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Original Article

Predicting Number of Traumas Using the Seasonal Time Series Model

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Abstract

Background: Road accidents and casualties resulted are among the current challenges of human societies, which have imposed a high cost on the economies of countries. **Objectives:** Prediction of accidents caused by driving incidents helps planners achieve a suitable model to reduce the occurrence of traumas resulted from the driving accidents. **Materials and Methods:** In this study, a seasonal time series model was used for predicting the number of road accident traumas. Data related to the patients referring to Imam Khomeini Hospital in Ilam Province were evaluated from March 2012 to June 2017. **Results:** The results showed that during November and October in 2015 and 2016, we had the highest number of accidents due to high traffic during New Year's Vacation, summer trips, and religious pilgrimages including the Arbaeen. Moreover, the results depicted that the seasonal Arima model was effective in predicting the number of traumas due to accidents. Furthermore, forecasting the model showed an ascending trend in the number of accidents in the following 3 years. **Conclusion:** The number of accident traumas in the forthcoming months can be predicted through time series models. Of course, these models can be used by managers as appropriate tools for traffic analysis. Furthermore, the increasing trend in the number of traumas indicates that serious consideration for planning and managing such events seems necessary for the administrators in the near future.

Keywords: Accidents, forecasting, interrupted time series analysis, traffic

Background

Road accidents are among the main social problems and the second major causes of life lost (disability-adjusted life years) in the world, which endanger human health. Injuries resulted from road accidents are so extensive that it is referred to as war on the roads.[1,2] The worst consequence in the traffic accidents is human casualties.[3]

According to the latest statistics of the country's forensic medicine in Iran, the number of deaths from the traffic accidents is 16,201 and the number of injuries is >335,000 per year. Moreover, financial losses of the road crashes in Iran exceed 4 billion dollars annually which has put Iran in a very worrying position compared to many other countries.[4,5] It should be noted that our country has become one of the crisis centers in the recent years so that the World Bank studies have formally considered the condition of Iran's traffic safety to be critical.[6]

Due to the geographical location of Iran as a vast country with expanded roads throughout the country, most of the accidents

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leading to death usually occur in the suburban areas. Therefore, the need for more medical care is felt. Consequently, it can be said that the main cause of these mortalities in the Iranian roads is because of less access to the medical cares in due time.

From health and hygienic perspective, severe injuries caused by road accidents are among the dangerous factors for health. Socially, these dangerous phenomena destroy families, and culturally,[7] they destroy the cultural instructors and family caretakers. Furthermore, politically, these phenomena demolish the political credibility of the crisis-hit countries, and from an economic point of view, they destroy the economic resources, including the human resources.[8] In this way, there is an urgent need to understand this deteriorating situation and manage the incidents.

One of the assisting tools for managing such incidents is predicting the number of traumas that would occur in the upcoming months. That is, predicting the volume of potential accidents in future would facilitate scheduling to estimate hardware and software facilities. Different techniques are available to predict and determine suitable predictive models. One of these techniques is the use of time series models. A time series model is a set of data related to a trend assessment that is measured over a specific time period.[9] Trend assessment and predicting the data can supply helpful information, which may finally lead to promote the ability of decision-making by the governors. For example, Houston and Richardson using time series analysis showed that changing the implementation of the seat belt law can decrease the risk of road traffic accident.[10] Moreover, the result of a study in the UK using the time series analysis showed that the advance of medical technology and medical care in the UK decreased the traffic-related fatalities.[11] Some efforts have been made in Iran for forecasting the road traffic. For example, Yousefzadeh-Chabok *et al*. tried to assess and forecast the trend of the road traffic accident using the time series modeling in Zanjan Province.[12] They applied a seasonal time series model and showed that the trend of the road traffic accident is decreasing in the future. Lotfi *et al*. forecasted the mortality rate of the road traffic accident in Yazd Province during 2012–2016 by the seasonal time series based on age categories.[13] Furthermore, Zolala *et al*. investigated the traffic accident fatalities by the seasonal time series and showed a decreasing trend in the accident mortality in Kermanshah Province.[14]

This article tries to provide a model for predicting the number of accidents in Ilam Province using the seasonal time series models.

Materials and Methods

In this cross-sectional study, the data related to the injured patients accepted in Imam Khomeini Hospital from March 2012 to June 2017 were evaluated [Figure 1]. The accidents and injuries were classified according to the tenth edition of the International Classification of Diseases. The recorded data were completed using forms and the damage recording

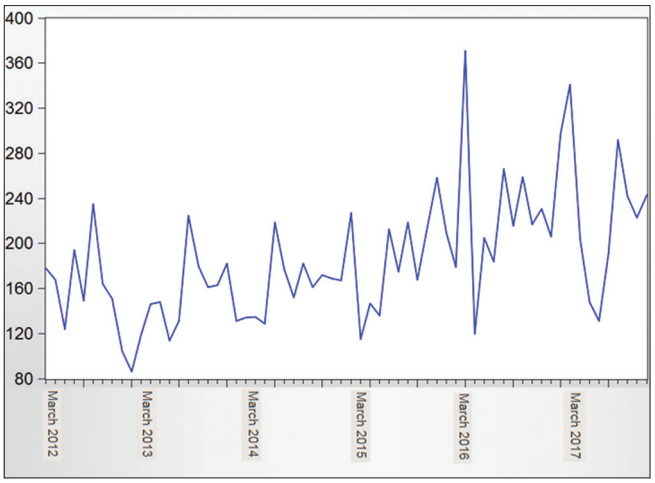

Figure 1: Trend of the number of road accident traumas during March 2012 – June 2017

software by the staff of the emergency department for the purpose of hospital interview and archiving.

To probe the trend, the autocorrelation function (ACF), partial ACF (PACF) plots, and a decomposition method were used to analyze the data with a seasonal type in the Eviews software (IHS software company, USA).

According to the behavior of the data, a seasonal time series pattern was used on the data. In the literature of the time series, necessity of the stationary of the series must be established in the mean and variances. Hence, the stationary property of the time series was examined by plots and the Dickey–Fuller test before the predicting process. For removing the nonstationary seasonality and the trend from the observations, both seasonal and order differencing were used for the series, respectively. Moreover, the nonstationary in the variance of the series was removed by the Box-Cox transformation.

In this study, major pattern of the models, including the Seasonal autoregressive integrated moving average model (SARIMA), was identified with different orders through the analysis of the ACF and the PACF plots.

To recognize the best-fit model, the pattern models were compared through the least root mean square error (RMSE), Akaike information (AIC), Schwarz-Bayesian information criterion(SBIC), and the residuals ACF and PACF plots as a goodness-of-fit criterion. For analyzing the model's residuals, correlation tests including the Breusch–Godfrey and the Watson camera tests were used. In addition, to measure the normal values of the residuals, the Jarque–Bera test was utilized.

The lowest value of the RMSE, AIC, and SBI illustrate the goodness of fitness among the pattern models. To select the best-fitted model by the residual analysis, the ACF and PACF plots of the residuals should not be meaningfully different from zero. In other words, all of the residuals should be observed into the boundary lines around the ACF and PACF plots with 95% of confidence intervals.

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After evaluating the pattern models, the SARIMA $(p,d,q)\times(P,D,Q)$ model was used for prediction. The parameters of p, d and q, and P, D, and Q represent the autoregressive, integrated, and moving average model in the nonseasonal and seasonal parts, respectively.

The best-selected fit model was used to predict the number of road accident traumas in Ilam Province for the next 3 years (March 2018–March 2020). All the analyses were performed using the Eviews 10 software.

Results

The results of the trend analysis indicate an ascending trend of the number of traumas caused by road accidents from March 2012 to June 2017 [Figure 1]. By comparing the number of accidents during the study, it was shown that the highest values of the accidents have been occurred in November and October during 2015 and 2016. It also indicated a seasonality pattern according to the series decomposition. On the whole, it was seen that the pattern of the assessing trend was repeated annually. Hence, we are faced with seasonality and nonstationary time series.

In addition, the result of the Dickey–Fuller test for the number of road accident traumas with a value of − 1.52 and a significance level of 0.80 showed the nonstationary of the data series. Nonstationary in mean was removed through the ordinary differencing with Lag 1. Then, the seasonality variation was removed by seasonality differencing with Lag 12.

Therefore, the test with a value of 499.5 and a significance level of 0.122 revealed that the first-order difference of the data had the capability to establish the stationary condition to fit the time series model.

The diagnosed models by the autocorrelation and partial ACFs suggested SARIMA models. Hence, five SARIMA models were fitted to the data, which according to the obtained values, the least amount of RMSE and Bayesian–Schwarz criteria were considered as the determinant of the appropriate model.

Table 1 shows the values of indices AIC, SBIC, and RMSE for the five models. By comparing the values based on the lowest value of the indices, the model SARIMA (1, 1, 1) × (1, 1, 1) had the lowest values compared to the others. Evaluation of the ACF and PACF error illustrations showed no significant difference between the models and the actual series ($P > 0.05$) [Figure 2]. Therefore, SARIMA (1, 1, 1) × (1, 1, 1) was considered as the best-fit model for predicting the number of road accident traumatic events.

In addition, in analyzing the residuals of the model, according to Table 2 and the results of the Bresch–Godfrey test, the Chi-square statistics of the lags for 1 to 3 residues were 2.66, 2.79, and 5.62, respectively, that were not significant at 5% error level ($P > 0.05$). Therefore, the zero assumption that the remainders are unbounded cannot be ruled out. On the other hand, the value of the Watson camera statistic is 2.05 which confirm the lack of correlation between the model's residuals. On the other hand, the amount of Jarque–Bera statistics for the residual values is equal to 0.256, which is not significant at the level of 5% ($P = 0.8 > 0.05$). Therefore, there is no reason to reject the normality of the residuals. Therefore, the

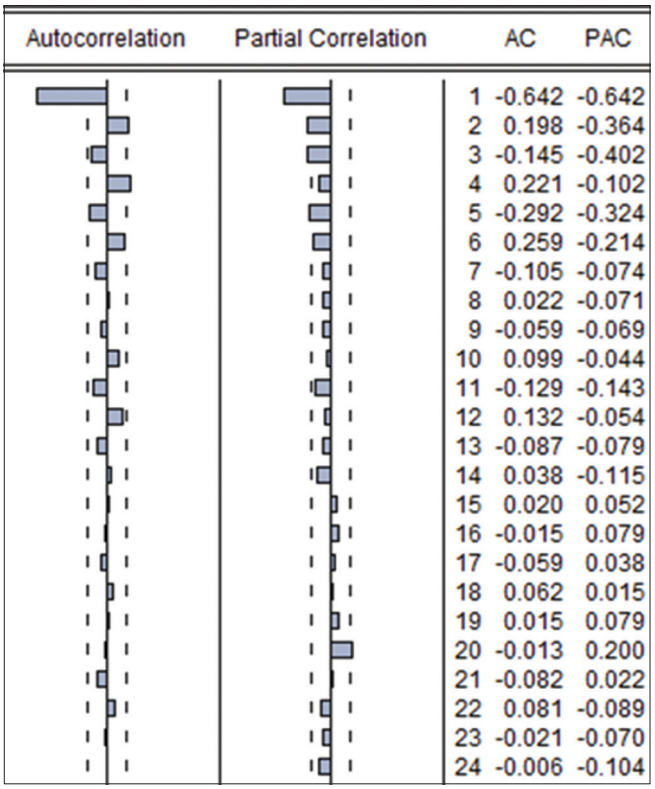

Figure 2: Partial autocorrelation function and autocorrelation function plots of the number of road accident traumatic events after removing the nonstationary in the data

Table 1: Values of the Akaike information, Bayesian-Schwarz, and root mean square error indicators for the SARIMA models

SARIMA models	RMSE	SBIC	AIC
SARIMA (1, 1, 0)×(1, 1, 0)	0.294	11.41	11.32
SARIMA (0, 1, 1)×(0, 1, 1)	0.289	11.39	11.24
SARIMA (1, 1, 1)×(1, 1, 1)	0.285	10.73	10.63
SARIMA (2, 1, 1)×(2, 1, 1)	0.302	12.46	12.08
SARIMA (2, 1, 2)×(2, 1, 2)	0.312	12.88	12.57

RMSE: Root mean square error, SBIC: Bayesian-Schwarz, AIC: Akaike information

Table 2: Chi-square statistics of self-correlation coefficients of time series residuals for the number of traumatic accidents

Significance level	Degree of freedom	Chi-square statistics	Lag order
0.095	1	2.66	1
0.246	2	2.79	2
0.131	3	5.62	3

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SARIMA (1, 1, 1) × (1, 1, 1) model has all the assumptions of a standard time series model.

By identifying the best-fit model, forecasting of the trend for the number of road accident traumas was done for the next 3 years with a 95% confidence interval [Figure 3].

According to the predicted values, the future of the number of road accident traumas will have an ascending trend. Moreover, we expect that majority of the road accident traumas will occur in the Autumn (November and October).

Discussion and Conclusion

Considering the fact that a large number of the victims in the traffic accidents constitute active human resources of the community; undoubtedly, the loss of these young resources as the main factor behind any country's development will bring about economic, financial, and social harms to the society.[15] Therefore, predicting the number of traumatic events resulted from road accidents in order to reduce the number of accidents is very important.

The results of this study showed that in November and October in which the number of religious pilgrimages increases in this province, we face a large volume of accidents. Our study findings also showed an ascending trend over the past and future years. Moreover, this study shows an increase in the level of traffic accidents in November and October during 2015 and 2016 as compared to the previous years. The main reason behind the increase in the number of accidents in these months is the rising increase of travels in this province during Arbaeen Hosseini (Arbaeen is a Shia Muslim religious observance that occurs 40 days after the day of Ashura. It commemorates the martyrdom of Husayn Ibn Ali, the grandson of the Islamic Prophet Muhammad, who was killed on the 10th day of the month of Muharram. During this special period of years including Arbaeen, >50% of the pilgrims chose the international border of Mehran in Ilam Province to go on a pilgrimage to the Atabat-Aliatts in Iraq).[8] These findings contradict the findings of similar researches in the prediction of the number of road crashes showing a downtrend. Comparing the results reported from Yousefzadeh-Chabok *et al*.,[12] Lotfi *et al*.,[13] and Zolala *et al*.[14] that forecast a decreasing trend in the rate of road traffic accident in Zanjan, Yazd, and Kermanshah Provinces, an increasing trend in Ilam Province was found then. This shows an obvious difference between Ilam and other provinces. According to the statistical reports, about 2 million people travel to Iraq in Arbaeen of which 60%–70% travel via the Ilam's borders. This may be due to the proximity of sacred places and the security of the foreign cities adjoining the borders of Ilam. On the other hand, the lack of development infrastructure, mountainous routes, and unfamiliarity with the roads could be among the reasons for the escalation of road accidents. Therefore, this issue requires the attention of the Western provinces to develop ways and means for preventing accidents.

Figure 3: Forecasting plot of the number of road accident traumas

In addition, informing people regularly about the status and conditions of the roads, broadcasting the traffic warnings, and advising people continuously through the national and local media will contribute significantly to prevent the accidents during this particular month (Arbaeen). Furthermore, along with the legal enforcement activities, cultural and educational activities can also play a vital role in reducing the number of accidents.

The lack of access to the details of the recorded accidents and low accuracy of the recorded cases due to the poor standard of the data recording software are among the limitations of this study. Furthermore, high number of recorded cases partly covered for the inaccuracy of the data record.

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Conflicts of interest

There are no conflicts of interest.

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