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Research article

Predicting the type of road accidents based on air temperature in Iran: A case study of roads in Qazvin province

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ABSTRACT

This study investigates the relationship between ambient temperature, weather conditions, and types of road accidents in Qazvin province, Iran. The research addresses a significant societal challenge of road accidents, particularly in developing countries like Iran. The objectives are to analyze the correlation between temperature and accident types and to develop a predictive model using data mining techniques. The study employs a quantitative approach, analyzing over 15,000 accident records from 2010 to 2020. The findings reveal a connection between the temperature variable and the type of road accidents as well as weather conditions. Additionally, data mining analysis identifies a predictable pattern among temperature variables, types of road accidents, and weather conditions. Implications of the study underscore the importance of considering temperature and weather conditions as secondary factors influencing accidents. The predictive model can aid decision-makers in formulating effective strategies to reduce accidents. Understanding the relationship between temperature, weather, and accident types enables the design of targeted interventions to enhance road safety. This research contributes valuable insights to accident reduction efforts and emphasizes the significance of addressing environmental variables in road safety planning and policy-making.

Moreover, the results of the data mining pattern analysis indicate that car overturning accidents in various weather conditions are the primary type of accidents, followed by chain accidents. However, the types of accidents vary based on different weather conditions and temperatures. The study highlights the intricate connection between weather conditions, temperature, and types of road accidents. By utilizing data mining techniques, the research provides a predictive model for accident patterns, offering valuable insights to enhance road safety strategies.

1. Introduction

Roads serve as the primary and most natural means of communication among human beings, enabling economic and social mobility. Early humans during the Stone Age, who inhabited mountains and caves, are recognized as the earliest contributors to the development of roads. However, since the inception of roads, road accidents have emerged as a significant cause of death and severe personal and financial injuries [1]. The occurrence of road accidents and resulting casualties poses a substantial challenge to human

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societies, imposing considerable economic costs on countries, particularly impacting developing nations where road accidents are a leading cause of death. Unfortunately, Iran stands out as a country witnessing an escalating accident rate, attributed to a lack of attention to safety principles and related factors, as indicated by available statistics [2].

Despite roads historically contributing to the advancement of civilization and supporting economic and social activities, recent years have witnessed a surge in accidents on both urban and suburban roads in Iran. The escalating number of casualties and accidents on a national scale raises concerns, especially considering Iran's disproportionate share of global accidents, accounting for one-fortieth of the world's accidents with only one-hundredth of the world's population. Approximately 20,000 deaths due to road accidents occur annually in Iran, with human, vehicle, road, and environmental conditions identified as the main causes of these accidents. Encouragingly, recent reports from the Iranian Police Traffic and Forensic Medicine Organization suggest a decrease in the number of financial and human casualties resulting from accidents.

Temperature, considered a secondary factor in accidents, has been explored in various research studies (such as [3]) as an influential element. Surprisingly, Khaledi et al. (2022) [4] found air temperature (both cold and hot) to be a significant contributor to road accidents in Iran. This article aims to investigate how temperature influences the types of road accidents under different weather conditions using data mining and decision tree analysis.

The types of accidents examined in this research include face-to-face accidents, chain accidents, vehicle rollovers, collisions with fixed objects, side-to-side accidents, front-to-back accidents, front-to-side collisions with humans, and leaving the road. Of course, in this research, weather conditions have been considered as one of the effective side factors in road accidents in Iran. Therefore, the main questions of this research are: 1. Are temperature and type of road accidents related? 2. What is the pattern of forecasting three factors of weather conditions, how accidents happen and temperature?

This research on the relationship between ambient temperature, weather conditions, and the type of road accidents holds relevance for various stakeholders. Researchers, policymakers, traffic safety organizations, and the general public are likely to care about the findings presented in this text. Understanding the relationship between temperature, weather conditions, and different types of road accidents can have significant implications for road safety measures, accident prevention strategies, and policy decisions. This information can help guide efforts to reduce the frequency and severity of road accidents, which is a concern for societies worldwide.

Moreover, this study indicates a significant relationship between ambient temperature, weather conditions, and the type of road accidents in Qazvin province. The study employs statistical analysis and data mining techniques to draw correlations and create predictive models for accident types based on temperature and weather conditions. The research contributes to the existing body of knowledge about road accidents and their contributing factors, shedding light on the importance of temperature in accident occurrence and severity.

While the text provides insights into the relationship between temperature, weather conditions, and accident types in the context of Qazvin province, it doesn't elaborate on the specific underlying mechanisms driving these relationships. Additionally, the text does not discuss potential implications of these findings beyond the scope of Qazvin province or the possible limitations of the study. Therefore, the findings have implications for road safety practices, policy-making, and accident prevention efforts.

If the relationship between temperature, weather conditions, and accident types is confirmed in other regions or countries, this information could be used to tailor road safety interventions based on weather forecasts. For instance, if a specific type of accident is more likely to occur under certain weather conditions, measures could be taken to mitigate the risk, such as improving road signage, enhancing visibility, or promoting safe driving behaviors.

Based on the presented text, further research can be conducted to explore and confirm the relationship between temperature, weather conditions, and different types of road accidents in various regions and countries. By extending this research, we can gain a broader understanding of the patterns and trends related to road accidents and their interactions with environmental factors. This expanded knowledge could lead to more effective road safety strategies and targeted interventions to reduce accidents and their associated casualties.

Several valuable studies have been conducted in the field of road accidents. For example:

Theofilatos et al. (2016) [5] conducted a study to predict road accidents by modeling rare events and demonstrated a negative relationship between accidents and speed.

Vakil al-Roaya & Zargar (2018) [6]determined and analyzed the factors affecting the occurrence of road accidents in the roads of Semnan province, highlighting the significant impact of the human factor.

Eugene & Ostendorf (2019) [7] emphasized the impact of traffic conditions on the occurrence and increase of accidents, with weather conditions often examined as effective lateral variables.

Hammad et al. (2019) [8] studied the conditions and causes of accidents in Punjab, Pakistan, showing that weather conditions such as rainfall, temperature, and storms had a significant impact on the increase of accidents in this region. Jalilian et al. (2019) [9] examined the main causes of road accidents in Iran and concluded that climatic factors are one of the most important factors affecting road accidents in Iran.

Bergel-Hayat et al. (2013) [10] investigated the relationship between accidents and road types and their relationship with weather conditions, highlighting the increase in accidents with increasing rainfall and frost, especially on intercity roads and highways. Maraj & Kuka (2019) [11] created a fuzzy logic model for predicting accidents on Albanian roads using the MATLAB fuzzy logic toolbox, emphasizing the importance of understanding road accidents to reduce their injuries.

Ali et al. (2020) [12] investigated the impact of factors such as temperature, rainfall, and the number index of health workers on the number of road casualties in Pakistan, demonstrating a direct impact of these variables on increasing road traffic. Alagarsamy et al. (2021) [13] used machine learning techniques to determine accident-prone spots in India, identifying spots with a higher risk of accidents based on predictions and placing these spots on guide maps to reduce the risk of accidents.

Sangkharat, Thornes, Wachiradilok & Pope (2021) [14] studied the impact of rain on road accidents in Thailand, showing that rain is related to an increase in road accidents.

Liang et al. (2021) investigated the effect of temperature on injuries caused by traffic accidents with the mediation of the time factor in Dalian, China, demonstrating a non-linear and delayed relationship between ambient temperature and traffic accident injuries. Basagana & Pena-Ramirez (2023) [15] estimated the relationship between temperature and the occurrence of accidents in Spain with the mediation of human factors, showing that high temperature increased.

While these studies differ in objectives, subjects, and research methods, the present study's findings offer valuable insights for relative accident reduction.

2. Materials and methods

This study is a type of developmental research that employs a quantitative approach to analyze road accident data. Due to the vast geographical scope of Iran and the high number of road accidents, Qazvin province has been selected as a case study.

Qazvin province was chosen due to its significant climatic and geographical diversity, as well as its status as a major transportation corridor between Northern provinces, cities of Iran, and other provinces. Its proximity to the capital has further contributed to its importance. Therefore, this research analyzes data related to accidents on the roads of Qazvin province over a ten-year period from 2010 to 2020.

The first question was addressed using inferential statistical methods and calculation of Spearman and Kendall's coefficients. Since our data in this section did not exhibit a normal distribution based on the tests in Table 1 (both Shapiro and Kolmogorov-Smirnov tests yielded a significance level less than 0.05, indicating non-normal data distribution), non-parametric tests were utilized.

To investigate the relationship and correlation between temperature and the type of accidents, a sample of 4,800 cases was selected from a larger dataset of approximately 15,000 accident records spanning the years 2010–2020. The sample selection was stratified to ensure representation across different years and months, with each year and month contributing between 3 and 10 cases, resulting in a diverse and comprehensive representation.

To address the second research question, a data mining technique was employed using the J48 decision tree algorithm within the "Weka" data mining software. The J48 algorithm was selected for its ability to generate a comprehensible clustering and decision tree based on statistical relationships between variables. This process involved utilizing the entire dataset of accidents in Qazvin province over the years 2010–2020, totaling approximately 15,000 incidents, to construct the decision tree. This approach aimed to provide robust and representative insights into the relationship between temperature and the types of accidents, revealing patterns and associations within the data.

The functioning of the J48 algorithm can be explained as follows:

Messy Data: Our dataset is akin to a messy room with information about accidents, including accident types, temperatures, weather conditions, etc.

Entropy: J48 identifies the messiest part of our data room, representing the factor with the most disorder when predicting the type of accidents (temperature).

Sorting and Organizing: J48 organizes the accidents based on temperature, identifying associations between higher temperatures and specific types of accidents.

Breaking it Down: For each temperature range, J48 further examines other factors such as weather conditions, continuing to break down the data until achieving more predictable groupings.

Decision Tree: The organized decisions form a tree-like structure, providing specific predictions based on factors like temperature and weather.

Simple Rules: The decision tree yields simple rules for predicting or understanding accident types based on factors like temperature and weather.

Pruning (Optional Cleaning): J48 may simplify the tree by removing branches that do not significantly contribute to predicting accident types, enhancing its effectiveness.

Ultimately, the research culminates in a decision tree tailored to Qazvin's accidents, aiding in predicting or understanding accident types based on factors such as temperature and weather.

3. Results

First question: Spearman and Kendall's correlation test (Table 2) was used to discover the relationship between the two variables of

Table 1
Tests of normality.

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Tempreture	0.095	4800	0.000	0.950	4800	0.000
type	0.150	4800	0.000	0.905	4800	0.000

a. Lilliefors Significance Correction.

ambient temperature and the type of road accidents, considering that the data were not normal.

H0 = the type of road accidents is not correlated with the ambient temperature

Considering that the significance (Sig) obtained in both correlation tests is less than 0.01 (as the test was conducted at the 99% confidence level), the null hypothesis is rejected. This implies that the two variables, namely the type of road accidents and temperature on the roads of Qazvin province, are correlated.

To address the second question, as previously mentioned, the decision tree drawing technique was employed in the "Weka" data mining software, utilizing the J48 algorithm. The result of this process is illustrated in Fig. 1.

In the data clustering phase, three nodes (variables) were taken into account: the type of accidents, weather conditions, and average ambient temperature. The first node or level of clustering, identified by the algorithm, is based on weather conditions (fog, rain, snow and blizzard, sunny, frost/Ice). The second level or node of clustering is based on the average ambient temperature. The final level or node was determined based on the type of road accidents, including face-to-face accidents (FF), chain accidents (MULTI), vehicle rollovers (Inver), collisions with fixed objects (STA), side-to-side accidents (SS), front-to-back accidents (FB), front-to-side (FS), collisions with humans (Human), and leaving the road (Out).

3.1. Second question

To address the second question, given the substantial volume of data (exceeding 15,000 records) and the necessity of identifying patterns between the main variables, the J48 data mining algorithm was employed in the "Weka" software. This algorithm has the capability to draw a decision tree for big data by utilizing clustering and matching techniques (Fig. 1).

This model predicts the probability of road accidents in Qazvin province from 2010 to 2020 based on temperature variables and different weather conditions.

Fig. 1 illustrates that on sunny days, accidents were more likely to occur without a significant relationship with temperature, compared to car rollovers.

In rainy weather conditions, at lower temperatures ranging from 0.8 °C to 7.7 °C, the probability of various accident types increases. For instance, at temperatures between 2.6 °C and 4.2 °C, the probability of chain-type accidents increases. Additionally, at temperatures above 3 °C, the probability of front-to-back accidents is higher.

In foggy weather conditions, various temperature ranges correspond to different probabilities of accidents, such as collisions with fixed objects and car overturning.

In freezing weather conditions, lower temperatures are associated with increased probabilities of chain-type accidents and car overturning.

In snow and blizzard weather conditions, specific temperature ranges are linked to increased probabilities of various accident types, including car rollovers and chain-type accidents.

These findings provide valuable insights into the relationship between temperature, weather conditions, and the likelihood of different types of road accidents in Qazvin province from 2010 to 2020.

4. Discussion

The findings of this research confirm the influence of ambient temperature on traffic accidents, aligning with previous studies such as Liang et al. (2021) [3], which emphasized the impact of ambient temperature on traffic accidents and public health. It is evident that temperature, along with other environmental factors, can serve as a secondary cause of accidents, influencing factors such as fatigue, sleepiness, and technical defects in vehicles, which are primary contributors to accidents. In this study, the main causes of road accidents were collected and analyzed from the perspectives of accident victims and police accident officers.

What sets this research apart is its investigation into the relationship between the type of accidents and ambient temperature,

Table 2
Correlations.

			Tempreture	type
Kendall's tau_b	Tempreture	Correlation Coefficient	1.000	−0.057[a]
		Sig. (2-tailed)	.	0.000
		N	4800	4800
	type	Correlation Coefficient	−0.057[a]	1.000
		Sig. (2-tailed)	0.000	.
		N	4800	4800
Spearman's rho	Tempreture	Correlation Coefficient	1.000	−0.080[a]
		Sig. (2-tailed)	.	0.000
		N	4800	4800
	type	Correlation Coefficient	−0.080[a]	1.000
		Sig. (2-tailed)	0.000	.
		N	4800	4800

[a] Correlation is significant at the 0.01 level (2-tailed).

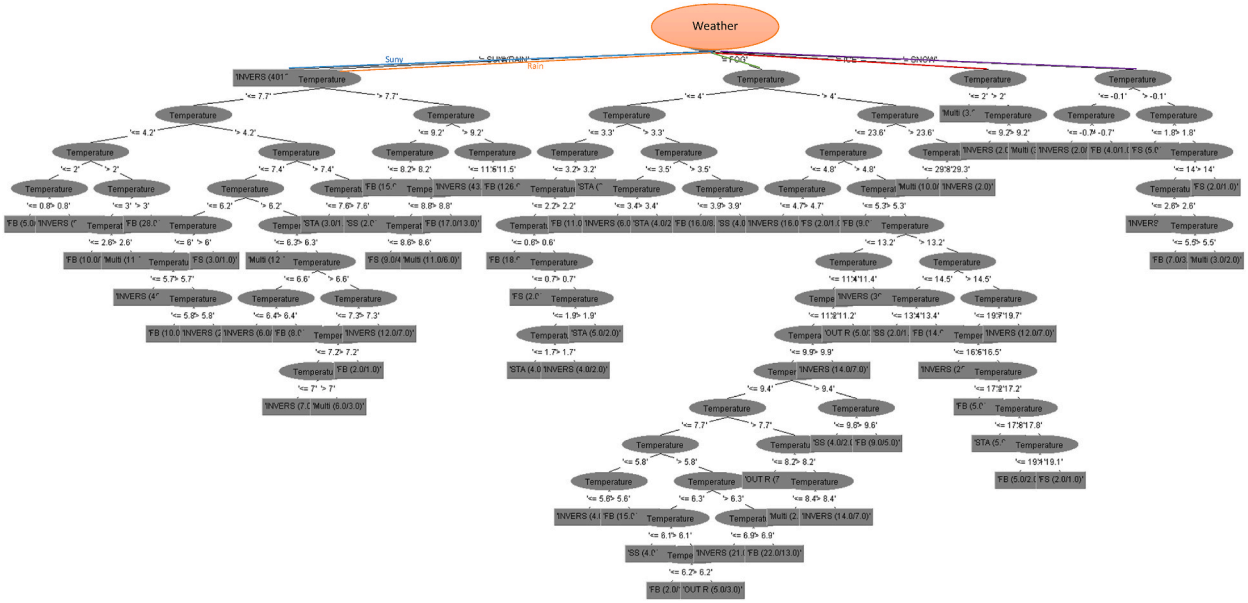

Fig. 1. Modeling (decision tree) of road accidents based on the type and manner of occurrence of road accidents in Qazvin province with temperature variable.

revealing that ambient temperature is associated with the occurrence of different types of accidents. This suggests that changes in ambient temperature can alter the likelihood of specific accident types, potentially affecting accident severity and resulting casualties. Therefore, predicting accident severity based on ambient temperature is feasible, and further research in cities and on roads with varying climatic and ambient temperature differences is recommended.

Noteworthy research has been conducted on the relationship between temperature and accidents, including Corcuera Hotz & Hajat's (2020) [16] study on the effect of temperature on attendance at Accident & Emergency Departments in London. Their results demonstrated a positive relationship between temperature and attendance, particularly among children and individuals with lower socioeconomic status.

Thus, temperature emerges as a significant variable in accidents that warrants examination from diverse perspectives. Considering global temperature changes, exploring the temperature factor alongside other environmental and human factors can contribute to accident reduction.

The application of Spearman and Kendall's correlation tests revealed significant findings regarding the relationship between ambient temperature and the type of road accidents, rejecting the null hypothesis and supporting previous research emphasizing the impact of ambient temperature on traffic accidents. These findings enhance our understanding of the factors influencing road safety.

Utilizing the J48 data mining algorithm to construct decision trees enabled a more comprehensive analysis of the complex relationships between weather conditions, ambient temperature, and the occurrence of different types of road accidents. This approach offers practical insights for policymakers, traffic management, and law enforcement agencies to prioritize accident prevention strategies based on identified patterns.

The decision tree model created through data mining provides a practical tool for predicting the likelihood of specific road accidents in Qazvin province. This predictive capability can support proactive measures such as road maintenance, improved traffic management during adverse weather conditions, and targeted awareness campaigns to reduce accident occurrences. The insights gained from this study can inform decision-making at both local and regional levels.

The study's findings underscore the importance of considering weather conditions and ambient temperature in road safety policies and regulations. Integrating temperature-related variables into road safety strategies can lead to more effective accident prevention measures, aligning with international efforts to enhance road safety and reduce accident-related casualties.

4.1. Key insights from this study include

Temperature's Role in Fatigue and Focus: The study highlights the connection between ambient temperature and driver fatigue, particularly in extreme temperatures. The higher occurrence of overturning accidents in sunny weather conditions suggests a potential link between temperature and reduced driver concentration, leading to loss of control.

Weather-Related Accident Trends: The research provides insights into how different weather conditions influence accident types. Rainy weather, for example, is associated with higher probabilities of car overturning and chain accidents due to reduced friction and increased slipperiness.

Visibility and Accident Types: Poor visibility conditions, such as fog and blizzards, are linked to specific accident types, such as

front-to-back and front-to-side collisions. This emphasizes the importance of improving visibility and driver awareness in such conditions.

Predictive Modeling for Accident Prevention: The study's decision tree modeling approach demonstrates the potential for predicting accident probabilities based on temperature and weather conditions. This modeling technique could be applied in real-time to enhance road safety measures and response strategies.

Totally, The main strengths of the study include its comprehensive analysis of road accidents in Qazvin province over a ten-year period, the use of non-parametric tests to address the non-normal distribution of data, and the application of data mining techniques such as the J48 decision tree algorithm to identify patterns and correlations between temperature, weather conditions, and different types of road accidents. The study's findings provide valuable insights into the relationship between temperature, weather conditions, and the likelihood of different types of road accidents, which can inform road safety measures and policy decisions. Additionally, the research methodology employed a quantitative approach and utilized statistical analysis to ensure robust and reliable results.

The data analysis in this article did not have any significant limitations, except for the complexity caused by the large volume and variety of data. At times, to enhance clarity, certain data sets were merged together.

5. Conclusion

As previously mentioned, road accidents have been a significant cause of loss of life and financial resources over time, prompting numerous studies to address this challenge from various perspectives. The availability of robust analytical and data mining software has brought forth discussions on forecasting and data analysis to facilitate informed decision-making and policy development in diverse societies. Concurrently, weather and its related elements are identified as contributing factors exacerbating accident occurrences in Iran, as confirmed by studies such as Behtooiy & Eltamasi (2020) [17]and Khaledi et al. (2022) [4]. Therefore, this research aims to forecast and analyze the relationship between weather conditions (rainy, sunny, snow, blizzard, frost, and fog), average temperature, and the occurrence of accidents in Qazvin province, an important region in Iran.

Examination of accident types on Qazvin province's roads reveals that overturning accidents exhibit a higher frequency than other types across different temperatures and weather conditions, while encounters with humans and face-to-face accidents have the lowest frequency. This observation suggests a correlation between temperature, driver fatigue, and lack of concentration towards their vehicles. Individuals in both low and high temperatures (cold and hot) often experience fatigue and boredom, leading to increased likelihood of speeding and unauthorized overtaking, thereby reducing their control over the vehicle. These factors are identified as significant contributors to car overturning accidents in Iran, as indicated by the findings of Khaledi et al. (2022) [4] and Behtooiy & Eltmasi (2020) [17].

The impact of ambient temperature on fatigue and vehicle control is particularly pronounced in sunny weather conditions, resulting in the highest probability of overturning accidents. Rainy weather conditions at lower temperatures elevate the likelihood of accidents such as car overturning and chain accidents due to reduced friction and increased slippage. Subsequently, foggy weather conditions also exhibit a strong association with accidents and temperature, with car overturning being the most prevalent type, followed by front-to-back accidents due to reduced visibility.

In freezing conditions, chain accidents are more likely to occur due to reduced vehicle control stemming from severe slippage and diminished visibility caused by ice reflection. Similarly, snow and blizzard conditions lead to common occurrences of overturning accidents, front-to-back, and front-to-side accidents due to slippery roads, wind presence, and route deviation caused by intense wind.

This study provides valuable insights into the relationship between weather conditions, ambient temperature, and road accidents. The combination of correlation analysis and data mining techniques offers a comprehensive approach to understanding accident patterns and predicting their occurrence. These findings have important implications for both theoretical research and practical road safety strategies, underscoring the significance of considering temperature-related factors in accident prevention efforts.

Moreover, this research advances our understanding of the intricate relationship between ambient temperature, weather conditions, and the occurrence of different types of road accidents. By uncovering these relationships, the study lays a foundation for evidence-based decision-making in road safety management. The findings underscore the need for integrated approaches that consider both environmental factors and driver behaviors when designing interventions to prevent and mitigate road accidents.

Furthermore, the research paves the way for future studies in diverse geographic regions with varying climate conditions. Expanding this analysis to different cities and road networks could yield valuable insights into localized accident patterns and help refine road safety strategies on a broader scale.

Overall, this study serves as a valuable resource for policymakers, transportation authorities, and researchers working towards reducing the frequency and severity of road accidents. By incorporating the lessons learned from this research, stakeholders can collaborate to create safer road environments and contribute to the overarching goal of improving public safety and well-being.

In conclusion, the findings of this research clearly demonstrate a relationship between accident types, weather conditions, and environmental temperature variables that can be utilized for predictive purposes, decision-making, and planning to reduce road accidents.

List of abbreviations

Not applicable.

Statements and declarations

Ethics approval and consent to participate: There was no conflict of interest in this article, and the data was taken from the database of the Iranian traffic police, and due to the anonymity of the individuals, ethical issues have been observed.

Authorship

All authors have made substantial contributions to all of the following: (1) the conception and design of the study, the acquisition of data, or the analysis and interpretation of data; (2) drafting the article or critically revising its important intellectual content; (3) final approval of the version submitted. The corresponding author has to declare the contributions of individual authors when submitting the article, *and both authors of this article ME and HB acknowledge the submission and review of this article by the Heliyon editorial board, and HB was a major contributor in writing the manuscript, ME Analyze the data and was a major contributor in writing the manu*script.

interests policy

The authors of this article and their relatives have not and do not have any financial or non-financial benefits related to this article, and no company or natural and legal person has given financial assistance to the authors to carry out the research of this article.

Consent for publication

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Informed consent

Informed consent was obtained from all individual participants included in the study.

Authors' information

Not applicable.

Data availability statement

Data will be made available on request. *The data that* support *the findings of this study are available from the corresponding author upon reasonable request.*

CRediT authorship contribution statement

Mahshid Eltemasi: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Hassan Behtooiey:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Data curation, Conceptualization.

Declaration of AI and AI-assisted technologies in the writing process

In this article, artificial intelligence is used only to edit the grammar and improve the readability of the text.

Informed consent was not required for this study because [In this article, the analysis of meteorological data and accidents has been used without considering the identity of people (only blind data) and there was no experiment on humans, animals, etc.].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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