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Original Article

Traffic Accident Mortality in Najafabad, Iran during 2011-2017

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Abstract

Background: Road traffic accident is one of the most important causes of disability and death in the young population. A significant number of people injured in road traffic accidents die after they arrive at the hospital.
Objectives: This study aimed to assess the trend of mortality in road traffic accidents and forecast it for the coming years using time series modeling.
Methods: This study investigated the trend of road traffic accidents and their victims in Najafabad, Iran, between 2011 and 2017. The ARIMA time series model was fitted on the obtained data and the best model was selected based on the least mean square error. Moreover, the model's goodness of fit was investigated by residuals ACF and PACF plots as well as Ljung-Box chi-square statistics.
Results: The trend analysis and ARIMA models were investigated, and the results showed a descending trend of fatalities due to traffic accident during 2011-2017. Afterwards, some models were fitted and ARIMA was selected (0, 1, 1), because it had the lowest mean square error value. By fitting the best model, the trend of traffic accident mortality was forecasted for five years (2018 to 2022). Finally, the forecasted values showed that future traffic accident mortalities had a decreasing trend.
Conclusion: The trend of mortality due to road traffic injuries declined, indicating a decreasing trend in deaths for the upcoming years. Therefore, the interventions that have been applied in recent years may be considered as useful.

Keywords: Road Accident, Time Series, Trend, Seasonality.

Introduction

In 2015, the World Health Organization (WHO) reported that traffic accidents caused 102.5 million deaths per year worldwide (2.1% of total deaths). Traffic accidents, after cardiovascular diseases, are a major cause of years of life lost with an estimated 16% of years of life lost being due to traffic accidents (1-5).

In general, road traffic injury mortality rates are higher in developing countries than in developed countries. WHO's Regional Office for the Eastern Mediterranean (EMRO) reported that about 10% of deaths are caused by traffic accidents, and that traffic accidents are ranked second for mortality by all WHO regional offices (1).

Iran, one of the Eastern Mediterranean countries, is home to about 1% of the world's population; however, more than 2.5% of all traffic accidents around the world occur in Iran (3). According to statistics, 22.7% of all disabilities and 17% of total deaths in Iran are due to traffic accidents; this is a much higher rate compared to high-income countries (6, 7).

A time series is a set of observations recorded from a variable which is measured over time. Generally, the purpose of using them is to identify a probabilistic model based on the available data and to predict values for the future. In a time series, by analyzing past behavior, a probabilistic model that fits the data is identified, and then, assuming that the data will behave similarly in the future and follow the data-fitting model, future values of the series are predicted. This analysis usually applies to data which is not independent and is sequentially dependent. This dependency between consecutive observations is of interest and is most used in

making predictions (7, 8).

An important step in selecting an appropriate forecasting method is to consider types of data patterns. Four types of time series data patterns can be distinguished: trend, seasonal changes, cyclical changes, and irregular changes. A time series can be composed of one or more of these components (8).

Classic models of time series are divided into stationary and non-stationary series. A model is stationary when the mean and variance remain constant over time; otherwise, it is non-stationary. The stationary nature of the data was investigated by plotting the time series before forecasting. If a time series is non-stationary, it is necessary to use some transformations to remove non-stationary data (9, 10).

Then, the autocorrelation function (ACF) and partial autocorrelation function (PACF) were plotted to identify models fitting to the data. The best model was selected by the least mean square error (MSE) (11).

Finally, the best fit model was used to forecast the future trend.

Data regarding traffic accidents and traffic accident-related deaths is recorded over several years. Based on the available data using time series models, the trend of accidents and deaths can be analyzed, and it can be determined whether this trend is increasing or decreasing.

Moreover, the effectiveness of any intervention applied during these years can also be analyzed.

Time series models can predict traffic accident mortality over the next few years. This may give policymakers an overview of the status of traffic accidents and deaths caused by them to aid in proper planning to reduce them.

Objectives

In this study, the mortality rate of traffic accidents in the county of Najafabad, Isfahan Province, central Iran was first investigated, and then it was forecasted through 2022 using time series modeling.

Materials and Methods

Study Design

The city of Najafabad is located 30 km west from the center of Isfahan province, Iran. According to the latest estimates (2016), it has a population of about 236,000. This study was designed to investigate the trend of traffic accident mortality in this city from 2011 to 2017.

Study Population

All deaths caused by traffic accidents in every year of the study was included. The population of Najafabad was used to calculate the incidence of traffic accident deaths by year.

Data Gathering and Statistical Analysis

Under the agreement of Najafabad Health Center, data was extracted with the help of relevant experts. Traffic accident mortality data is sent to the relevant unit from hospitals and health centers which are covered by the city every month and recorded. Iranian Vital Horoscope reports, which are updated at health centers every year, were used to determine the city's population.

The data used in this study was extracted from the records of road traffic victims in Najafabad between 2011 and 2017.

Time series analysis was used to detect a model and predict future amounts of a set of statistical data collected at regular time intervals. An unvaried time series model can be decomposed into four components: trend, seasonal changes, cyclical changes, and irregular changes. A time series can be composed of one or more of these components (8).

Classic models of time series are divided into stationary and non-stationary series. A stationary time series is one whose statistical properties, such as the mean, variance, and autocorrelation, are all constant over time. Hence, a non-stationary series is one whose statistical properties change over time (10).

To consider these main features, a time series plot is necessary to determine, in particular, whether there is a trend, a seasonal component, any apparent sharp changes in behavior, or any outlying observations. Box-Cox transformation was used to remove non-stationary data in variance and to remove seasonal variation and trend by seasonality differencing and ordinary differencing (9).

This study used autocorrelation function (ACF) and partial autocorrelation function (PACF) plots to identify models fitting to the data. The best model was selected by the least mean square error (MSE). The model's goodness of fit was investigated by residual ACF and PACF plots, which should not be significantly different from zero. Moreover, Ljung-Box chi-square statistics were determined so that the residual was uncorrelated and the model would appear to fit well if this test was not significant.

Finally, the best fit model was used to forecast the trend of road accidents for the next five years.

To analyze the data, time series modeling was used to determine the trend and to forecast the future trend. All analyses were performed using Minitab 17.

Ethical Consideration

The protocol of the study was conformed in ethical committee of Mashhad university of medical science (Ethical code: IR.MUMS.MEDICAL.REC1398.620).

Results

During the years 2011 to 2017, the number of deaths caused by traffic accidents in Najafabad was 97, 83, 92, 48, 88, 72, and 71, respectively.

The result of the trend analysis showed a descending trend of fatalities due to traffic accidents, as shown in Table 1 and Figure 1. A comparison of the number of accident fatalities during the years of the study revealed that the highest number of fatalities occurred in 2011 (97 cases) and the lowest number of fatalities occurred in 2014, indicating a 50.51% reduction in comparison with 2011. According to Table 1, changes in the mortality rate sometimes increased and sometimes decreased compared with the previous year.

Moreover, Figure 1 shows a time series plot in which the trend is decreasing and there is non-stationarity in the mean, the variance, and possibly the seasonality variation. In addition, the stationary can be investigated by using the autocorrelation and partial autocorrelation plots, which showed non-stationarity in the mean and variance. The Box-Cox transformation was used to remove the variance, and non-stationarity in the mean was removed through ordinary differencing with lag 1.

Table-1. Comparison of Decrease and Increase in Road Traffic Mortality Trend, 2011 – 2017

Years	Mortality (n)	The changes of the mortality rate compared to the year 2011	The changes of the mortality rate compared to the previous year
2011	97	-	-
2012	83	-14.43	-14.43
2013	92	-5.15	+10.84
2014	48	-50.51	-47.82
2015	88	-9.27	+83.33
2016	72	-25.77	-18.18
2017	71	-26.80	-1.38

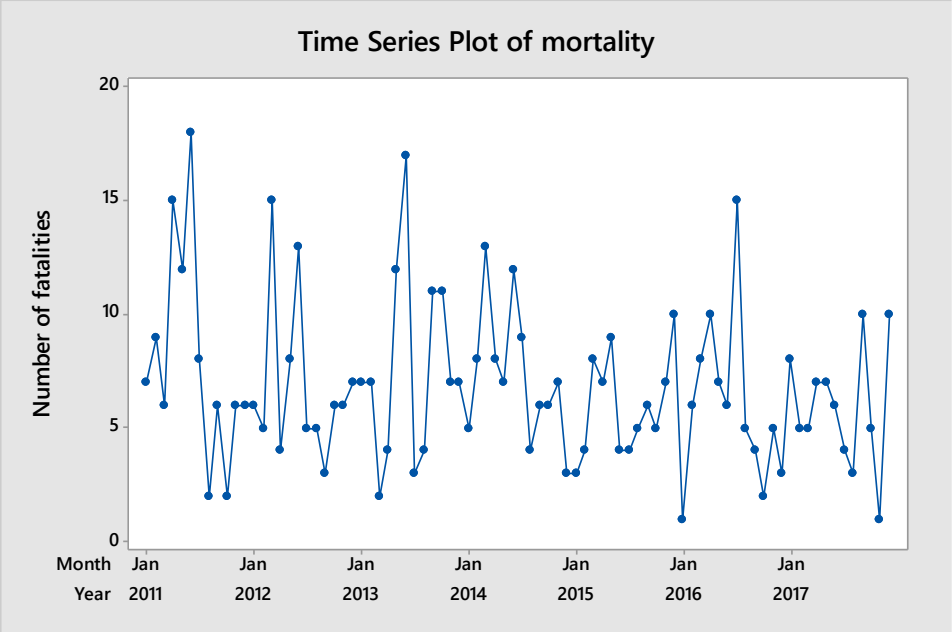

Figure-1. Trend of road traffic accident mortality, 2011-2017

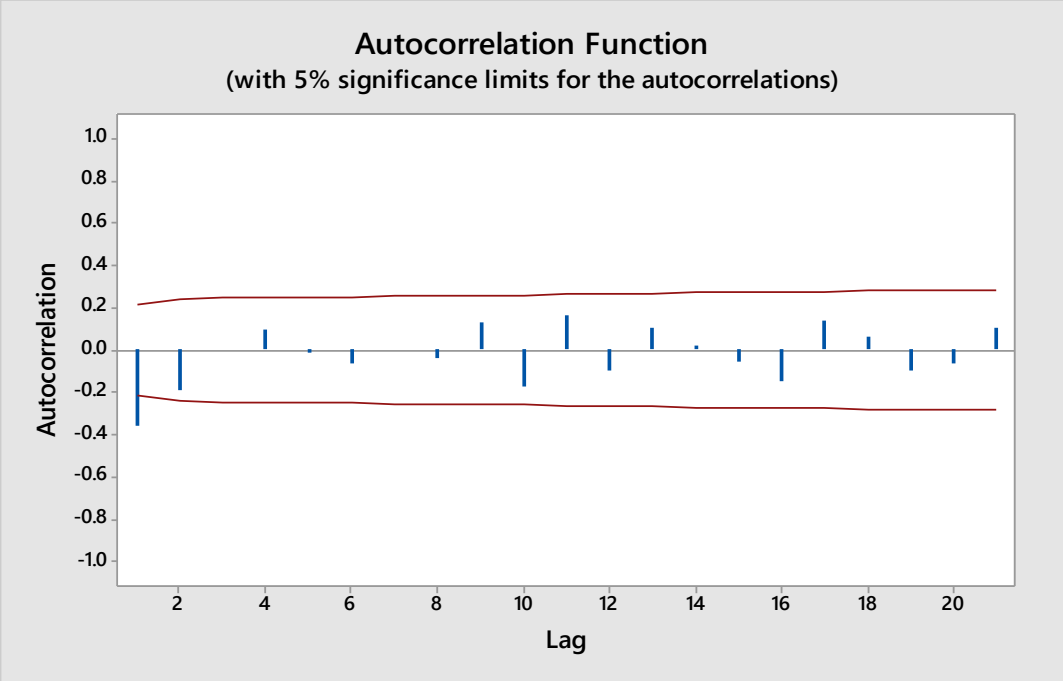

Figure-2. Autocorrelation function plots of accident mortality after removing non-stationarity in the data

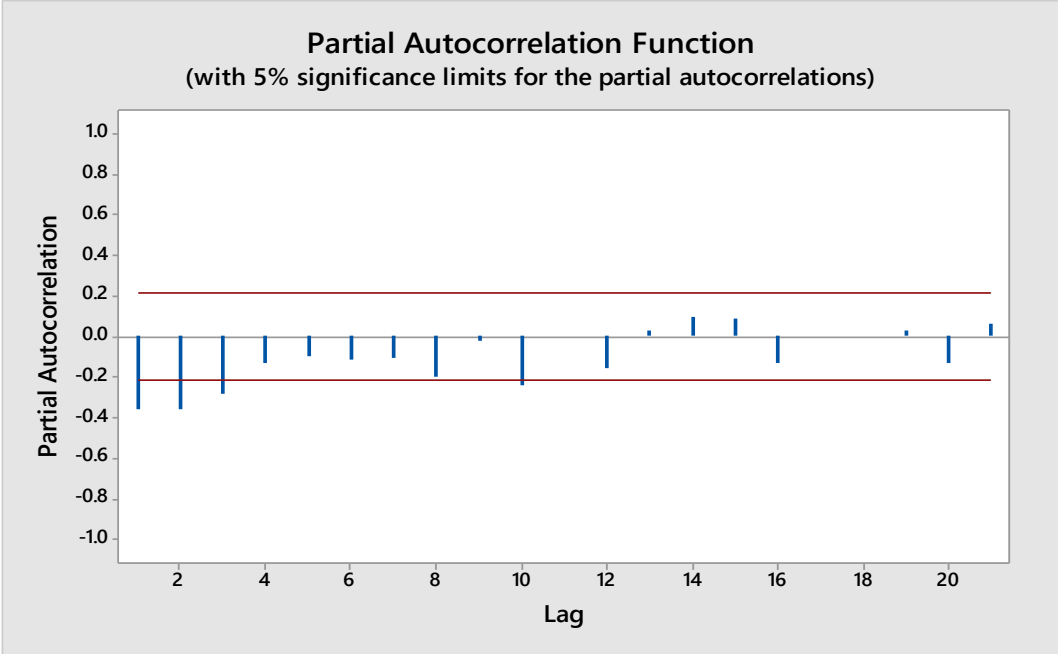

Figure-3. Partial autocorrelation function plots of accident mortality after removing non-stationarity in the data

The probable models of ARIMA or SARIMA were identified through the ACF and PACF function plots. The diagnosed models are shown below.

SARIMA (1, 1, 3) (1, 0, 0)12

ARIMA (1, 1, 3)

ARIMA (0, 1, 1)

The models were fit and the best diagnosed model was selected based on the lowest value of MSE. Among the models, ARIMA (0, 1, 1) had the lowest MSE value (Table 2).

After fitting the models, the correlation of the residual was investigated. ARIMA gives two statistics that can be used to conduct a test of correlation for the residuals: the Ljung-Box chi-square statistic and the *p*-value. For the best model, *p*-values are quite large (greater than the usually chosen -level of 0.05), the test is not significant; thus, the residuals appear to be uncorrelated. Moreover, evaluating the ACF of the residuals for the accident mortality data showed non-significant spikes (within the confidence limits), indicating

that the residuals appear to be uncorrelated. Therefore, the ARIMA (0, 1, 1) model appeared to fit well (Figure 4). This model can be used to make forecasts.

By identifying the best fit model, the trend of traffic accident mortality was forecasted for the next 5 years (60 months) with a 95% confidence interval. Figure 5 shows the trend of traffic accident mortality and forecasts. The forecasts (red) were determined using the fitted model and are displayed together with their 95% confidence limits.

According to the forecasted values, future traffic accident mortality will have a descending trend. The mortality rates for the next 5 years are shown in Table 3.

Table 2. Estimated Parameters for the Identified Models

Type of model	Coefficient	SE	p-value	MS	The modified Box-Pierce (Ljung-Box)			
					p-values			
SARIMA (1,1,3)(1,0,0)					Lag 12	Lag 24	Lag 36	Lag 48
AR(1)	-0.21	0.45	0.63	12.88	0.34	0.30	0.51	0.54
SAR(12)	0.033	0.12	0.78					
MA(1)	0.63	0.43	0.15					
MA(2)	0.39	0.39	0.32					
MA(3)	-0.046	0.13	0.73					
Constant	-0.038	0.027	0.15					
ARIMA(1,1,3)								
AR(1)	-0.25	0.77	0.74	12.79	0.45	0.35	0.55	0.59
MA(1)	0.59	0.77	0.44					
MA(2)	0.43	0.63	0.50					
MA(3)	-0.05	0.16	0.75					
Constant	-0.03	0.03	0.34					
ARIMA(0,1,1)								
MA(1)	0.97	0.62	<0.001	12.72	12.72	0.62	0.33	0.40
Constant	0.45	0.029	0.26					

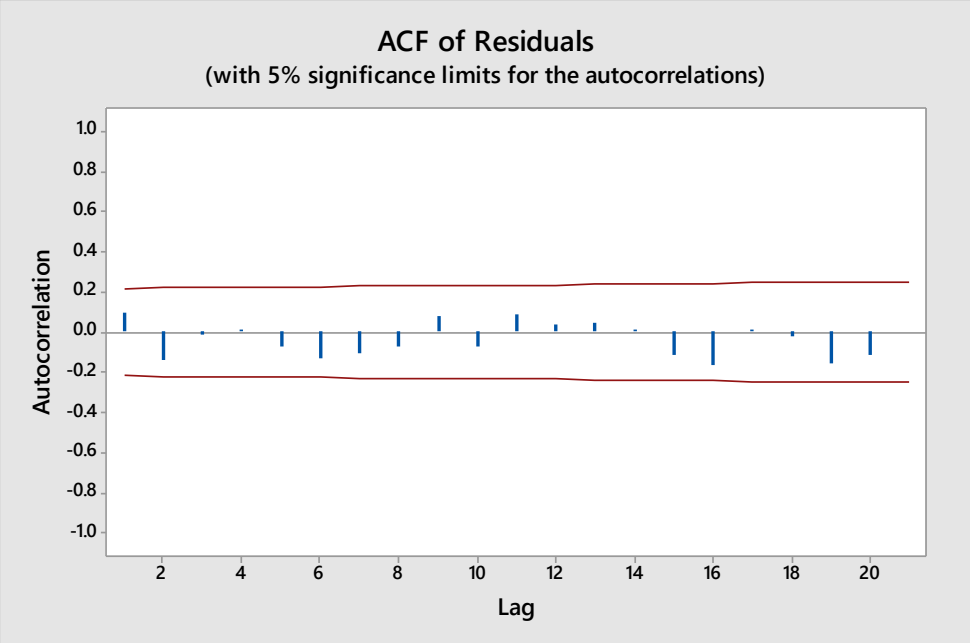

Figure-4. Autocorrelation function plots of accident mortality

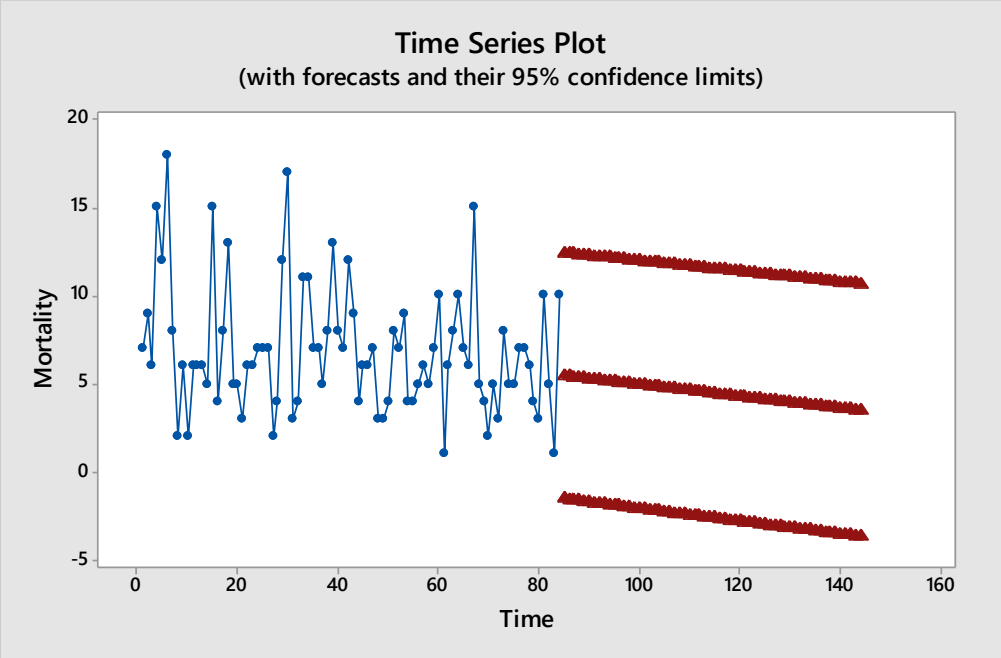

Figure-5. Forecasting plot of traffic accident mortality

Table-3. Forecast of the road traffic mortality trend for the next 5 years

Years	Mortality (n)	The changes of the mortality rate compared to the year 2011	The changes of the mortality rate compared to the last year
2018	68	-29.89	-4.22
2019	58	-40.20	-14.7
2020	53	-45.36	-8.62
2021	49	-49.48	-7.54
2022	44	-54.63	-10.20

Discussion

The current results demonstrated that the mortality rate of road traffic accidents (RTAs) had a decreasing trend in Najafabad during the 7-year period under study (2011-2017). Moreover, the results showed that the highest and lowest values of fatalities occurred in 2011 and 2014, respectively. Overall, in spite of the increasing population and number of vehicles, the trend of traffic fatalities during the study period declined. In 2010, the RTA mortality rate was high (20.1 per 100,000) in low- and middle-income countries, and the estimated rate for Iran was 32 per 100,000 (12). Thus, to prevent RTAs and reduce mortalities in our country, some interventions such as modified rules, media, and public education on the use of seat belts in cars and safety helmets for motorcyclists as well as issuing heavy fines to offending drivers have been implemented over recent years (6, 13). In other countries, such as European countries (14) and the United States (15), enforcing these interventions had a positive effect on decreasing RTA mortality. In northern and western Europe, the trend of RTA mortality was reduced by the implementation of programs such as speed limits (14).

The results of the trend assessment in this study are consistent with those of a similar trend study by Mahdian et al., showing that the death rate due to RTAs in Iran statistically declined from 43.1 per 100,000 in 2006 to 21.1 per 100,000 in 2013 in Kashan, Iran (6). The current results are also consistent with the findings of Yousefzadeh et al. in Zanjan Province, Iran (3).

In the current study, seasonal variation in RTA deaths was not observed. The seasonality pattern in RTAs was expected due to a peak travel time in summer (2) and snow and slippery roads in winter (16). Therefore, a lack of seasonal changes may be due to the insufficiency of high quality data.

The trend of RTA mortality was forecasted for the next 5 years, showing that this rate would have a descending trend. This finding is in agreement with findings in another recent

study (17). This decreasing trend is due to multiple interventions implemented in recent years by different actors in the trauma system, i.e. the police force, road operators, fire brigades, medical assistance and other organizations (14).

The current study had certain limitations, such as a lack of data on different interventions for RTA control in Iran; and pedestrian, motorcyclist, and detailed locale and time of accidents, which was not available to us. Therefore, it is suggested that future research with a combination of all this data be conducted to gain an accurate understanding of the trend of fatal traffic accidents in Isfahan Province.

Conclusions

The trend of mortality due to road traffic injuries declined during the years under study, and there will be a decreasing trend in deaths in the coming years. Therefore, the interventions applied in recent years may be considered as useful.

Acknowledgments

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Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

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