the increase of aggressive driving led to an increase in fuel efficiency varying from 78.5% to 137.3% for petrol vehicles. Generally, fuel efficiency would be varied by 2–27% for different drivers [9].

On the other hand, driving behaviour has been known as an involved factor in 90% of crashes [10]. Drivers' behaviours would change due to the weather conditions, and this change in driving conditions may be responded to differently by drivers depending on their driving behaviour and experience [11].

So far, various parameters have been studied in the study of drivers' changing behaviour. In most cases, the driving behaviour questionnaire has been used as the primary assessment tool. The pioneering work in this area was conducted by Reason et al. [12] who developed 50-item driver behaviour questionnaire that included three factors: violations, dangerous errors, and harmless lapses. This questionnaire has been adapted or extended by many researchers over the years in different geographic regions.

Parker et al. [13] developed the shorter version of the questionnaire with fewer items (24 items). It evaluated driving behaviour with the same factors with slight changes. Over the years, the modified version of the questionnaire with 27 and 28 items considering aggressive violation has been developed as well. For example, Gras et al. [14] researched with 28-item questionnaire in Spain, and they concluded that behaviours related to law violation would incur increment of traffic crashes. Mattsson [15] used the same questionnaire and found that this questionnaire's structure is not stable at different subgroups of drivers. As such, researchers considered the effect of other factors on driving behaviour as well. For example, Mallia et al. [16] used 18-item questionnaire to survey 301 Italian drivers and found that drivers' personality traits are directly or indirectly associated with aberrant driving behaviours.

In previous studies, researchers have also been interested in further investigating behaviours related to car crashes. In a survey conducted by Taubman-Ben-Ari et al. [17], the driving style was discussed and analyzed. With this approach, driving behaviour studies have been expanded to reveal and identify the aspects of driving styles, and then their relationship with involvement in crashes has been investigated. For this purpose, a 44-item tool known as "multidimensional driving style inventory (MDSI)" was used that included eight factors that fall into the following four categories: reckless and careless driving style, stressed driving style, nervous and aggressive driving style, and positive and patient driving style. The first three categories had an overlap with previously used tools that have been investigated to a great extent in the literature, but the positive and patient driving style was considered for the first time. Hence, dealing with positive driving behaviours in recent studies has received more attention. A survey of 525 French drivers by Guého et al. [18] used a 41-item instrument that had a six-factor solution for driving behaviour questionnaire. This version consisted of the original version of the driving behaviour questionnaire by Reason et al. [12]; the extracted questionnaire from Aberg and Rimmo [19]; and the positive driving behaviour questionnaire by Özkan and Lajunen [20]. The study also confirmed the relationship between age, gender, weekly mileage, driving behaviour factors, and the rate of driver crashes.

Nordfjærn et al. [21], with a 22-item instrument and 634 domestic Iranian drivers and 135 expatriate Iranian drivers, analyzed three driving behaviour factors: errors, emotional violations, and ordinary rule violations. It was observed that emotional violations were more common among those domestic drivers, and there was also a clear relationship between emotional violations and errors with crashes, while for the expatriate drivers, this was true only for the ordinary rule violations.

Although previous studies have shown that environmental conditions would significantly impact driving behaviour [22], there are limited studies that have investigated the effect of environmental conditions in driving behaviour dimensions. In particular, there is a lack of comprehensive study that has examined the effect of rainy weather on driver behaviour dimensions in the driver behaviour questionnaire. Given the importance of the effect of rain on increasing the probability of crashes [23] and the relationship of driver behaviour on fuel efficiency [7], it is important to examine the possibility of change in driving behaviour in driver behaviour questionnaire. Therefore, this study aims to develop a modified version of the driving behaviour questionnaire by including items related to driving behaviour under rainy conditions in order to evaluate the changes in driving behaviour.

2. Method and Material

2.1. Questionnaire. In the first part of the questionnaire, items about the demographic characteristics of drivers are asked. Demographic characteristics include gender, age, education, and marital status. In the same section, questions were asked about the driving experience, average driving time per day, and the history of crashes.

The second part of the questionnaire consisted of items about driving behaviour in dry weather conditions on a six-point Likert scale (1: never, 6: always). Then, drivers were asked to answer the same questions again, assuming they were driving in rainy weather, to have the same instrument for analyzing the differences in behavioural dimensions. Regarding this goal, it is important to consider the perceived differences between driving behaviour items in rainy and dry conditions. Thus, considering this issue, a new questionnaire was prepared using the items of driving behaviour questionnaires of Reason et al. [12]; Taubman-Ben-Ari et al. [17]; Lajunen et al. [24]; and Parishad et al. [25] for both dry and rainy conditions. Drivers and transportation engineers were asked to identify the items with no perceived differences in rainy and dry weather in a focus group study (five graduate students, one professor, one expert from the municipality, and two experts from consulting engineers). Items with no perceived differences were deleted, and the final questionnaire for rainy and dry weather was prepared.

2.2. Sampling. The questionnaire survey was approved by the Human Research Ethics Committee of the Civil Engineering Department of the University of Tehran. The survey was conducted from October 2018 to April 2019 in Qom city, Iran. Qom is located in the center of Iran and has a population of 1,229,964 [26]. The drivers in this city have experienced an average of 5 rainy days per month in the study period. Moreover, the information regarding the amount of rainfall (mm) in a five-year period is provided in Table 1, and also information about average rainfall in the study period is shown in Figure 1 [27]. The required data were collected through a paper questionnaire via face-to-face interviews with various light vehicle drivers to ensure that drivers correctly answered and fully understood the items. All drivers had a driving license and had an experience of driving at least once a month during the past year.

The questionnaires were distributed to drivers at various locations in the urban areas, such as parking lots, public places, shopping malls, and universities, after confirming the license status and driving experience. All the respondents were informed of the purpose of the investigation, and they participated voluntarily without any reward. Furthermore, the participants were assured about anonymity and confidentiality. Finally, 1050 questionnaires were collected, and 680 of the questionnaires without any missing value were used for analysis. The sample size was estimated based on the Cochran formula [28] and evaluating different study samples in this field of study in Iran [25, 29, 30].

2.3. Analysis Procedure. The primary purpose of this driving behaviour questionnaire was to assess drivers' behaviour during the rain. The effect of rain based on differences in demographic characteristics was then examined. Therefore, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to identify the dimensional structures of the driving behaviour questionnaire under rainy conditions. It is worth mentioning that the sample was divided into two subsamples, and EFA and CFA were conducted on the two subsamples, respectively. All of the statistical analyses were performed using AMOS 23.0 and SPSS 22.0 software.

EFA was conducted using varimax rotation, and then the Kaiser–Meyer–Olkin (KMO) test was used to test the minimum requirement for factor analysis. The scree plot determined the number of components alongside interpreting dimensions based on the reference questionnaires by considering an eigenvalue greater than one. For items, a minimum factor loading of 0.4 was considered as a criterion for retaining or removing that item from the questionnaire.

After performing EFA on the questionnaire of driving behaviour in rainy weather and determining the behavioural categories, CFA was performed on this questionnaire's items. Then, the driving behaviour questionnaire in dry weather was evaluated by CFA according to the same categories. Maximum likelihood estimation was used to test the fitness of the factor structures. Evaluation of other types of indices was used for the fitness, such as chi-square/degrees of freedom (DF), root mean square error of approximation (RMSEA), comparative fit index (CFI), and incremental fit index (IFI).

Table 1: Rainfall amount from 2015 to 2019 in Qom.

	Rainy days	Rainfall (mm)
2019	53	224.7
2018	38	93.58
2017	29	61.64
2016	49	58.18
2015	52	98.89

Also, Cronbach's alpha reliability coefficients were calculated to evaluate the questionnaire items' internal consistency. After assessing the items and determining the behavioural factors, by using non-parametric tests (for instance, sign and Wilcoxon tests), comparisons were made between differences in individuals' driving behaviour with different characteristics. The average weight of items in each category was used as an indicator of the behavioural factor to compare differences in driving behaviour due to rainfall using the mentioned tests.

3. Results

3.1. Sample Characteristics. Table 2 identifies the different features of the sample. Among the 680 drivers who answered the questionnaire, 498 were males (73.2% of the sample), and 182 were females (26.8% of the sample). Although there is a lack of official data on the distribution of male and female drivers in Iran, the female drivers' distribution in this study closely aligns with the distribution of female drivers (21%) in a previous study that investigated self-reported crashes among Iranian drivers [29]. The male respondents' average age is 39 years, and the female respondents' average age is 33 years.

About 75% of the sampled drivers had more than five years of driving experience, with an average of 2.6 hours of driving time per day. A majority (95%) of respondents had not experienced any serious or fatal crashes while driving. But at least 20% of them had experienced a crash with damage in their vehicle.

3.2. Dimension Structure of the Questionnaire. To validate the questionnaire, 680 respondents were divided into two groups. At first, 380 respondents were randomly selected for EFA, and other respondents were used for CFA. Table 3 shows the factor structure of the questionnaire under rainy conditions. Table 4 shows the significant parameter estimates based on the demographic characteristics. The explanation of the results from EFA and CFA is presented in the next subsections.

3.2.1. Exploratory Factor Analysis of Driving Behaviour Questionnaire in Rainy Weather. EFA was conducted by using 380 primary random respondents. Items with factor loading less than 0.4 and cross-loading with a difference less than 0.2 have been removed. The result of the KMO test, which has been used to evaluate the adequacy of the sample, was equal

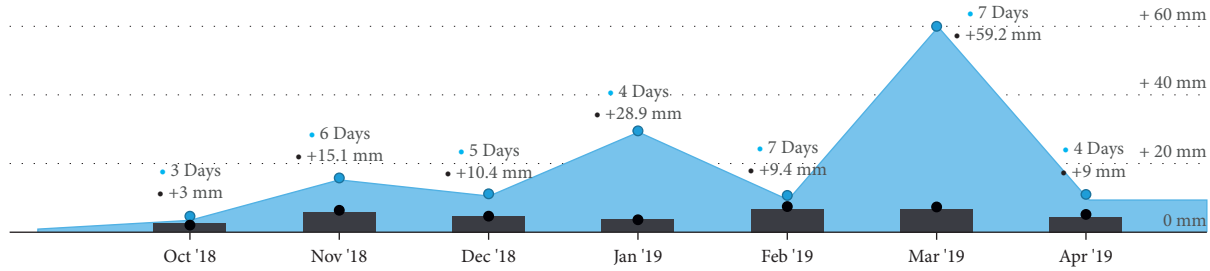

Figure 1: Average rainfall amount (mm) and rainy days in Qom from October 2018 to April 2019 (source: [27]).

Table 2: Sample characteristics (sample size = 680).

Variable	Description		Frequency	(%)
Gender	Male		498	73.2
	Female		182	26.8
Age of driver (years)	≤25		97	14.3
	26–35		180	26.5
	36–45		270	39.7
	46–55		109	16.0
	55<		24	3.5
Educational background	Under diploma		89	13.1
	Diploma		211	31.0
	B.A		264	38.8
	M.A or higher		116	17.1
Driver's marital status	Single	Male	76	11.2
		Female	56	8.2
	Married	Male	422	62
		Female	126	18.6
Average driving per day (hours)	≤2		433	63.7
	3–4		138	20.3
	5–6		67	9.9
	6<		42	6.2
Driving experience (year)	<1		49	7.2
	1–5		111	16.3
	6–10		141	20.7
	10<		379	55.7
Frequency of crashes with damage in vehicle	0		555	81.6
	1–2		115	16.9
	3≤		10	1.5
Frequency of crashes with injury	0		652	95.9
	1–2		27	4.0
	3≤		1	0.1

to 0.890, which indicates the acceptable value for the analysis [31]. Finally, three items were removed from the questionnaire (10, 13, and 14), and as shown in Table 3, as a result of exploratory analysis, 19 items were included in four factors of driving behaviour, which accounts for a total of 52% of the variance.

3.2.2. Confirmatory Factor Analysis of Driving Behaviour Questionnaire in Rainy Weather. CFA was performed using the remaining respondents (300) to assess the fitness of the dimensional structures of the factors extracted in the driving behaviour questionnaire for rainy weather. The fit indices for this model showed that the model fitted the data reasonably well [32, 33]: chi-square/DF = 1.764, RMSEA = 0.051, CFI = 0.909, and IFI = 0.911.

3.2.3. Confirmatory Factor Analysis of Driving Behaviour Questionnaire in Dry Weather. According to the analysis performed on the questions related to driving in rainy weather, the classification of items in all four factors was in full compliance with the reference questionnaires. In the driving behaviour questionnaire in dry weather, using 300 random respondents, CFA was performed as well, and the fit indices showed an acceptable model fitness [32, 33]: chi-square/DF = 1.896, RMSEA = 0.055, CFI = 0.891, and IFI = 0.893.

3.2.4. The Final Modified Version of the Driver Behaviour Questionnaire in Rainy Weather. Table 3 indicates the results of factor loads and items of these four factors. The first dimension of driving behaviour in rainy weather was identified with six items. These items are all indicative of

Table 3: Factor structure of the driving behaviour questionnaire under rainy condition.

No.	Item	Factor loading	*M* (S.D.)
Factor 1: high velocity with a law violation—30.39% of the variance			
5	In a rainy situation, I get bored by the slow driver in front and overtake from the right	0.741	2.16 (1.415)
4	In a rainy situation, when in a traffic jam and the lane next to me starts to move, I try to move into that lane as soon as possible	0.712	2.41 (1.414)
2	In a rainy situation, in a traffic jam, I think about ways to get through the traffic faster	0.664	2.94 (1.581)
18	In a rainy situation, I cross a junction knowing that the traffic lights have already turned against me	0.553	1.66 (1.099)
11	In a rainy situation, I drive so close to the car in front deliberately or flash him to drive faster or overtake	0.509	1.86 (1.254)
22	In a rainy situation, I disregard the speed limit on a motorway	0.415	1.57 (1.127)
Factor 2: drivers' slips—8.87% of the variance			
6	In a rainy situation, I fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late	0.704	2.36 (1.445)
3	In the rainy situation, I hit something when reversing that I had not previously seen	0.638	1.97 (1.135)
8	In a rainy situation, I switch on one thing, such as the headlights, when I meant to switch on something else, such as the wipers	0.634	1.85 (1.212)
20	In a rainy situation, I get distracted or preoccupied and realize belatedly that the vehicle ahead has slowed and I have to slam on the brakes to avoid a collision	0.606	2.29 (1.327)
16	In the rainy situation, on turning left, I nearly hit a cyclist who has come up on my side	0.591	2.13 (1.264)
Factor 3: positive and cautious driving behaviour—7.18% of the variance			
15	In the rainy situation, I drive cautiously	0.738	5.44 (1.106)
7	In the rainy situation, I base my behaviour on the motto "better safe than sorry."	0.680	5.14 (1.367)
19	In the rainy situation, I am always ready to react to unexpected maneuvers by other drivers	0.665	4.80 (1.529)
1	In the rainy situation, at an intersection where I have to give right-of-way to oncoming traffic, I wait patiently for cross-traffic to pass	0.663	5.37 (1.026)
Factor 4: aggressive driving behaviour—5.61% of the variance			
21	In a rainy situation, I become angered by a certain type of driver and indicate my hostility by whatever means I can	0.670	2.18 (1.296)
9	In the rainy situation, I swear at other drivers	0.665	1.57 (1.069)
17	In a rainy situation, I sound my horn to indicate my annoyance to another road user	0.657	2.13 (1.362)
12	In a rainy situation, driving makes me feel frustrated	0.617	2.04 (1.353)

hasty driving behaviours that lead to law violation behaviours. Therefore, this dimension is called "high velocity with a law violation," which comprises 30.39% of the total variance. The result of Cronbach's alpha test is 0.753 for rainy items and 0.730 for dry weather items.

The second dimension deals with drivers' slips, all of which are related to driver errors and mistakes. This factor with five items represents 8.87% of the total variance. The result of Cronbach's alpha test for this dimension in rainy and normal weather conditions is 0.721 and 0.641, respectively, which both indicate the appropriate internal consistency of the items of this factor with each other.

The positive and cautious driving behaviour as the third dimension of the questionnaire includes four items with appropriate loading values. These items include 7.18% of the total variance, and Cronbach's alpha test resulted in 0.655 for rainy weather conditions and 0.605 for dry weather conditions, which are in an acceptable range.

Four items related to aggressiveness in driving were classified in the fourth dimension of the questionnaire, which addresses about 5.61% of the total variance. Cronbach's alpha for this group is 0.722 in rainy weather and 0.704 in dry weather. All of this group's items with acceptable loading values are in accordance with similar grouping items in the original questionnaires.

As mentioned in the objective of the study, we aimed at developing a modified version of the driver behaviour questionnaire. The evaluation of changes in driving behaviour is possible by this instrument. Although the main focus of the previous versions of the driving behaviour

Table 4: Differences in driving behaviour from rainy conditions based on demographic characteristics.

	Gender		Age					Marital status	
	Male	Female	≤25	26–35	36–45	46–55	55<	Single	Married
Aggressiveness	−4.53**	−2.27*	−1.33	−5.05**	−4.74**	−3.17**	−0.17	−2.40**	−4.29**
High velocity with law violation	−9.17**	−8.23**	−9.71**	−10.40**	−8.84**	−6.55**	−6.14**	−7.66**	−9.22**
Slips	−0.80	−1.36*	3.23**	−1.52*	−1.79**	−1.71	−0.56	1.06	−1.43**
Positiveness and cautiousness	3.11**	4.67**	5.67**	4.54**	2.49**	2.49**	3.82**	3.76**	3.48**
	Educational background				Driving experience (year)				
	<Diploma	Diploma	B.A.	M.A.	<1	1–5	6–10	10<	
Aggressiveness	−2.53**	−3.85**	−3.66**	−5.71**	0.43	−3.34**	−3.99**	−4.63**	
High velocity with law violation	−6.12**	−9.66**	−8.91**	−9.70**	−7.31**	−9.39**	−8.67**	−9.07**	
Slips	−0.52	0.11	−1.74*	−1.38	−0.27	0.09	−0.80	−1.39*	
Positiveness and cautiousness	−0.28	4.56**	4.14**	3.20**	3.32**	5.82**	3.28**	2.98**	

*Significant at the 0.05 level. **Significant at the 0.01 level.

questionnaire in Iran was on risky behaviours like violations, errors, and aggressiveness, items relating to the positive behaviours and cautiousness have also been included in the modified version for rainy weather (items 15, 7, 19, and 21). Furthermore, it is worth mentioning that not all of the items in previous versions of the DBQ are relevant for the rainy weather. As a result, after evaluating them in a focus group, those items that had no logical difference between rainy and dry weather were not included in this version. For example, forgetting where the driver has parked his/her car in a multilevel car parking cannot be expected in the rainy weather. So, all the items of the modified version of DBQ are logical and suitable for rainy weather.

4. Discussion and Conclusions

By obtaining a suitable instrument to evaluate drivers' behaviour in rainy weather and a similar tool for dry weather conditions as investigated in this study, it is possible to examine drivers' likely driving behaviour during rainfall. One of the most affected driving behaviours during rainfall is the tendency of high velocity with law violation behaviours. According to the results, about 8.91% of fast, hasty driving behaviour with driving rules' violation are reduced during the rain. The change in driving environment characteristics with more challenges posed by the rainfall could be the reason why drivers tend to retreat from speeding and try to drive more carefully. This finding supports the observations from a previous study by Ahmed and Ghasemzadeh [34], where it was found that there is a reduction in driver's speed during light rain (23%) and heavy rain (29%).

Among the high velocity with law violation dimension's items, the most notable representative item is disregarding the speed limit by drivers. When driving in rainy weather, ignoring the speed limits, in particular, is reduced by 6%. These findings are similar to those by Faria et al. [6] who noted that drivers tend to drive more slowly during heavy rainfall. Also, under heavy rain conditions, the average speed of traffic flow is reduced by 22% compared to dry weather. This reduction in the average speed of traffic flow could be related to drivers' risk perceptions and the chance of collision in rainy conditions [35].

Irrespective of rules' violation because of hastiness, drivers with remarkable high-velocity behaviour can be considered drivers with high acceleration and speed variance. Based on factor analysis conducted by Coloma et al. [36], high acceleration and speed variance can result in less fuel efficiency. So, the effect of rain on air quality can be further investigated, especially the changes in driving behaviour that lead to fewer emissions.

The maximum amount of change in high-velocity behaviour was related to drivers' action of overtaking from the right side of the slow driver in front. It was observed that drivers are 13% less likely to overtake from the right when driving in rainy weather than in dry weather. Gender differences were also observed. Female drivers showed lower high-velocity behaviours with law violation when driving in dry weather (4.56% less) and in rainy weather (3.62% less) than male drivers.

Behavioural differences between the two genders have led to the changes in driving behaviours and also the impact of external factors on risky behaviours. For example, men are more likely to engage in high-risk behaviours like high velocity with law violations. So, the differences in the significant effect of rain on driving behaviours between male and female drivers are expected [37].

As expected, drivers' tendency to drive fast with law violations would decrease by aging. For example, Yadav and Velaga [38] reported that speed compliance is positively associated with drivers' age. This decreasing trend was also observed in violation of law while driving in rainfall, and the most affected group includes young drivers who are under 35. This issue could be related to a lack of enough experience under different weather conditions.

A noteworthy point in the results is the relationship between drivers' marital status and driving behaviour in rainy conditions. Married drivers have not only less tendency to drive fast or violate the law compared to single drivers in dry weather but are also less susceptible to these actions during rains. Although there is limited literature relating marital status to driving violations, it seems that single drivers are more prone to express risky behaviours like high velocity and violations [39, 40]. The differences between single and married drivers can be due to social or psychological indicators. As a prime example, responsibilities in

the family would result in significant changes in driving behaviour. Taamneh and Alkheder [41] justified the comprehension differences of regulatory and warning traffic signs between single and married drivers by higher social responsibilities of married drivers. Another possible explanation was provided by Teye-Kwadjo [42], where it was speculated that married drivers might have dependents, such as partners and children, to support as well as properties and investments to protect, and therefore, they seem to be more risk-averse while driving. Hence, the higher impact of rain on married drivers compared to single drivers, specifically in risky behaviours like aggressive and high velocity with a law violation, can be expected. Although the rain had a significant impact on single drivers in both aggressiveness and positiveness, the effect on females for aggressiveness and on males for positiveness was not significant.

A variety of reasons could affect the expression of aggressive behaviours while driving. In this study, after reviewing the results, it was observed that driving in rainfall could reduce aggressive behaviours by up to 3.92% compared to dry weather conditions. Specifically, the use of horns can be considered one of the most obvious ways of expressing aggression while driving. This item has been affected more than other items among the items of aggressiveness while driving.

Similar to the comparison between men and women in high velocity with law violations behaviours, in aggressive driving behaviours, women are less likely to express aggression, either driving in rainy or dry weather. These findings are similar to the study by Parishad et al. [25]. Also, rainfall has less effect on women's aggression while driving compared to men (2.27% and 4.53%, respectively).

As was expected, aggressive driving behaviours are more evident in young drivers. The remarkable point is that they are even eager to change aggressive behaviours under rainy conditions. For example, it was observed that young drivers under 25 did not change their aggressive driving behaviours in rainy conditions. This may be due to their relatively less driving experience or preparedness to take risky behaviour. However, this behaviour will affect not only the safety but also the fuel efficiency and environmental outcomes. Aggressive and experienced drivers have high fuel consumption and emissions [43]. So, decreasing the aggressiveness of drivers in rainy weather may yield fewer emissions.

Being married or not can also affect the expression of aggressive driving behaviours. While driving in dry weather conditions, single drivers are more likely to drive aggressively than married ones. In addition, the rate of reduction of this behaviour in single drivers during rain is about 2% less than married drivers. While driving in the rain, married drivers and single drivers are approximately 4.29% and 2.40% less aggressive, respectively, as compared to when driving in dry conditions. These results indicate that single drivers are less affected by rainy conditions.

With the increase in educational status, the drivers' aggressive behaviours while driving reduced. The lowest reduction in aggressive behaviour is for drivers with a diploma or lower, which is approximately 2.53%, and the highest reduction in this behaviour is for drivers with a master's degree and above, which is approximately 5.71%.

Studies have shown that drivers who have more driving experience than others have substantial aggressive behaviour changes when driving in rainy weather. As highly experienced drivers are more likely to experience driving in various weather and road conditions, including rainy weather, and are more aware of the potential dangers they may face, they are more likely to reduce their aggressive behaviours. This reduction is 4.63% for drivers with more than ten years of driving experience; on the contrary, drivers with less than one year of driving experience did not have any change in aggressive behaviours. It is to be noted that the effect of rain on the aggressiveness of both male and female drivers with less than one year of driving experience is not significant.

After analyzing results on the occurrence of errors and slips while driving in the rain, it was observed that there was no significant difference with driving in dry weather conditions. It was found that the errors associated with the improper use of vehicle functions such as windshield wipers increase during rain. Likewise, the distraction and error in items indicate that the driver's attention to other cars, pedestrians, and the surrounding area decreases when it rains.

"Positive and cautious" driving behaviour was examined as final behaviour. The difference in this group of driving behaviours affected by rainy conditions was significant. In general, the positive behaviours of drivers while driving reflect their cautious performance. Under rainy conditions, drivers generally show about 3.5% more caution and patience. Some of the findings of the present study in this field are consistent with previous research studies. Based on Hamdar et al. [22] results, when the visibility level is higher, drivers follow the car in front of them with a shorter distance. The evidence shows that drivers express cautiousness during rainfall due to the more challenging driving conditions on slippery roads [22]. Although men and women showed similar positive and cautious behaviours while driving in dry weather conditions, the effect of rainfall on the caution and positive behaviours of women was observed to be 1.5 times that of men.

The display of cautious behaviour by drivers under normal conditions generally increases with age, but it was observed that the relationship between age and driving behaviour is not straightforward under rainy conditions. Although older drivers are still more cautious than younger drivers when it is raining, younger drivers are more affected than older drivers under rainy conditions. In the Iranian context, we can consider drivers younger than 35 years as young drivers, between 36 and 55 years as middle-aged drivers, and those older than 55 years as old drivers. In addition to the significant correlation between driving experience and drivers' age, it is assumed that most older drivers have more driving experience. For example, about 87% of middle-aged drivers have more than ten years of driving experience. Similarly, more than 91% of drivers older than 55 have more than ten years of driving experience. On the other hand, just 25% of young drivers experienced driving for more than ten years. Additionally, even the

young drivers with more than five years of driving experience are less than 60% (58%). Therefore, considering the fact that experiencing different driving conditions is one of the undeniable parts of the driving experience, old drivers benefit from these broad experiences and are less affected by rainy weather than young drivers.

Furthermore, although both middle-aged and old drivers are less affected than young drivers, it can be observed that the impact of rain on the cautiousness of middle-aged drivers is less than young and old drivers. In order to prevent distraction-related crashes, it is crucial to discard irrelevant stimuli and unimportant responses or distractions and concentrate on driving tasks, especially in rainy weather when unpredictable events can occur. The focus and inhibition of distraction is a cognitive function that develops until young adulthood and decreases with an increase in age; young and old drivers are more susceptible to distraction than middle-aged drivers [44]. So, it can be assumed that distractions caused by external factors like rainy weather may lead the drivers to be cautious. Eventually, more impact from rainy weather on young and old drivers compared with middle-aged drivers is expected due to the fact that they feel more need to be cautious.

Given that there is a lack of comprehensive study that has examined the effect of rainy weather on driver behaviour in the driver behaviour questionnaire, this study provided evidence on the importance of considering the effect of rainy conditions on driving behaviours in the driving behaviour questionnaire. Regarding the fact that weather conditions and driving behaviour have always been inseparable parts of analyzing crashes, the findings of this study provide valuable insights into the underlying relationship between driving behaviours and weather conditions. So, adopting weather countermeasures like advisory speed or warning systems by considering specific rain effects on the driving behaviour may increase the efficiency of the policies toward minimizing the risky behaviours.

Furthermore, providing education or training to the driver regarding the risk of driving in inclement weather along with necessary precautions may be an effective approach to prevent crashes in harsh weather conditions. In particular, the results of this study regarding different groups of drivers while driving in the rain have to be taken into account to provide a better educational path. For example, middle-aged drivers expressed they felt more confident and showed less positiveness and cautious behaviour while driving in rainy weather than old and young drivers. Therefore, the less they are cautious in the rain, the more they may be prone to crashes. So, some refresher courses for middle-aged drivers can be a beneficial strategy to encourage them to be cautious in inclement weather. Likewise, drivers with a weaker educational background (below diploma) are less affected by the rainy condition, resulting in higher risky behaviour in inclement weather. So, specific educational courses for this group have to be considered to improve their awareness about the outcomes of risky behaviours in harsh weather conditions.

In addition to safety effects, since aggressive driving, high acceleration, and speed variance have been reported to result in high fuel consumption and emissions, the findings from this study are valuable resources to understand the relationship between weather, driver behaviour, and emissions in the future studies. In the future, more studies on different geographic regions may increase confidence in the findings.

5. Limitations of the Study

The current study is based on self-reported measurements, and as such, the vulnerability to socially desirable responses may exist. To minimize the bias, we assured the participants of anonymity and confidentiality of the responses. Moreover, Lajunen and Summala [45] concluded that social desirability bias has relatively minor impacts on self-reported responses to aberrant behaviours. Although comparisons between the present study and previous studies have been made before conducting the survey to ensure a representative sample, the lack of official data regarding the distribution of drivers in different age groups and gender may have caused some unbalances in the sample, i.e., undersampling or oversampling. Further, we only surveyed light vehicle drivers in urban areas. Future studies may analyze light and heavy vehicle drivers in urban and rural areas. Moreover, it is also worthy to notice that in this study, drivers' behaviour in both rainy and dry weather has been investigated in the same city and with the same drivers. So, it is necessary to give due consideration to different local factors like culture, educational background, road signs and regulations, driving habits, and so on when applying the results from this study to other geographic regions.

Data Availability

The data used to support the findings of this study are available from the second author on request through email: kayvan.aghabayk@ut.ac.ir.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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