Original Article

Modeling Time Series of Mortality Cases Due to Traffic and Non-Traffic Accidents in Northwestern Iran from 2013 to 2022

Abstract

Background: Globally, accidents rank as the third leading cause of mortality, following cardiovascular diseases and cancer. Accidents also account for 12% of the global disease burden. This study aims to examine the trends in mortality cases resulting from both traffic and non-traffic accidents. **Materials and Methods:** This descriptive-analytical study utilized recorded data from the Health Deputy of West Azerbaijan Province, Iran, spanning from 2013 to 2022. A complete census was conducted across the entire province during the study period, yielding a total of 7716 fatalities due to traffic accidents and 7316 deaths due to non-traffic accidents. The Box-Jenkins AutoRegressive Integrated Moving Average (ARMA) models were employed for time series analysis. Descriptive analysis was performed using SPSS software, while modeling conducted using R Studio and SAS. **Result:** A total of 7716 deaths were recorded due to traffic accidents, and 7316 deaths were attributed to non-traffic accidents. Among traffic-related fatalities, 19.67% were female and 80.33% were male. In contrast, for non-traffic accidents, 29.65% of the victims were female and 70.35% were male. The ARIMA model was employed for modeling based on autocorrelation and partial autocorrelation plots, with the ARIMA (2, 0, 0) (2, 0, 0) model identified as the best fit for traffic accidents and the ARIMA (1, 0, 1) (2, 0, 0) model for non-traffic accidents in the context of monthly mortality time series. **Conclusions:** The predictions for both traffic and non-traffic accidents indicated a decreasing trend in mortality. Furthermore, mortality trends and distributions for both categories of accidents exhibited similarities.

Keywords: *Accidents, non-traffic, time series, traffic*

Behrouz Fathi[1,2], Vahid Alinejad[3], Mitra Galvani[4], Fatemeh Rostampour[5]

[1]Social Determinants of Health Research Center, Clinical Research Institute, Urmia University of Medical Sciences, Urmia, Iran, [2]Department of Health Economics and Management, School of Public Health, Urmia University of Medical Sciences, Urmia, Iran, [3]Department of Community Medicine, School of Medicine, Urmia University of Medical Sciences, Urmia, Iran, [4]Health System Research Development Unit, Clinical Research Institute, Urmia University of medical Sciences, Urmia, Iran, [5]Department of Biostatistics and Epidemiology, Faculty of Medicine, Urmia University of Medical Sciences, Urmia, Iran

Address for correspondence:
Dr. Fatemeh Rostampour, Department of Biostatistics and Epidemiology, Faculty of Medicine, Urmia University of Medical Sciences, Urmia, Iran. Postal Code: 5735181922
E-mail: Fatemeh.rostampor@yahoo.com

Introduction

Accidents and incidents rank as the third leading cause of mortality worldwide, following cardiovascular diseases and cancer.[1] According to the World Health Organization (WHO), an accident is defined as an unforeseen event that causes recognizable harm and is characterized as an unexpected and unplanned occurrence that can lead to injury.[2] The advent of the Industrial Revolution and its subsequent transformations have drastically altered human living conditions.[3] Currently, accidents and incidents represent a significant drain on governmental resources and programs. Factors such as climate change, anthropogenic environmental alterations, and rapid technological advancements have contributed to both an increased frequency of accidents and a heightened vulnerability of populations.[4] Accidents are the second leading cause of disabilities, contributing to physical and psychological trauma, and in severe cases, can lead to death. Approximately 15,000 individuals suffer minor injuries daily. Globally, accidents account for 12% of the disease burden, with road traffic incidents being the leading cause of mortality from accidents.[5] According to the latest WHO Global Status Report on Road Safety (2023), while global road traffic mortality rates have remained largely unchanged, Iran continues to report some of the world's highest rates of road traffic fatalities. Although substantial interventions have been implemented, the country still grapples with a significant public health burden attributable to road traffic injuries.[6] Traffic accidents rank as the eighth leading cause of death worldwide and the primary cause of death among individuals aged 15–29.[7]

In Iran, it is estimated that about 9 million accidents occur each year, making

How to cite this article: Fathi B, Alinejad V, Galvani M, Rostampour F. Modeling time series of mortality cases due to traffic and non-traffic accidents in Northwestern Iran from 2013 to 2022. Iran J Nurs Midwifery Res 2026;31:148-53.

Submitted: 09-Nov-2024. **Revised:** 22-Jul-2025. **Accepted:** 29-Jul-2025. **Published:** 02-Jan-2026.

Access this article online

Website: https://journals.lww.com/jnmr

DOI: 10.4103/ijnmr.ijnmr_384_24

Quick Response Code:

them one of the primary causes of hospitalization and mortality.[8] Furthermore, Iran has one of the highest traffic accident mortality rates compared to other countries.[9] Accidents predominantly result in mortality among younger individuals, leading to a significant loss of potential life years, which in turn negatively affects life expectancy at birth and the economy and society as a whole.[10]

The first step in preventing and controlling casualties resulting from this major issue is to collect baseline data regarding its scope and related factors. Therefore, this study aims to provide precise information on mortality rates, identify trends in occurrence, and predict future incidence through time series analysis, particularly in light of the lack of similar studies in the region. This information will enable policymakers to implement preventive and control measures, especially for at-risk groups.[11] Time series analysis is a statistical methodology for longitudinal study designs involving repeated measurements at specified intervals, such as daily, weekly, or annually. This type of analysis is utilized for forecasting, characterizing, elucidating, and controlling diseases. Due to the availability of comprehensive recorded data within the health system, time series analysis has attracted particular interest in medical and health research in recent years.[12] In medical sciences, time series modeling has been employed for diseases such as Crimean–Congo hemorrhagic fever[13] and tuberculosis.[14] Consequently, researching to elucidate patterns of occurrence is a vital objective in disease prevention. This study aims to examine the trends in mortality cases due to traffic and non-traffic accidents in West Azerbaijan province of Iran from 2013 to 2022.

Materials and Methods

The objective of this descriptive-analytical study was to conduct an epidemiological investigation and time series modeling of mortality cases due to traffic and non-traffic accidents in West Azerbaijan Province from March 21, 2013, to March 20, 2022. The sampling was conducted as a complete census across the entire province during the study years, resulting in a total of 7,716 fatalities due to traffic accidents and 7,316 fatalities due to non-traffic accidents recorded. The inclusion criteria were individuals whose deaths occurred in West Azerbaijan Province and were officially recorded. All data were provided anonymously, without identifying information about the deceased. The descriptive variables were gender, age group, and location of death. For time series analysis, the ARIMA (p, d, q) (P, D, Q) model was utilized. Three key steps were taken in the modeling process to facilitate predictions: model identification, parameter estimation for the selected model, and model evaluation. To determine the order of the Moving Average (MA) and Autoregressive (AR) terms included in the ARIMA model, sample Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) graphs were employed. Specifically, an ARIMA model with p-AR components and q-MA components is suggested if statistically significant autocorrelation is observed in the sample ACF plot at q-time lags and significant sample PACF at p lags. The goodness of fit and Akaike's Information Criterion (AIC) were combined to select the final model (order). The goodness of fit was assessed using the residual autocorrelation function to ensure that no additional autocorrelation was present in each fit. Descriptive analysis was performed using SPSS software, while time series modeling was conducted using R Studio and SAS.

Ethical considerations

This study was approved by the Ethics Committee of Urmia University of Medical Sciences (code: IR.UMSU.REC.1402.258). The data used in this study were collected without direct involvement of participants, and all information was received anonymously without any identifiers. All relevant ethical guidelines and regulations were followed. This manuscript is free from plagiarism. All authors confirm that the study was conducted honestly and with integrity, with no data fabrication or falsification. All ethical standards for scholarly research were fully observed.

Results

During the study period, a total of 7,716 deaths due to traffic accidents and 7,316 deaths due to non-traffic accidents were recorded in West Azerbaijan Province. Among the 7,716 traffic-related deaths, only 1,518 (19.67%) occurred in females, while 6,198 (80.33%) occurred in males. Of the 7,316 non-traffic-related fatalities, 2,170 (29.65%) were among women and 5,146 (70.35%) were among men. Regarding traffic accidents, 2,911 (37.70%) deaths occurred in rural areas, while 4,805 (62.20%) occurred in urban areas. For non-traffic accidents, 3,088 (42.20%) took place in rural areas, and 4,227 (57.70%) in urban areas. Fatalities in public areas and on roadways were more prevalent than those at home or in hospitals for both categories of the accidents. In non-traffic incidents, the number of deaths in hospitals and homes were nearly the same, while in traffic accidents, the rate of mortality at home was lower [Figure 1]. Overall, the mortality rate was the highest among individuals aged 11 to 30 years. Traffic-related deaths were most prevalent in the 31–50 age group, while non-traffic-related deaths were more common in the 11–30 age group. Among individuals over 70 years old, non-traffic accidents were more frequent.

In the initial phase of time series analysis, a time series plot of monthly mortality data due to traffic and non-traffic accidents was created. The time series plot indicated that both data series were stationary in terms of variance, as the variability of the series remained relatively constant over time. The Box-Cox test was employed to assess the variability in variance. The results showed no evidence of instability in the series' variance. Both the lower and

upper confidence limits included a value of one, indicating consistent data dispersion. In the decomposition analysis, both types of accidents exhibited an increasing trend from the beginning of the study period, with a noticeable decline in traffic-related incidents starting in 2019. However, from mid-2020, mortality cases began to rise sharply again [Figure 2].

The identification of the AR parameter was conducted through the examination of the PACF plot. In the traffic-related series, a significant partial autocorrelation was observed at lag 15 among the first 20 lags, resulting in an assignment of p = 1. The analysis of the PACF plot to determine the seasonal parameter P revealed significant partial autocorrelation at lag 5 within the first 20 lags, leading to an assignment of P = 1. In the non-traffic section, none of the partial autocorrelations in the first 20 lags were significant; therefore, p = 0 and p = 0 were assigned. Given the absence of seasonal differentiation, the order of the seasonal parameter is D = 0. In the traffic section, an examination of the autocorrelation plot for the parameter q revealed significant autocorrelation at lag 12 among the first 20 lags, leading to an evaluation of q = 1. Additionally, the autocorrelation plot in the non-traffic section was significant at lag 1, resulting in the assignment of q = 1.

Based on the ACF and PACF plots, the ARIMA model was employed for modeling, with the ARMA (1, 0, 1) (0, 1, 1) model without a constant term selected as the initial model for the time series behavior of monthly mortality due to traffic and non-traffic accidents. Additionally, using the auto-ARIMA feature in R software, the ARIMA (2, 0, 0) (2, 0, 0) model with zero mean was chosen for traffic accidents, while the ARIMA (1, 0, 1) (2, 0, 0) model with zero mean was selected for non-traffic accidents as the best fit. Subsequently, the appropriateness of the final model was confirmed through residual plots for both models, demonstrating the independence and normal distribution of the residuals [Figure 3].

In the final stage, predictions of mortality cases from traffic and non-traffic accidents were generated based on the final models. According to the forecasts, traffic-related fatalities were anticipated to increase in the early months of the year and subsequently decrease, although the overall number was projected to be lower than in previous years. Non-traffic accidents were generally expected to be less frequent than traffic-related incidents, and the number of cases was predicted to decline.

Discussion

Based on the results of this study, over 80% of traffic-related mortalities and approximately 70% of non-traffic accidents involved men. Across all age groups in the study, the mortality rate was the highest in the 11–30 age group. Traffic-related fatalities were most frequent among individuals aged 31–50, whereas non-traffic deaths were

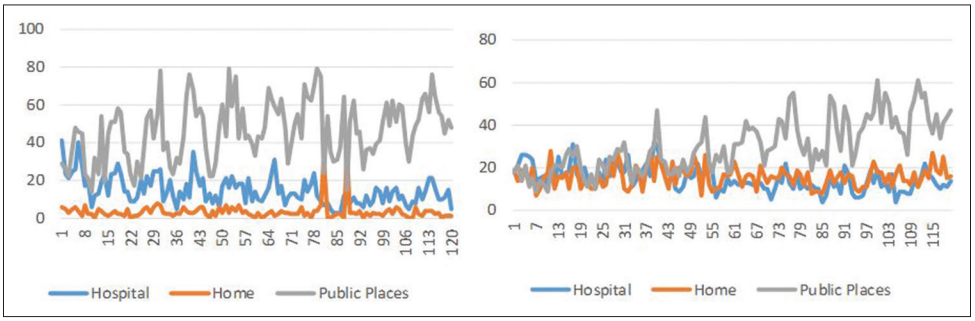

Figure 1: Distribution of mortality due to traffic and non-traffic accidents based on the place of death

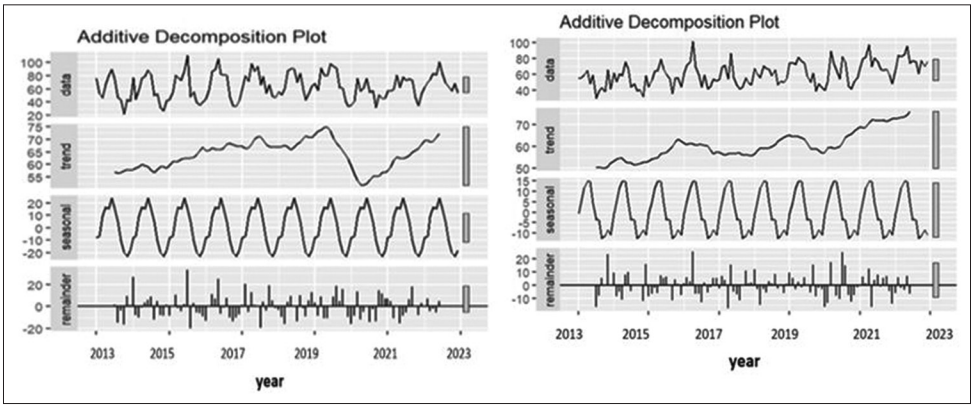

Figure 2: Decomposition of time series mortality due to traffic and non-traffic accidents in West Azerbaijan province, Iran, 2013–2022. A*: Observed data; B: Trend component; C***: Seasonal change component; D****: Random change**

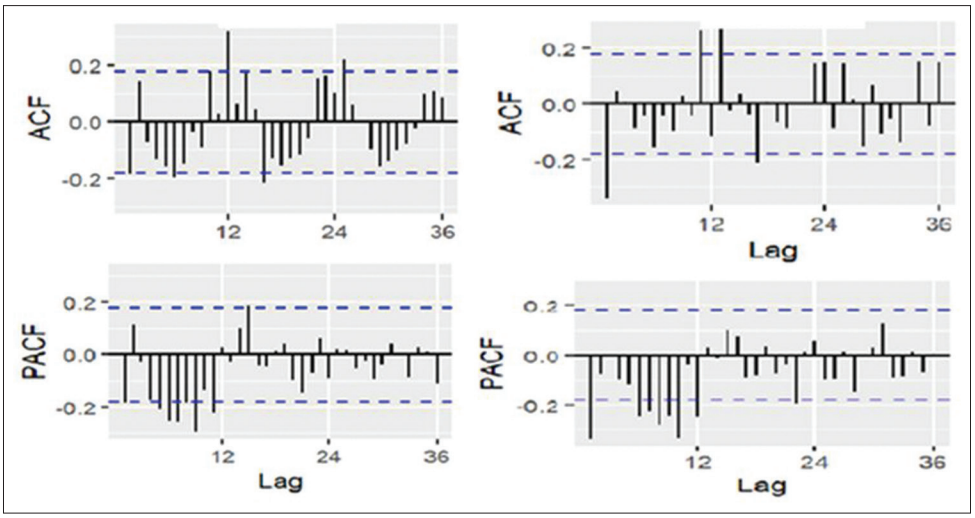

Figure 3: ACF and PACF chart of mortality cases from traffic and non-traffic accidents in West Azerbaijan Province. *: Autocorrelation Functio; **: Partial Autocorrelation Function

more common in the 11–30 age group. In a recent national study, Moradi *et al*.[15,16] reported that 77.3% of fatal road traffic injuries in Iran occurred among men, which is consistent with previous findings in regional studies. Similarly, in a study by Shokoohi *et al*.,[17] over 50% of traffic accident deaths occurred among individuals aged 21–50, and 78% of the victims were men. Akbari *et al*.[18] demonstrated that the likelihood of death from falls was three times greater in men compared to women, with the average age of the victims being 40 years. The observed gender disparities in fatal accidents emphasize the complex interaction of biological, social, and behavioral factors influencing risk exposure and vulnerability. Men may exhibit higher levels of risky behaviors such as speeding, driving under the influence of alcohol or drugs, and not wearing seat belts, which makes them more susceptible to traffic-related mortalities. Furthermore, men, particularly those at younger ages, were more likely to be employed in high-risk occupations, such as construction, mining, and manufacturing, where accidents are more prevalent.[19]

Most deaths from both traffic and non-traffic accidents occurred in urban areas, however, this difference was less pronounced for non-traffic accidents. Mortality in both types of accidents was more common in public spaces and on roads than in homes or hospitals. In non-traffic accidents, deaths were nearly equal between hospitals and homes, whereas in traffic accidents, home fatalities were much less frequent. According to a recent national registry-based study, most deaths from both traffic and non-traffic accidents in Iran continue to occur in urban areas, and in both groups, fatalities are more frequent in public spaces and on the roads compared to homes or hospitals. These findings are now confirmed with national data up to 2022.[20] Several recent studies have examined the epidemiological features of fatal road traffic injuries across various provinces of Iran, highlighting both regional patterns and the impact of intervention strategies.[15,21] In the study by Shokouhi *et al*.,[17] nearly half of the victims died at the accident scene (48.39%), with 41.14% dying in hospitals, 8.08% during transportation, and only 1.81% at home. The higher rate of mortality in both traffic and non-traffic accidents in urban areas underscores the hazardous environment associated with densely populated city centers. Factors such as high population density, heavy traffic, infrastructure limitations, and crowded households may contribute to elevated accident rates, thereby increasing the risk of mortality for both residents and travelers.[22] While urban areas experience the highest mortality rates from accidents, the difference between urban and rural environments is less pronounced in non-traffic accidents. This observation suggests that, although urbanization generally increases the risk of accidents, non-traffic accidents are influenced by a broader range of factors beyond urban density. In rural areas, agricultural and livestock-related work, combined with less adherence to safety protocols, may contribute to reducing the disparity between traffic and non-traffic accidents.[23] The elevated mortality rates on roads and in public spaces underscore the crucial role of infrastructure and the necessity for urban planning interventions aimed at safety promotion and risk prevention in public areas.

Non-traffic fatalities occur with similar frequency in hospitals and homes, whereas traffic accident mortalities are less common at home. This disparity may reflect differences in immediate response and medical care availability following accidents, as well as the severity and rapid onset of traffic-related injuries, which often result in high on-site mortality. In contrast, non-traffic accidents may involve lower-impact injuries or slower injury progression, allowing for greater survival until hospital care can be reached.[17] The analysis of long-term trends in traffic and non-traffic accidents revealed that both types exhibited an

increasing trend at the beginning of the study, followed by a decline from 2019, coinciding with the peak of the COVID-19 pandemic. The decrease in traffic accidents during this period was particularly significant. Studies by Adiningsih *et al*. and Oguzoglu et al. further supported these findings.[24,25] A substantial reduction in traffic accidents was also noted during the pandemic. However, from mid-2020, the number of mortalities sharply increased again. Globally, 2021 marked the second consecutive year of rising motor vehicle mortalities, with an 8.30% increase in 2021 and an 11% rise in 2020. This trend reflects the complex interplay of factors affecting accident-related mortalities over time. Notably, the reduction during the global COVID-19 pandemic aligns with broader global trends, reflecting decreased vehicle traffic due to lockdowns, travel restrictions, and remote work arrangements. The downward trend in non-traffic accidents may also be attributed to heightened awareness of health and safety issues during the pandemic. However, several factors likely contributed to the sharp rise in mortalities after mid-2020, including the easing of lockdown restrictions, the resumption of economic activities, and changes in travel and recreational behaviors as people adapted to the "new normal".

The Pent-up demand for travel and increased mobility following periods of confinement may have led to riskier behaviors, resulting in a spike in both traffic and non-traffic accident mortalities. The final predictive model suggested a decline in mortality in the future compared to previous years which is supported by the findings of Khalaj *et al*.[26] In predicting the number of traffic accident emergencies, the ARIMA (0, 1, 3) (0, 1, 1) 12 model was selected as the best fit, providing a stable forecast for future incidents. Given the wide range of factors influencing traffic and non-traffic accidents and their fatal outcomes, the existence of different models to predict future trends is unsurprising.

The generalizability of the study's findings should be considered in light of the specific context of West Azerbaijan province. As a border and transit province, it has a lower density of highways compared to more affluent provinces. The generalizability of the present findings is limited by the unique regional characteristics of West Azerbaijan province, as a border and transit area with lower highway density compared to more affluent provinces. Importantly, this study relied solely on data from the Health Department; incorporating information from traffic police could have enhanced data completeness and allowed for direct comparison. The absence of integrated data from the Highway Patrol and detailed information about individual accident cases limited the study's ability to differentiate mortality patterns across specific subtypes of traffic and non-traffic accidents (such as falls and drownings). Therefore, despite the predictive value of the time-series analysis, interpretation of future trends should be approached with caution, and ongoing improvements in registration and accident surveillance systems are strongly recommended.

Conclusion

Mortality from both traffic and non-traffic accidents was significantly higher among men and within younger age groups. However, the average age at death was lower for non-traffic accidents compared to traffic accidents. Furthermore, unlike traffic accidents, fatalities from non-traffic accidents occurred more frequently in rural areas. Predictive modeling using time-series analysis can assist planners and policymakers in taking timely and informed actions for the prevention and control of such accidents. Ultimately, it is recommended that future studies focus on examining the various types of traffic and non-traffic accidents that result in mortality, as well as the associated risk factors.

Acknowledgments

We would like to express our sincere gratitude to our colleagues at the Health Deputy of the Province for their invaluable support throughout this research. We also extend our appreciation to the Security Department of the Health Deputy for their assistance and cooperation.

Financial support and sponsorship

Urmia University of Medical Sciences

Conflicting interest

Nothing to declare.

References

1. Amidei Cb, Salmaso L, Bellio S, Saia M. Epidemiology of traumatic spinal cord injury: A large population-based study. Spinal Cord 2022;60:812-9.
2. McCullogh E, Macpherson A, Harrington DW, Pike I, Hagel B, Buchan C, *et al*. Built environment change for injury prevention: Insights from public health professionals across public health units in Ontario, Canada. BMC Public Health 2025;25:31.
3. The industrial revolution, technoscience and society: Implications for science, policy and society". Technological Forecasting and Social Change, 161:120252.
4. Sharifi A, Simangan D, Nagendra H, Roberts D. A review of the global climate change impacts, adaptation, and mitigation reports of the Intergovernmental Panel on Climate Change (IPCC) Environ Sci Pollut Res Int 2022;29:28133-9.
5. Bucsuházy K, Matuchová E, Zůvala R, Moravcová P, Kostíková M, Mikulec R. Human factors contributing to the road traffic accident occurrence. Transp Res Procedia 2020;45:555-61.
6. World Health Organization. Global status report on road safety 2023. Geneva: World Health Organization; 2023. Available from: https://www.who.int/publications/i/item/9789240077614. [Last accessed on 2024 Oct 06].
7. Myran DT, Pugliese M, McDonald AJ, Xiao J, Fischer B, Finkelstein Y, *et al*. Cannabis use disorder emergency department visits and hospitalizations and 5-year mortality. JAMA Netw Open 2025;8:e2457852.
8. Mohammadi M, Ahmadi A, Esmaeili A. The frequency of accidents in Saqez in 2014: A short report (Persian). J Rafsanjan Univ Med Sci 2017;15:885-92. Available from: http://journal.rums.ac.ir/article-1-3574-en.html.
9. Zarrin Z, Gholamizadeh K, Talebi-Ghane E, Ayubi E, Hamidi O. Understanding road accident injury dynamics in

Iran: a growth mixture modelling perspective. BMJ open 2025;15:e084036.
10. Farzadfar F, Naghavi M, Sepanlou SG, Moghaddam SS, Dangel WJ, Weaver ND, *et al*. Health system performance in Iran: A systematic analysis for the Global Burden of Disease Study 2019. The Lancet 2022;399:1625-45.
11. Wu N, Green B, Ben X, O'Banion S. Deep transformer models for time series forecasting: The influenza prevalence case. arXiv preprint arXiv: 200108317 2020.
12. Hamilton JD. Time series analysis: Princeton university press; 2020.
13. Arslan H, Zengin S. Evaluation of the predictability of Crimean–Congo hemorrhagic fever cases in Turkey using ARIMA models J Infect Public Health 2021;14:667-73.
14. Esmaeilzadeh N, Bahonar A, Foroushani AR, Nasehi M, Amiri K, Hadjzadeh M. Temporal trends and prediction of bovine tuberculosis: A time series analysis in the North-East of Iran. Iran J Vet Res 2022;23:12.
15. Moradi A, Khabazkhoob M, Sistanizad M, Beheshti S, Naderi M, Keshavarz H, *et al*. Epidemiology of road traffic injuries in Iran; Analysis of national data during 2017–2018. J Inj Violence Res 2021;13:33-43.
16. Moradi F, Salmani F, Haghdoost A, Borhaninejad V, Mousavi SG, Bagheri H. Epidemiology and health outcomes of road traffic injuries in Kerman, Iran: A longitudinal study. Iran J Nurs Midwifery Res 2020;25:245-50.
17. Shokouhi M, Rezapur-Shahkolai F. Fatal road traffic injuries in Hamadan Province, Iran. J Disaster Emerg Res 2018;1:67-74.
18. Yavari P. Epidemiology reference of common diseases of Iran. Vol II. Chapter 16. 3rd ed. Tehran: Gap Publishing House; 2021.
19. Mahnaz Y, Mojtabi N, Javad MM. Investigating the fall of children and teenagers and determining the time indicators of providing emergency services 115, Shiraz, 2016.
20. Khezri A, Ghasemi F, Soroush A. Rising trend in traffic accident mortality in Iran after a decade of reduction: A national registry-based study from 2006 to 2022. BMC Public Health 2024;24:1359.
21. Soori H, Royanian M, Zali AR, Movahedinejad AA. Road traffic injuries in Iran: The role of interventions implemented by traffic police. Traffic Inj Prev 2009;10:375-8.
22. Halim H, Bustam B, Saing Z. The forecasting of a traffic accident in the pandemic of Covid-19. Turk J Comput Math Educ 2021;12:3664-9.
23. Ameri M, Karimnia A. Epidemiological investigation of pedestrian traffic accidents in Iran. Rahvar 2013;4:65-9.
24. Adiningsih S, Halim R, Kalsum U. Factors associated with death due to road traffic accident in Muaro Jambi Regency in 2019-2021. J Berk Epidemiologi 2024;12:151-61.
25. Oguzoglu U. COVID-19 Lockdowns and Decline in Traffic Related Deaths and Injuries; 2020.
26. Khalaj TA, Sangsefidi N, Fakoor V, Jamali J, Ghavami V. Forecasting the number of dispatches for prehospital emergency traffic accidents in Mashhad. EBNESINA 2022;24:50-9.