



PREDICTION OF FATAL ROAD TRAFFIC CRASHES IN IRAN USING THE BOX-JENKINS TIME SERIES MODEL

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ABSTRACT

Introduction: Frequency of traffic related mortalities is increasing worldwide. The present study aimed to predict deaths from road traffic accidents for the first time in Iran.

Methods: All death statistics from traffic accidents in Iran between March 2004 and March 2011 were available for analysis. The Box-Jenkins time series model was used for trends purposes. Death from traffic accidents were predicted from March 2011 to March 2013 and then compared with the actual frequencies.

Results: Overall, 21548 deaths (95% CI: 15426-27669) due to road traffic accidents were predicted for 2011 compared to 2010, with a negative growth of 7.32%. The corresponding frequency was 20404 deaths from road traffic accidents (95% CI: 9914-30893) for 2013 compared to 2011 with a negative growth of 5.31%. An accuracy rate of 93% was found for prediction of fatal traffic accidents compared to the formal reports by the government.

Conclusions: The Box-Jenkins time series model is an acceptable method for prediction of road traffic accidents.

Keywords: Accidents, Death, Iran, Traffic, Prediction

INTRODUCTION

Frequency of traffic related mortalities is increasing worldwide. It is estimated that by continuing the current trends for road traffic accidents to 2020, proportion of deaths will be increased up to 83% in middle and low income countries and up to 27% in high-income communities (Peden *et al.*, 2004; Mohan, 2008).

No accurate and reliable death prediction for road traffic accidents has been done Iran so far. According to the Iranian Forth Development Plan, the government has been obliged to decrease the trends of road traffic accidents by 10% annually. To achieve this goal, it is necessary to predict the rate of fatal accidents and to suggest controlling models.

Time series is a sequence of numerical data that usually occurs in uniform intervals over a period of time. The main application of time series analysis is forecasting (Azar and Momeni, 2001; Jandaghi, 2005). There are several techniques to predict behavior of the time series forecasting model which can be categorized to quantitative and qualitative methods.

The Box-Jenkins predicting model known as ARIMA¹ is one of the qualitative models in which the seasonal and random changes are considered in addition to the trends analysis. This model is only used for "stationary" time series. Therefore, the "differential methods" should be turned into a "stationary series" in advance. Using the ARIMA method, the model should be selected first, and then the model parameters as well as test series prediction (phase III) should be carried out.

METHODS

In the present cohort study, all traffic accidents from March 2004 to March 2011 reported by the Center of Information and Communication Technology (ICI, equivalent to FAWA abbreviation in Persian language) affiliated to the Iranian traffic police were analyzed using SAS software.

To determine deaths trends in the country, the time series method was used. Monthly trends rather than annual were used to improve the predictions. Box and Jenkins time series models were employed. Predictive multiple regression was used to determine the relationship between a dependent variable and a series of independent variables. When the outcomes was more than two levels, or determine which variables affect the probability of a particular outcome, logistic regression was selected. Following model fitting, the importance of each variable that entered the model was confirmed.

¹ Auto Regressive Integrated Moving Average

In addition to regression, the residuals were also checked to assess the model. The residual in the logistic regression, is the difference between the observed and predicted probabilities. Time series steps were: remove the non-stationary component, identify specific ARIMA models, estimating parameters, residue analysis and finally, the evaluation model predict. Finally, the predicted rate of death from traffic accidents in the first 10 months of 2011 was compared with the actual numbers.

The proposal of the present study was confirmed by the Shahid Beheshti University of Medical Sciences, Tehran-Iran Ethical Committee.

RESULTS

The death trends of road traffic accidents either monthly or annually showed a seasonal and a non-stationary pattern. Although, the available data were collected on a monthly breakdown, it was observed that the pattern changes were repeated once every 12 times. Increased traffic injuries leading to death was observed in certain months of the year (summer holidays) when the frequency of trips and journeys were rapidly increased. There are signs of non-stationary in the time series and for being stationary, it must be done by seasonal and then non-seasonal differencing (Figure1).

Table 1 shows the index values of AIC² & SBC³ for estimating ARIMA models with the first difference, by the first order difference and then seasonal difference (1, period 12) of the time series. The seasonal or non-seasonal differencing with more than first order was not necessary. The AIC can increase by differences of seasonal and non-seasonal rank². The higher differences of the ranks also elevated the differences seriously. The lowest AIC (790) for the model was 4SARIMA (0, 1, 1) × (0, 1, 1)₁₂ which is suitable for fitting to the series (Table 1).

The next step was to investigate auto correlated of the residuals after fitting model (*Residual = Predicted value - True value*). The statistical test did not reject the null hypothesis of uncorrelated residual in any of the time intervals (Table 2).

The correlation between the residuals and figures showed that the null hypothesis of uncorrelated residuals cannot be rejected.

After determining the best-fit model for the series and estimating related parameters, the third phase of Box-Jenkins fitting model was evaluated for series prediction. Using the SARIMA (0,1,1) × (0,1,1)₁₂ model, it was predicted that in 2011 compared to 2010, approximately 21548 deaths (95% CI : 15426-27669) due to road traffic accidents will occurs, with a negative rate of 7.32% .

²AKAIKE Information Criterion

³SCHWARTZ Bayesian Criterion

⁴Seasonal Auto Regressive Integrated Moving Average

Also in 2013 compared to 2011, about 20404 deaths (95% CI: 9914-30893) with negative rate of 31.5% will be occurred (Figure2).

Meanwhile, ARIMA model for time series of deaths due to traffic accident for males and females was extracted. This model predicts that in 2011 compared to 2010, there will be approximately 17088 deaths (95% CI: 12281-21895) by traffic accidents for males with a negative rate of 7.06%. Also in 2013 compared to 2011, overall, 16448 deaths (95% CI: 8531- 24364) with negative rate of 3.75% in males. The corresponding rates for females were 4540 deaths (95% CI: 3008- 6073) with negative growth of 6.64% in 2011 and 4169 deaths (95% CI: 1676-6661) with negative growth of 8.18% in 2013. Majority of deaths in both years and both genders, were occurred in August and September (summer holidays).

DISCUSSION

The present study is representative in terms of quantity (sample size) and quality of data which approved by the Iranian government. Also this study is unique as no prediction has been estimated so far for about car crashes leading to death in Iran.

A significant reduction was observed in fatal traffic accidents in Iran during 2011 and 2012 compared to the previous years in general and in female drivers in particular. However, the magnitude of these reductions was not identical.

Mortality rate from road accidents was significantly higher in summers compared to the other seasons, probably due to increased trips and journeys during summer holidays. A specific increase in fatal traffic accidents was observed in March which is the first month of New Year in Iranian calendar. In a British study using the same methodology as the present study, it was estimated that by continuing the current deaths trend in this way, the rate of fatal traffic accident will be reduced to 33% (Diguseppi *et al.*, 1997). A Chinese study in Shanghai using the Gary dynamic statistical model GM (1, 1), found that risk of fatal traffic accidents in recent years has increased from 7.78 to 14.18 per 100,000 people and will be increasing for the coming years (Yan-hong *et al.*, 2006). Also a similar Chinese study that investigated road traffic injuries from 1951 to 2003 using Box- Jenkins techniques and the ARIMA model showed a good agreement between the predictions made for fatal traffic accidents and real frequencies in 2003 (Li Yan-Hong *et al.*, 2006).

The WHO has predicted that deaths related to traffic accidents in the whole world and most countries (except for high- income countries) will be increased by 2020 (Peden *et al.*, 2004). Therefore, it seems the slight reduction in fatal traffic accidents in Iran during the recent years is consisted with the pattern of high- income countries.

According to the actual results and data obtained from the Iranian government in 2011 by the end of January, overall, 17,643 deaths due to traffic accidents have been recorded. This figure is consisted and comparable with prediction of 18,964 deaths in traffic accidents made for 2011 by the end of January using the model fitted to the time series, which represents an accuracy rate of 93%. As a conclusion, the Box-Jenkins time series model is an acceptable method for prediction of road traffic accidents. It helps police and policy makers, to modify regulations and lows and establishing preventive and protective approaches and strategies.

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Figur-1. Time series of traffic accidents deaths by month and year

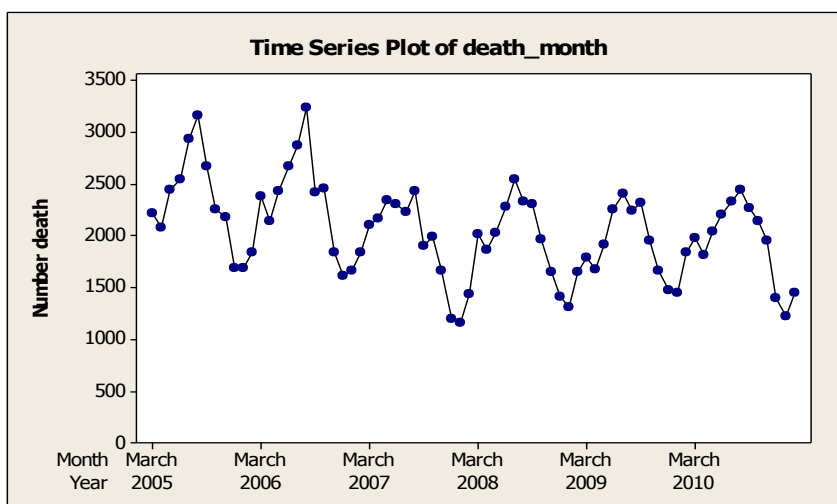


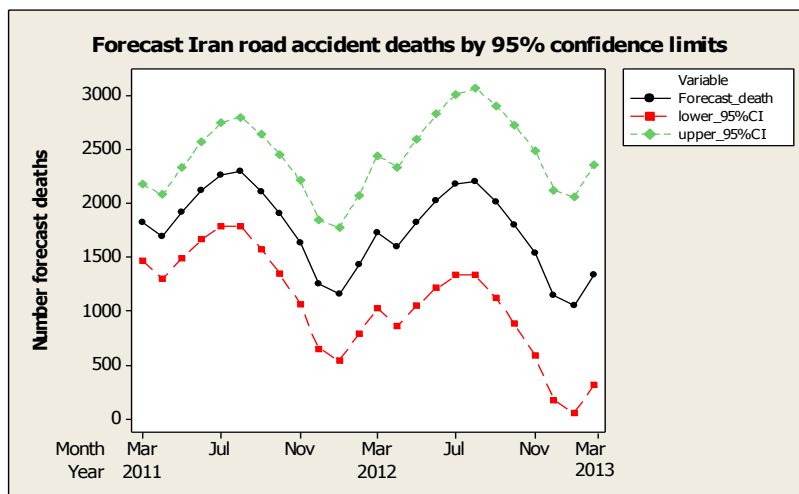
Table-1. AIC & SBC values for estimating ARIMA models and also by the first order differencing and then seasonal differencing (1, period 12) of the time series

Row	Difference (1)	Seasonal difference (1, period 12)			
	Model	AIC	SBC	AIC	SBC
1	ARIMA (0,1)	1009	1014	799	803
2	ARIMA (0,2)	1009	1014	812	816
3	ARIMA (0,12)	984	988	803	808
4	ARIMA (1,12)	986	992	790	797
5	ARIMA (2,12)	985	992	805	811

Table-2. Chi square statistic of the autocorrelation coefficients of the time series residuals of deaths due to traffic accidents

Intervals	χ^2	Degrees of freedom	-P (value)
6	1.42	4	0.8405
12	1.85	10	0.9974
18	6.76	16	0.9776
24	15.08	22	0.8589

Figure-2. Deaths prediction from traffic accidents (with approximate forecasts)



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