

Research Article

Evaluating Safety Issues for Taxi Transport Management

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Taxi drivers face many problems every day including safety issues. The tendency to quickly transport passengers to their destinations for more income has resulted in dangerous driving behaviors leading to traffic violations. So, taxi drivers need appropriate support and training programs to improve safety and reduce the risk of crashes. Implementing different support and safety training programs requires an effective management system. There is a dearth of research on the safety issues of taxis from the perspective of taxi organization managers. This study aims to evaluate the safety issues of taxi transport management through a case study of the Tehran Taxi Organization. A questionnaire survey was conducted with 22 regional managers and 20 transportation specialists of the Tehran Taxi Organization. Issues related to taxi drivers, roads and road users, vehicles, and management systems were evaluated in the questionnaire. Participants determined the relevance level and priority ranking of each question. The level of agreement was then tested using the Kendall concordance test. According to the results, the use of GPS was selected as the best in-vehicle monitoring system that can be used to evaluate drivers in the fleet. Participants believed that passengers' loading and unloading had the most risk for taxi users. The start-inhibit technology to detect open doors was unanimously evaluated as an efficient technology for taxi safety. With respect to educating taxi users, starting education in schools had the most relevance and priority. Recommendations for increasing the safety of taxis include the use of GPS in taxis to monitor and evaluate drivers, receiving crash reports from police and submitting monthly safety assessment reports, flexibility in drivers' working hours' schedule, providing training on drivers fatigue management, and evaluating drivers' health.

1. Introduction

Motor vehicle crashes and the resulting damages are one of the leading causes of fatality in the world. According to the World Health Organization, about 1.35 million people worldwide are killed in road crashes each year. A large number of the world's fatalities on the roads (74%) occur in middle-income countries [1]. It is also reported that the estimated road traffic death rate per 100000 population for Iran is 20.5 (48.7% belong to 4-wheeled vehicles) which is much higher than high-income countries (7.94 for high-income countries) and also more than middle-income countries (18.04 for middle-income countries) [1]. Tehran Taxi Organization reported that the city of Tehran, with approximately 84,000 active taxis, has one of the largest taxi fleets in the world. According to [2], the share of public transportation in urban trips is about 48.9% from which

24.3% belong to taxis. Although the taxi industry has a central function in any public transport system, it is often given less prominence by city planners and policymakers compared to other modes of public transport [3]. Measurement of public opinion with reliable statistical methods can provide useful insights to the decision-makers [4]. Safety issues related to the taxi driver, road, and vehicle are major challenges of the taxi industry. In the context of taxi drivers' safety, many studies focused on driving behavior, working conditions, and also risky drivers' characteristics and subsequent consequences [5–7]. Despite many studies conducted in the past to identify various risk factors contributing to taxi crashes, there is a lack of study of safety problems of taxis from the perspective of managers. The management system is responsible for certifying, training, and supervising drivers and has a vital role in improving taxi safety. Thus, the managers' perceptions about taxi safety

issues which are related to the driver, road safety, and vehicle can determine future safety plans of the organization. As the goal of safety researchers has always been to reduce accidents and losses, evaluating safety issues of taxis can lead to achieving higher safety standards and fewer crashes.

1.1. Objectives of the Study. There is a dearth of research on how managers and transport specialists of taxi organization, who are the decision-makers in the adoption of management strategies and new technologies for improving taxi drivers' safety, perceive the taxi drivers' safety issues. This study aims to address the knowledge gap by evaluating the safety issues of Tehran taxi industry using the knowledge and perceptions of taxi transport managers and also investigating the potential effectiveness of various technologies via a questionnaire survey. Past studies on bus and truck safety management have shown that by investigating the current practices used by the transport management or agencies to reduce injuries, appropriate recommendations can be developed to enhance the safety of the drivers, vehicles, and road users [8–10]. However, there is a lack of study of safety problems of taxis from the perspective of managers. This study will highlight major taxi-related safety problems which are unanimous among managers and experts and also provide practical recommendations to achieve higher safety standards. As the participants in this study are managers and experts of the Tehran Taxi Organization, their opinions can determine their priorities for future decisions. The results of this research can be a valuable resource for countries that have a similar transportation system as Tehran.

1.2. Structure of the Paper. The paper is organized as follows. Section 2 is intended to explain and review previous studies on taxi safety issues including workplace road safety, taxi driver's risky characteristics and driving behavior, and also the importance of a management system to improve safety. Section 3 describes the methodology adopted for this study that includes participants, study design, and data analysis. It is followed by Sections 4 and 5 that present the results and the relevant discussions, respectively. Finally, in Section 6, the conclusions of this study and the recommendations are presented.

2. Literature Review

In the next two sections, a review of relevant studies on the taxi driver's risky behavior, workplace safety issues, and the importance of a management system to improve taxi drivers' safety is presented.

2.1. Taxi Driver Unsafe Behavior and Workplace Safety Issues. Taxis efforts to increase passengers' transport by getting passengers to their destinations quicker for more income have resulted in more dangerous driving behaviors [11]. A study by Adl et al. [12], reported that, in the city of Tehran, 52.5% of taxi drivers have unsafe driving behavior and 46% of these high-risk behaviors are done repeatedly (more than

80% of the time). These risky behaviors can result in driving violations [13, 14]. These behaviors include not using turn signal light, not observing a safe distance from the car in front, abruptly changing lanes, and crossing the red light [15–17]. In addition, the occurrence of these risky behaviors is positively and directly related to the probability of traffic crashes [7, 18].

Taxi drivers, as a key element in the taxi industry, face many problems every day including workplace safety issues. For example, fatigue caused by long driving hours [19], high workload, and more shifts directly increase the likelihood of an accident and indirectly cause fatigue and abnormal driving behavior [20]. Also, difficult working conditions for drivers can cause physical and mental problems such as cardiovascular diseases, muscle aches, stress, and sleep disorders [6]. Other problems that threaten the driver's health are smoking and use of alcohol, which are commonly used by the drivers to prevent drowsiness [21, 22]. All of these problems have led to higher mortality rates because of work for taxi drivers (14.9%) versus other occupations (3.3%) [23]. A study by Kasemy et al. [24] suggested setting a clinic for an intermittent checkup and health education for taxi drivers.

Many studies have been conducted to determine the factors related to crashes and assess the safety of taxis [5, 25, 26]. In general, these factors can be related to driver characteristics, environmental factors, and organizational management [27]. For example, a study by [26] found that, contrary to intuition, older, more educated taxi drivers reported more unsafe driving behaviors, compared to younger, less educated. Also with the aging of drivers, it increases the likelihood of crashes [25]. Another study found that driving at night increases the chance of fatality and injury from traffic crashes [5, 8]. Moreover, a large number of crashes are related to driver's errors, i.e., a person's driving behavior and cognitive ability are decisive in these crashes [29].

2.2. The Importance of Management System and Managers' Perspective. The evidence from past studies indicates that there is a difference between the behavior of taxi drivers and other drivers, and therefore, there is a need to consider these differences in taxi drivers' training programs [25]. It is not conceivable to administer different training programs for taxi drivers without an effective management system, given their behavioral differences compared to other drivers. The management system is responsible for certifying, training, and supervising drivers. However, usually in practice, verification of competencies is conducted without a base or rule, monitoring drivers is simple, and training is short-run and not rigorous. It is argued that little awareness of safety issues not viewing taxi safety as a priority and gaps in specific safety expertise, knowledge, and resources could be the reasons [30]. It is important to mention that taxi markets are local in nature as no cities are the same [3], although it is expected that the initiatives which have proven successful in developed countries can be successfully applied in developing countries that are subject to different social and economic contexts [31]. However, many sociodemographic

characteristics (such as employment) were found to be important in transport planning [32].

There is a dearth of research on the safety issues of taxis from the perspective of taxi organization managers. Previously, few studies have been conducted on safety issues and problems from the perspective of managers of bus and truck organizations. These studies have been conducted with different purposes such as providing management solutions to identify problems of the bus and commercial truck companies [10] or conducting questionnaire survey for bus managers that include questions on drivers' choices and training, drivers' motivational programs, user training, and management programs related to safety issues [9]. In addition, in studies conducted by managers of bus transportation companies, the use of new technologies like intelligent transportation system (ITS) or automatic vehicle location (AVL) has been found very effective in increasing safety and supervision [33]. Also, the use of new technologies has increased the safety of taxis as well [34]. Understanding the risks and benefits of such systems presents an opportunity to recalibrate more accurate community perceptions of driver safety [35], which can be achieved by considering demand-responsive solutions, and change the policy focus in order to improve public transport service [36].

In addition to the unsafe driving behaviors of taxi drivers, inaccessibility to reports of taxi drivers' crashes and lack of monitoring driver choices are other taxi safety problems of the city. However, the Tehran Taxi Organization has made substantial efforts to increase drivers' awareness of taxi safety issues. These efforts include basic driver training, the use of incentive and punishment systems, and the use of new surveillance technologies. However, no specific study has been performed on the relevance and effectiveness of these methods. Literature suggests there is a need to monitor the impact of road safety management tools and control the appropriateness of safety management efforts [37].

3. Methodology

A flowchart showing the steps followed in this study is shown in Figure 1. With the taxi driver safety issues identification based on relevant literature review and consultation with drivers, a questionnaire was designed (refer to appendix). The questionnaire included questions related to the taxi driver, road and road users, and use of technologies in taxis (refer to Section 3.2 for more details on the rationale behind the questions). The data collection included a survey of 42 participants that included 22 regional managers and 20 transportation specialists from the Tehran Taxi Organization (refer to Section 3.1 for more details on participants). To analyze the data, relevance and priority ranking was determined for each item followed by the Kendall concordance test to identify the priorities of participants and their evaluation. Finally, the relevant results and discussions were made.

3.1. Participants. Tehran Taxi Organization is responsible for evaluating and monitoring the performance of taxi drivers. Considering that the metropolis of Tehran has 22

urban areas, this organization has a manager in each area to perform the mentioned tasks. All 22 regional managers of the Tehran Taxi Organization, as well as 20 transportation specialists of this organization (average work experience of 16 years), participated in this survey. Among the participants, 41 were male and one was female. The sample size was limited by the number of managers and transport specialists available at the Tehran Taxi Organization. Also, previous studies in the context of bus safety recruited 26 bus managers to evaluate their opinions regarding safety issues [8, 33]. Therefore, it is assumed that the current sample size is sufficient for the present study.

3.2. Study Design. Using the experience of previous studies which applied the questionnaire survey method to assess bus and truck safety management [9, 10, 33], the primary questionnaire was framed. Questions were modified to fit into the taxi safety issues. Also, due to the differences in the safety policies and priorities between the case study presented in the paper and the previous literature, several questions were revised to fit the context of the study country. Moreover, the opinions of representatives of the Taxi Organization and taxi drivers were considered in the development of the survey questionnaire. Finally, a detailed survey questionnaire was prepared for managers and experts of the Tehran Taxi Organization to assess issues and problems related to the safety of taxis. The questionnaire consisted of three main sections as follows.

3.2.1. Questions Related to the Taxi Driver. As taxi drivers play an important role in the taxi industry, evaluating various safety issues related to taxi drivers can help the administrator to better identify the safety priorities. Based on the previous literature, most critical drivers related issues were selected and assessed in Questions A1 to A7. Drivers' characteristics, health issues, incentive programs for drivers, and also training programs were evaluated in this section.

3.2.2. Questions Related to Road and Road Users. Due to the high share of taxis in public transport and their constant presence in the traffic flow, the interaction between taxis and other road users such as passenger cars and pedestrians has always been an important issue for transport planners. To evaluate these issues in terms of frequency and consequences for other road users, this section was provided.

3.2.3. Questions Related to the Use of Technologies in Taxis. The use of new technologies to increase vehicle safety and monitor taxi drivers has been widely investigated before. To identify the best monitoring and driver assistant systems from the point of view of taxi transport managers, several systems with respect to feasibility of use and current taxi organization's policies in the study country were provided in the questionnaire.

Research details were provided to the participants through a representative of the Tehran Taxi Organization. Then, the questionnaires were given to 22 regional

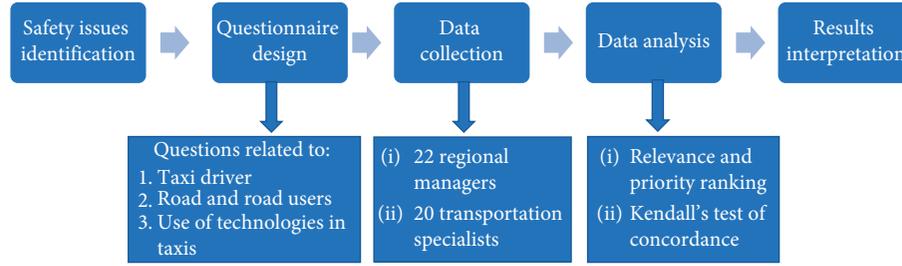


FIGURE 1: Flowchart showing the steps involved in the present study.

managers through the “office automation” of Taxi Organization and were completed for 4 days from December 28, 2019, to January 1, 2020. Twenty transportation specialists working in the Tehran Taxi Organization also completed the questionnaires through face-to-face interviews. For each question in the questionnaire that deals with a specific topic of taxi safety, several solutions were proposed. Borrowing from literature on bus safety management studies [8, 33], the relevance and priority ranking framework was utilized to assess managers’ perceptions regarding taxi safety issues. The participants were asked to answer the questions using the two criteria of “relevance” and “priority” ranking. First, they were asked to select one of the five available Likert scale items (very high, high, medium, low, and very low) to determine the effectiveness or relevance of each item in terms of safety. They were then asked to rate three items for questions in Section A and five items for Sections B and C in terms of the most important safety priorities.

3.3. Data Analysis. Table 1 is used to weight the indices [33]. The score = 3 indicates medium effectiveness with a mean score higher than 3 considered as effective. Using the given weights, the weighted mean of the two criteria of relevance and priority ranking was determined for each item, which made it possible to compare different items in each question.

To better identify the priorities of participants and their evaluation, we applied the Kendall concordance test. The level of agreement and consensus of managers were specified in terms of ranking priorities of the items in each question. In this test, using Kendall’s concordance coefficient, the amount of selection concordance of n items is determined by m individuals [38]. The null hypothesis in this test is that there is no concordance between the priorities and they are completely independent. The null hypothesis is rejected when at least one person is in concordance with the other person or all in choosing the priority. The Kendall concordance coefficient (W) is a nonparametric statistic with values ranging from 0 to 1. A value of 0 means no concordance between choices, and a value of 1 means that the choices are unified [39]. The value of W can determine the actual estimate of concordance between the participants and show how strong this concordance is [40]. The statistical value of W is defined as follows:

TABLE 1: Weights for computing weighted mean.

Effectiveness	Very high	High	Medium	Low	Very low	
Weight	5	4	3	2	1	
Ranking	1	2	3	4	5	Not ranked
Weight	5	4	3	2	1	0

$$W = \frac{12S}{m^2(n^3 - n)} \quad (1)$$

The parameter S is the sum of the squared deviations from the mean and is calculated as follows:

$$S = \sum_{i=1}^n (R_i - \bar{R})^2 \quad (2)$$

If we assume that item i has a r_{ij} priority index that is scored by selector j and has a total of n items and m selectors, R_i and \bar{R} parameters are defined as follows:

$$R_i = \sum_{j=1}^m r_{ij} \quad (3)$$

$$\bar{R} = \frac{1}{n} \sum_{i=1}^n R_i \quad (4)$$

Table 2 guides how to interpret the results of the Kendall concordance test [8]. According to this table, questions with a value of $W \geq 0.5$ have a good concordance between most managers and specialists, which reflects the concordance of people’s opinions and the use of similar criteria in ranking options [38].

Another parameter by which the significance of the test can be examined is through the chi-square (X^2). This parameter helps us to examine the significance of the Kendall test by calculating P value. At a 95% confidence level, P values $\leq 5\%$ indicate the significance of the test. The following equation is used to calculate X^2 :

$$X^2 = m(n - 1)W \quad (5)$$

The parameter n is the number of items available for prioritization, m is the number of participants, and W is the Kendall concordance coefficient.

TABLE 2: Interpretation of Kendall's W .

W	Interpretation
$W \leq 0.3$	Weak agreement
$0.3 \leq W \leq 0.5$	Moderate agreement
$0.5 \leq W \leq 0.7$	Good agreement
$W \geq 0.7$	Strong agreement

4. Results

4.1. Relevance and Priority Ranking of the Proposed Solutions. To evaluate the solutions proposed in each question and determine their level of relevance and priority ranking, the weighted mean was determined according to the weights allocated by each participant. Figures 2–8 show the results for questions in Section A (Questions A1 to A7). The questions of this section examined safety issues and problems related to taxi drivers from the perspective of managers and transportation specialists. These issues include the taxi driver's risky characteristics, training programs and assessment, driver incentives and punishment, and driver physical and mental health assessment programs.

The results of Question A1 revealed that driver fatigue and drowsiness were found to be the most important risk factors of the driver in terms of relevance and priority ranking. They are followed by inexperienced driver as the factor associated with risk. The results also revealed that while the driver's insufficient training was found to be important (relevance score = 3.76), it had the lowest priority among other driver's risk factors.

In the context of primary training, related to Question A2, practical training with a vehicle was chosen to be more effective than theory classes or simulators. It was found to have the highest priority among initial training programs. Moreover, managers perceived sample materials such as books, not effective in comparison with other driver training programs. Also, they had the lowest priority for taxi transport planners.

In regard to driver-related health problems, in Question A3, managers and specialists considered all items highly relevant (mean score of 4.48). The results of the priority ranking scale revealed that problems related to alcohol and drug use had the highest priority for taxi managers in terms of safety. It is interesting to note that participants perceived general health issues and wrong lifestyle, the lowest priority among other health issues. It is to be noted that since the managers and specialists were not taxi drivers, they responded based on their experiences of interactions with taxi drivers in the past and their overall perceptions of taxi driver safety issues.

With regard to incentives and punishments, according to responses to Question A4, it is highly important to give special privileges and rewards to drivers as incentives for safe driving behavior. Managers also believed that allocating rewards for safe driving had more priority than penalizing drivers for unsafe driving, even though these penalties were found to be effective according to the relevance scale.

The results of Question A5 showed that taxi transport planners unanimously assumed driver monitoring by GPS as

the best way to evaluate drivers in the fleet. It is followed by the periodic observation of drivers as the second effective way to evaluate drivers in the taxi fleet.

The answers to Question A6 revealed that medical examinations and periodic health check-ups were found to be the most effective way to assess drivers' health. Consulting programs and fatigue management programs were also found to be effective for health assessment. Medical examinations had the highest priority for managers in the context of drivers' health assessment.

In Question A7, regarding the management of drivers' problems, financial rewards and remedial trainings can be very effective in improving the safety behavior of drivers. The results of the priority ranking scale showed that managers and experts perceived remedial trainings had more priority than monetary rewards in this context.

Figures 9–12 show the results for the road section and road users (Questions B1 to B4). In these questions, the response of managers on road safety issues and the conflicts with other road users are assessed with respect to taxis. Efforts have been made to investigate the most dangerous maneuvers and actions of taxis while using roads. At the same time, in this section, the managers' opinion on the impact of different methods of educating users has been determined.

According to the managers of Taxi Organization in Question B1, the most important maneuver that can be dangerous and lead to crashes for taxis is crossing intersections. It is followed by hard braking and lane changes which involved high risk and consequences for other road users. The results of the priority ranking scale were consistent with the relevance scale and showed that crossing intersections, hard braking, and lane changes, respectively, had more priority from the point of view of managers. It is to be noted that managers and specialists were asked to identify the high-risk maneuver in terms of severity of crashes and consequences for other road users using their experiences in the context of taxi safety (which may include their familiarity of relevant statistics, reports, etc.).

Question B2, which showed the causes of crashes, revealed that ignorance of observing the safe distance from the front vehicle (relevance score of 4.36), driver's mistake (relevance score of 4.26), and inside visibility (relevance score of 4.26) are the main causes of crashes in participants' opinions. However, managers perceived drivers' error had more priority than other causes of crashes in terms of severity and consequences for other road users.

According to the results of Question B3, passengers' loading and unloading were found to have very high priority and relevance in the context of safety factors of passengers.

The results of Question A4 regarding the role of training programs for users showed that starting education in schools has a better impact than theoretical or practical training programs.

The results of the questions of the vehicle section (Questions C1 and C2) are shown in Figures 13 and 14. In this section, managers' responses to new systems related to taxi safety have been assessed.

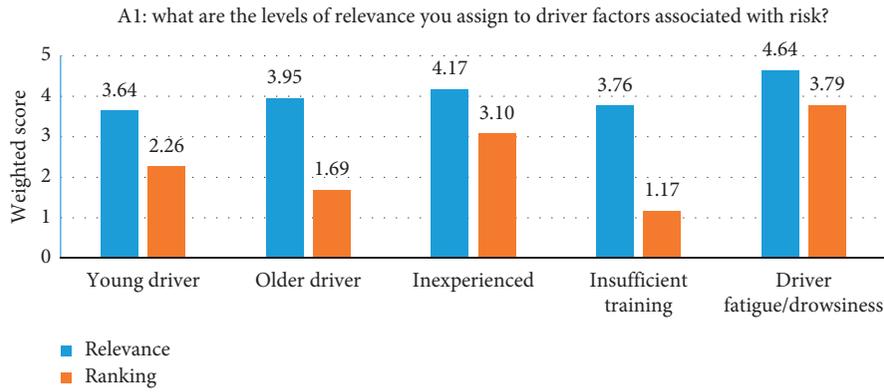


FIGURE 2: Weighted mean of relevance and priority ranking related to Question A1.

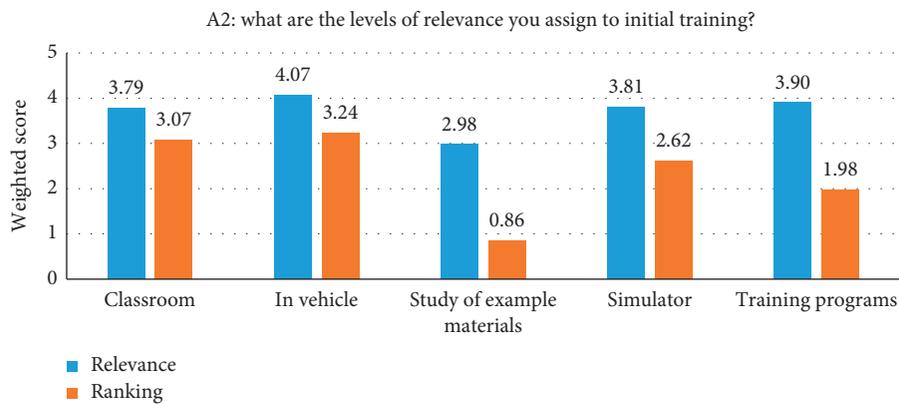


FIGURE 3: Weighted mean of relevance and priority ranking related to Question A2.

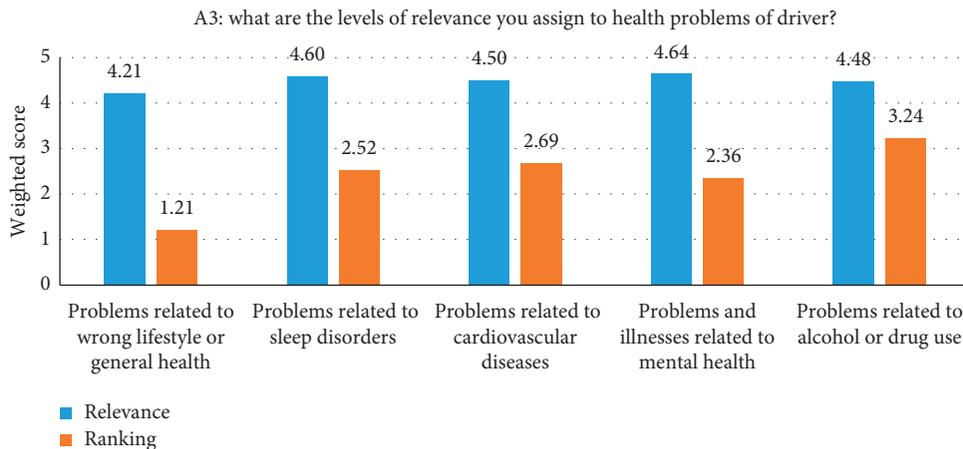


FIGURE 4: Weighted mean of relevance and priority ranking related to Question A3.

According to the respondents, in Question C1, the use of vehicle control and monitoring system by GPS had the most relevance and priority in terms of driver monitoring by new technologies. It is followed by the on-board system to the analysis of incipient failure. The managers perceived digital

tachograph had the lowest priority among in-vehicle monitoring systems.

In terms of choosing the driver assistance system (Question C2), the managers considered the start-inhibit technology to detect open doors as the most effective feature

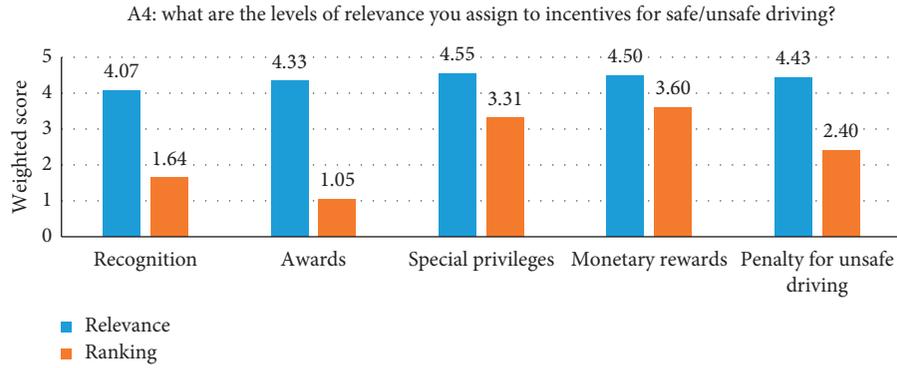


FIGURE 5: Weighted mean of relevance and priority ranking related to Question A4.

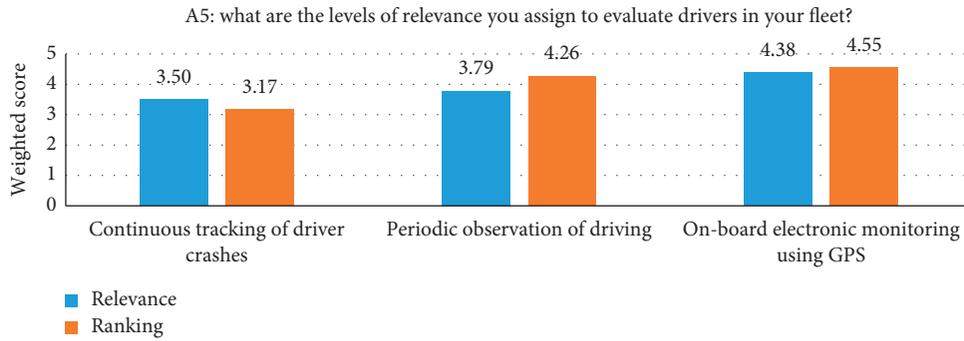


FIGURE 6: Weighted mean of relevance and priority ranking related to Question A5.

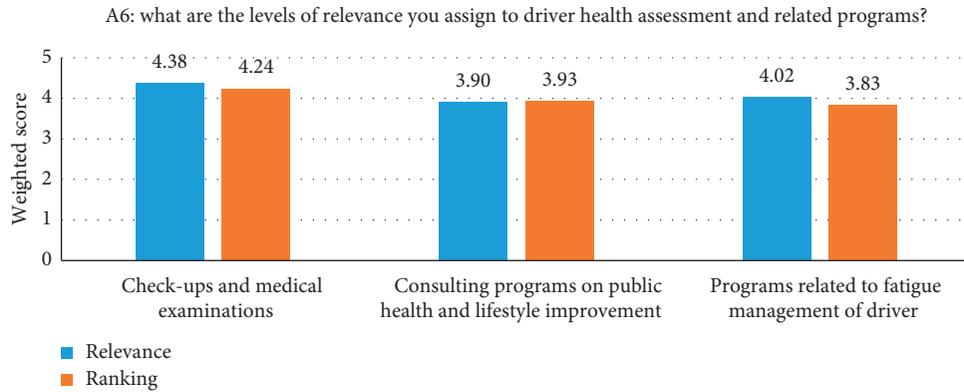


FIGURE 7: Weighted mean of relevance and priority ranking related to Question A6.

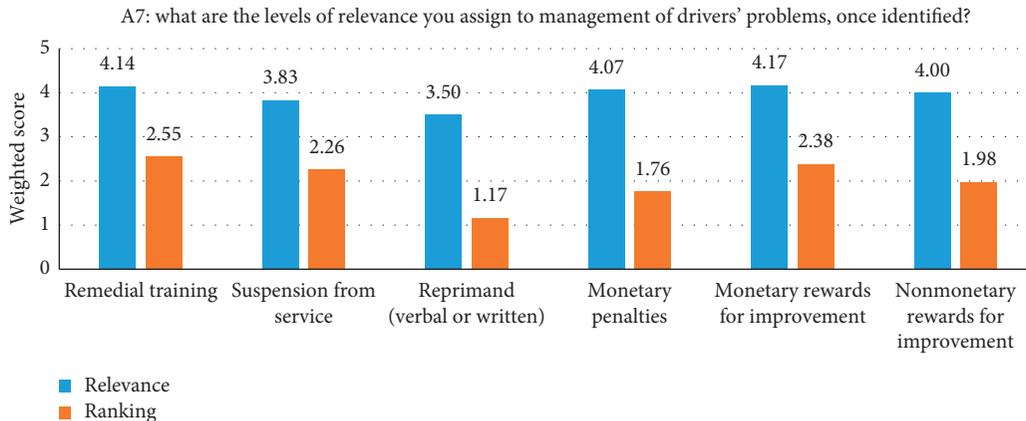


FIGURE 8: Weighted mean of relevance and priority ranking related to Question A7.

B1: what are the levels of relevance you assign to these maneuvers of taxi in terms of risk and severity of accident consequences for other road users?

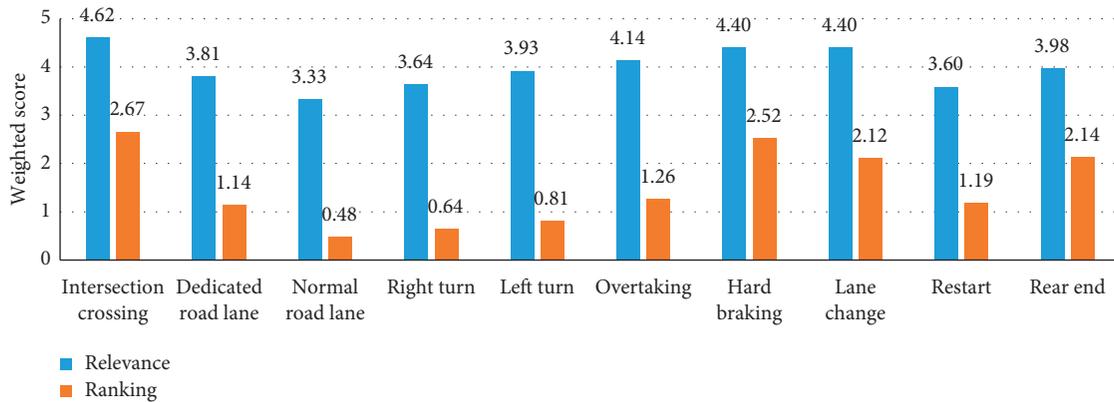


FIGURE 9: Weighted mean of relevance and priority ranking related to Question B1.

B2: what are the levels of relevance you assign to these possible causes of accident for safety by frequency and severity of the consequences?

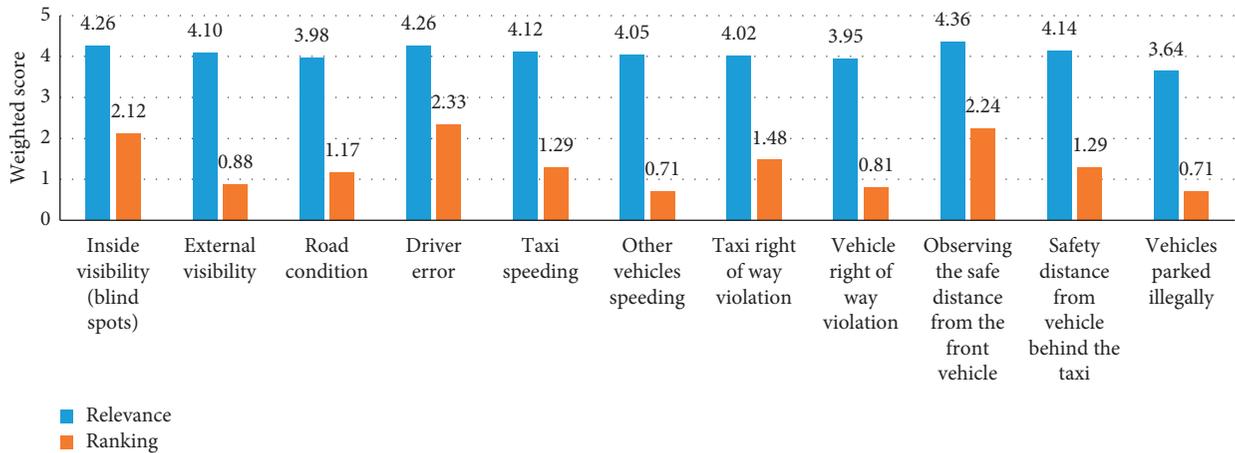


FIGURE 10: Weighted mean of relevance and priority ranking related to Question B2.

B3: What are the levels of relevance you assign to these factors for safety of passengers and pedestrian on the movement and operation of the taxi?

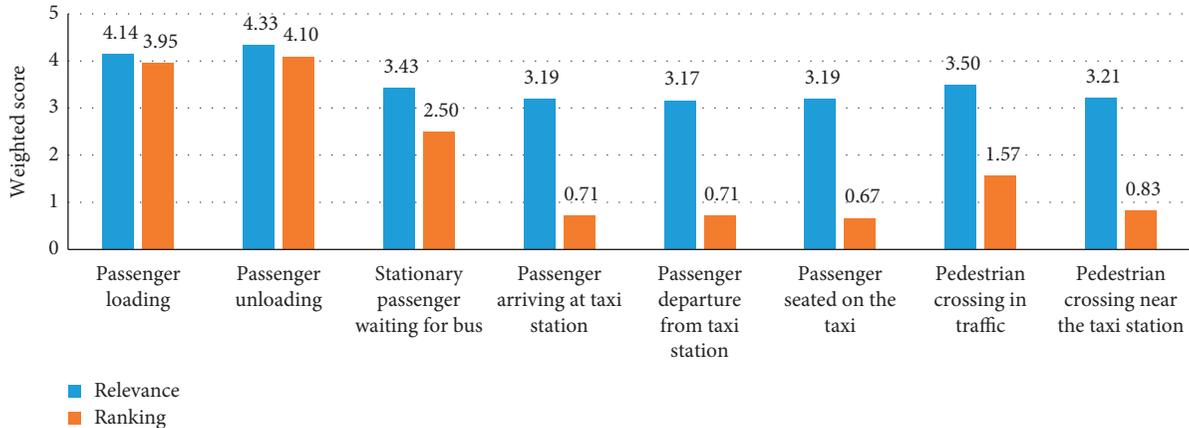


FIGURE 11: Weighted mean of relevance and priority ranking related to Question B3.

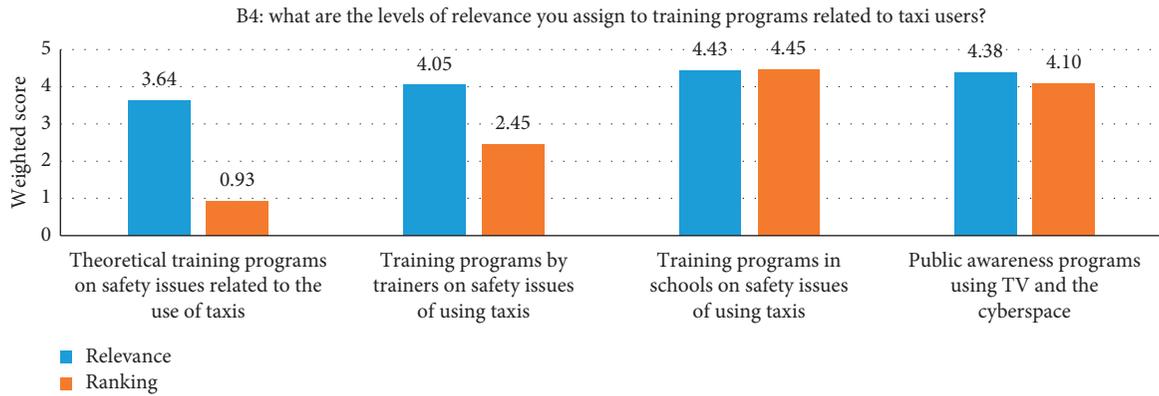


FIGURE 12: Weighted mean of relevance and priority ranking related to Question B4.

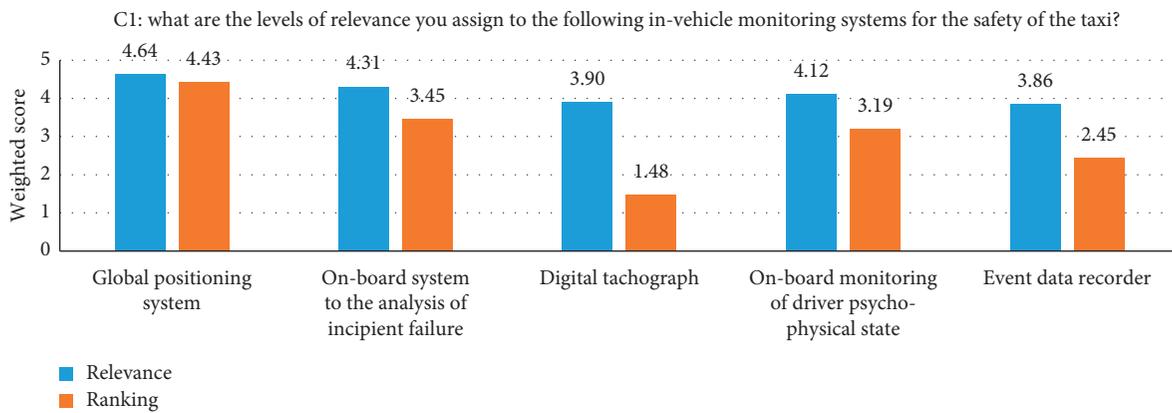


FIGURE 13: Weighted mean of relevance and priority ranking related to Question C1.

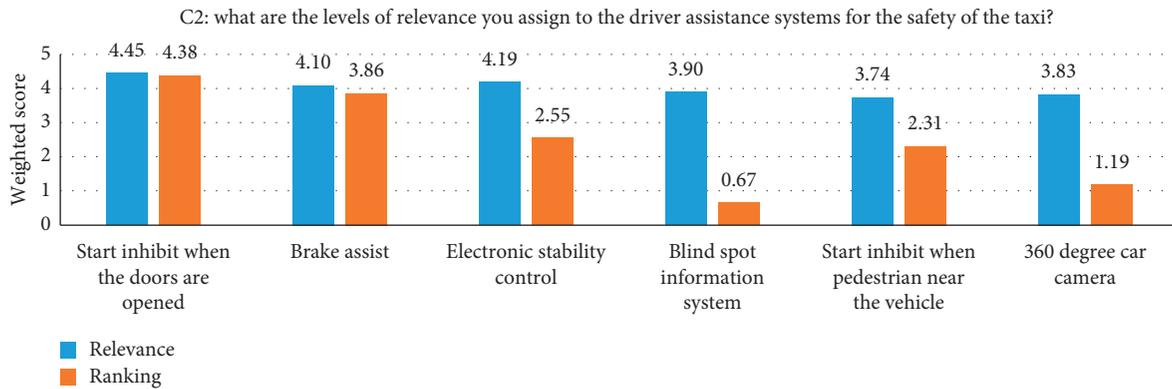


FIGURE 14: Weighted mean of relevance and priority ranking related to Question C2.

in the context of taxi safety. Also, brake assist was found to have a high priority among proposed items.

4.2. Kendall's Test of Concordance. The relevance results showed that most items scored more than three (i.e., the medium effectiveness) in terms of relevance in improving safety. To better identify the priorities of participants and the level of agreement and consensus among managers in terms of ranking priorities, Kendall's concordance test was

applied. The results of the Kendall test are provided in Table 3.

Kendall's concordance coefficient indicates that, in Questions A5 (drivers' assessment in the fleet), B3 (the safety of passengers and pedestrians when using a taxi), B4 (training programs for taxi users), and C2 (the most effective driver assistance system), there is a good concordance ($W \geq 0.5$) between participants. This coefficient for Question C1 (the best in-vehicle monitoring system) is 0.49. This decent concordance between the participants means that

TABLE 3: Kendall's test of concordance.

Question	W	X^2	P value
A1	0.223	37.393	$\geq 5\%$
A2	0.172	28.929	$\geq 5\%$
A3	0.105	17.596	$\geq 5\%$
A4	0.206	34.551	$\geq 5\%$
A5	0.531	44.635	$\geq 5\%$
A6	0.045	3.762	$\leq 5\%$
A7	0.051	10.749	$\leq 5\%$
B1	0.162	61.348	$\geq 5\%$
B2	0.109	45.572	$\geq 5\%$
B3	0.521	153.067	$\geq 5\%$
B4	0.559	70.389	$\geq 5\%$
C1	0.490	82.381	$\geq 5\%$
C2	0.605	127.109	$\geq 5\%$

managers agree on the high priority of the proposed solution. It also shows that this solution, according to the managers, improves the safety of the problem. Only in Questions A6 (driver health assessment) and A7 (drivers' problem management), the items selected by the participants were found to be nonsignificant.

5. Discussion

5.1. Taxi Driver, Road and Road Users, and In-Vehicle Systems. The results from Question A1 revealed that fatigue and drowsiness were found to be the most important risk factors for the driver. This is consistent with the results of [41] which considered fatigue as one of the most important factors that can cause an accident. In general, fatigue reduces the speed of reaction and increases the number of errors in decision making. It is important to note that professional drivers thought that fatigue was more serious for other drivers than for themselves, and they also thought that they were effective in counteracting the effect of fatigue on their driving performance. This optimism bias is the most probable reason for a prolonged driving time which can contribute to fatigue [19]. Additionally, driver age is one of the demographic factors that made a significant contribution to the taxi drivers' fatigue [42].

Regarding the role of initial training for taxi drivers (Question A2), due to the differences in the attitude and driving behavior of taxi drivers compared to other drivers, they should be given different trainings [25]. Such targeted "risk training" in drive test has the potential to encourage safe driving behavior [43]. In addition, driving safety workshops and seminars could be scheduled to implement behavior and attitude change programs [30]. Also, reading books and educational booklets has the least impact on drivers' initial trainings from the point of view of managers. This can be examined from two perspectives. Firstly, because of the high workload of taxi drivers, they may not have sufficient time to study [20]. Secondly, many drivers do not have academic education or have only primary education, which can affect the amount of studies they can undertake [44–46].

The results of Question A3 showed that all proposed items were found to be highly important according to the

relevance scale. Given that the drivers' health condition can directly affect driving behavior and thus the likelihood of an accident [47, 48], a system needs to be established to monitor drivers' health. This system can improve the drivers' performance by determining factors that threaten the health of drivers and thus reducing the likelihood of crashes [49]. A great number of drivers' health problems are related to poor working conditions, i.e., the length of the workday and the number of days worked in a week leave little time for recreational activities and lead to a sedentary lifestyle which can cause health issues [6]. Furthermore, according to the answers of Question A6, medical examinations can be the most effective way to assess their health. Also in this question, fatigue management programs were considered important for the participants (mean score of 4.02). This is consistent with the results of Question A1 on risk factors. As fatigue in taxi drivers is different from drivers who drive long distances [50], training programs should be implemented to teach drivers how to reduce fatigue and stress. These programs can improve their working conditions [6].

With regard to incentives and punishments, according to Question A4, managers perceived that it is highly important to give special privileges and rewards to drivers. Assuming that, for long hours of driving, most drivers' incomes are low and even lower than basic income in some cases [51], providing these privileges and rewards may assist drivers to meet their financial needs. However, government support is needed to implement these incentive programs. Moreover, nonfinancial rewards can be given to the drivers in the form of vehicle consumables such as tires, discount coupons, and similar items. Consistent with the results of this question, bus managers considered bonuses and awards highly effective in the context of improving bus safety [33]. Further investigation is needed to better identify the benefits and challenges of the incentives and punishments programs in the context of taxi safety.

In Question A5, driver monitoring by GPS was the best way to evaluate drivers in the fleet. The advantages of this system are accurate information about drivers' current location and distance travelled, easy communication with the operator in case of any problems, and reporting unauthorized speed or crashes. In addition, taxi GPS trajectories data which contain massive spatial and temporal information of urban human activity and mobility can provide valuable sources to investigate residents' travel demand and future planning [52]. Using this system can also reduce the likelihood of physical attacks on the driver [53]. In Question A7 regarding the management of drivers' problems, financial rewards can be very effective, but this item does not have a high priority index. This could be due to the limited financial resources of the organization. Remedial training was also found to be effective with high priority in terms of managing drivers' problems. These trainings include consultation and safety workshops which intend to improve skill deficiencies.

The results of Question B1 showed that managers perceived intersection crossing, the most important maneuver of the taxi in terms of risk and severity of accident consequences. According to studies conducted in various countries, including the United States, Norway, and

Bangladesh, 34 to 41% of all car crashes occur at or near intersections [54–56]. This indicates that the intersections are the most dangerous places in terms of the probability of crash for cars on the street. Additionally, hard braking was found second important dangerous maneuver which can cause accidents. Establishing restricted zones for taxis in order to pick up and drop off passengers for a better point-to-point service can result in fewer sudden stops by taxis along the street that is unexpected for other drivers [57].

The results of Question B2 revealed that driver's error had more priority than other causes of accidents from the point of view of managers. [58] reported that more than 70% of crashes are due to driver errors. Since the effect of driver's mistake is decisive in many crashes [29], one of the solutions that can reduce crashes due to the nonobservance of safety distance and driver's mistake is to use the driver's assistant system for driving at a safe speed and appropriate distance. This system can effectively reduce reaction time, reduce interactions with other road users, and maintain a safe distance with the front car [59]. To avoid human errors in driving and improve safety, autonomous or driverless cars are being investigated in depth in the literature [60] with researchers predicting that such vehicles would be soon in the market in near future [61]. Also, [62] reported that the potential consumers may be willing to pay more for using autonomous transportation modes if they become available in the future.

The results of Question B3 showed that passengers' loading and unloading have a very high priority and relevance in terms of passengers' safety. In the opinion of experts in this field, ensuring the safety of taxi passengers is more significant than pedestrians. This observation is consistent with the findings from a study on bus transport management [33]. In the context of educating users, participants believed that starting education in schools has a better impact than theoretical or practical training programs. From an early age, these trainings can familiarize people with the safety issues of taxis and reduce the risk. The use of media and public awareness programs can also be effective. Due to the rapid expansion of cyberspace and the potential to connect with many people, there is an opportunity to use cyberspace for education to taxi drivers.

The managers unanimously perceived GPS as the most effective in-vehicle monitoring system. The results of this question are consistent with the results of Question A5 where it was reported that the evaluation of drivers in the fleet by the GPS received the highest score for relevance and priority ranking. Leveraging various benefits of equipping a taxi fleet with GPS [53], most managers agree on the efficiency of this system. Moreover, due to the dynamic nature of the work driving environment, the organization should constantly monitor the taxi fleet to evaluate current strategies and identify potential risks [30]. On the other hand, [63] discussed the limitations regarding the use of GPS data in the context of taxi and mentioned that taxi trajectories represent a very small portion of urban mobility in most of the cities, and thus, there is a need to consider nontaxi users.

The results of Question C2 showed that the start-inhibit system to detect open doors was the most effective driver assistance system. According to the results of Question B3, which considered passengers' loading and unloading highly crucial in terms of risk, this system can assure passengers' safety during these two maneuvers. In one study, managers of bus companies also found this system to be very effective in increasing bus safety [33].

5.2. Assessing Consensus among Managers. Given the *W* coefficient in Question A5 and Question C1, managers unanimously chose the use of the GPS as the best in-vehicle monitoring system and the best way to evaluate the driver in the fleet. One of the problems with the Taxi Organization is the lack of an accurate report of drivers' crashes and the difficulty in receiving them from the police. Given the direct impact of drivers' driving behavior on the rate of crashes [29], these reports can be a good criterion for evaluating a driver. The GPS can provide a good alternative for controlling and evaluating the drivers in the fleet, with features such as easy communication with the operator, providing drivers' current location, and automatic crash notification. The GPS, in addition to the reports received from passengers, can provide the basis for creating a driver ranking system, similar to the ride-hailing services rating system such as Uber [64].

According to the results of the Kendall test for Question B3, passengers' loading and unloading have the highest priority in terms of safety. As an effective way to reduce the risk of this movement, managers in Question C2 unanimously chose to use the start-inhibit technology to detect open doors. In addition to using this new technology, passenger safety training can be effective in reducing risk when getting in and out of a taxi. According to responses in Question B4, these trainings should begin at an early age and at schools to have the greatest impact.

6. Conclusions

Taxi is one of the on-demand passenger transport modes that serve the transport demand in the metropolitan area of Tehran. However, various factors such as driver's characteristics, environmental factors, or inadequate management programs of the taxi organization have brought about many safety-related problems. Although the Tehran Taxi Organization has made substantial efforts to increase drivers' awareness of taxi safety issues, no specific study has been performed on the relevance and effectiveness of these programs. To tackle these issues, the opinions of managers and specialists of the Taxi Organization were assessed regarding taxi safety issues through a questionnaire survey. Given that these people are the main decision-makers about the organization's safety plans, their opinions and suggestions can determine their priorities for future decisions. Furthermore, Tehran has one of the largest taxi fleets in the world, and therefore, the results of this research can be a valuable resource for countries that have a similar transportation system as Tehran.

The participants responded to questions related to the taxi driver, road network and road users, and the use of new technologies to increase vehicle safety and management issues and programs. According to the findings of this study, the managers considered most of the items under those questions to be effective, which indicates the prevalence of safety issues in taxis. Participants stated that using technologies such as GPS will improve the safety of taxis. The use of GPS was unanimously chosen as the best in-vehicle monitoring system. In addition, participants believed that this system can be the best way to evaluate drivers in the fleet. The start-inhibit technology to detect open doors was evaluated unanimously efficient by managers considering the high risk of passengers' loading and unloading. The intersections are the most dangerous places in terms of the probability of taxis crashes and that the failure to observe a safe distance from the front car and driver's mistake are the main causes of crashes in participants' opinions. With respect to educating taxi users, starting education in schools has the most relevance and priority. In terms of driver risk factors, managers found fatigue and drowsiness to be very important but received less priority in driver health assessment programs. Although the managers considered the programs related to driver health assessment and the problems in this area very important, no unity was seen regarding the priority of these cases. Based on the results of this study, the following recommendations for taxi safety managers and policymakers to improve the safety of taxi drivers and their working conditions are suggested. It is to be noted that these recommendations are independent of the limitations of the organization, but can be altered based on existing conditions:

- (1) The use of technologies such as GPS to improve the safety of taxis can be very effective. Monitoring and evaluating drivers by intelligent control systems such as GPS can provide a basis for identifying drivers' problems and weaknesses. Based on this information, suitable specific training programs can be targeted to the driver to improve their driving performance. GPS can also be used to create a driver ranking system, similar to those used by ride-hailing services. Having said that, there may be privacy issues for drivers due to the use of GPS. However, drivers may be prepared to accept surveillance through GPS and loss of privacy if it would mean that the taxi industry would be regulated better, with improved safety and financial rewards. Further, the acceptance is more likely if taxi drivers are allowed to participate in the decision-making process and to have a say on who controls it, who decides what information to collect, and how to use it.
- (2) It is suggested to cooperate with the police authority to receive crash reports. Also, managers should submit a monthly safety report to evaluate the actions that are implemented. In addition, a person or a group with a specialty in vehicular safety can be assigned to evaluate crashes and assess safety.
- (3) In order to prevent drivers' fatigue, it is recommended to change drivers' working conditions by modifying drivers' working hours. It is also necessary to provide fatigue management training programs for drivers, which include trainings to recognize and prevent fatigue. Also, installation of drowsiness and fatigue detection system in taxis may improve the safety of the drivers.
- (4) In addition to safety issues, anger management, stress and fatigue management, addressing the possible problems of drivers' health and lifestyle, and eating habits are also important. For easier learning, non-face-to-face trainings through the online medium by using the cyberspace are recommended.
- (5) It is necessary to conduct periodic assessments of drivers' health. These programs can include periodic check-ups, addiction tests, drivers' psychological assessment, and counselling programs to improve their lifestyle and avoid bad habits.
- (6) Allocating financial and nonfinancial rewards to safe drivers can be effective to encourage safe driving practices and improve drivers' driving performance. Nonfinancial rewards can be given to the drivers in the form of vehicle consumables such as tires, discount coupons, and similar items.
- (7) It is suggested to start trainings related to the safety of taxi users from schools. Moreover, the use of cyberspace and different online media can be effective to teach these items.

More research is needed on taxi driver training and policy decisions in the taxi industry. It would be good to develop programs to evaluate taxi drivers' work concerns to foster positive changes. Failure to assess suitable safety strategies by taxi organization managers could lead to a significant waste of resources and continued loss of life and property. Moreover, in our present study, we only analyzed the perceptions of managers and specialists. There is a need to consider taxi drivers' beliefs and evaluate them regarding the discussed issues so that a better taxi driver risk management framework could be developed to improve taxi drivers' safety. By conducting similar studies in other countries that have similar cultural context, it could help to identify and prioritize different challenges to improve taxi safety.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

The Survey Questionnaire of transport management. (*Supplementary Materials*)

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