Original Article

Time Series Analysis of Monthly Suicide Rates in West of Iran, 2006–2013

Abstract

Introduction: Iran's western provinces have higher suicide rate compared to the other provinces of the country. Although suicide rates fluctuate over time, suitable statistical models can describe their underlying stochastic dynamics. **Methods:** This study was conducted to explore the fluctuations of the monthly suicide rates in the most populated western province of Iran using exponential smoothing state space model to compute the forecasts. For this reason, the monthly frequencies of completed suicides were converted to rates per 100,000 and a state-space approach was identified and fitted to the monthly suicide rates. Diagnostic checks were performed to determine the adequacy of the fitted model. **Results:** A significant seasonal variation was detected in completed suicide with a peak in August. Diagnostic checks and the time series graph of the observed monthly suicide rates against predicted values from the fitted model showed that in the study period (from March 2006 to September 2013), the observed and predicted values were in agreement. Thus, the model was used to obtain the short-term forecasts of the monthly suicide rates. **Conclusions:** In this study, we had no significant trend but seasonal variations in the suicide rates that were identified. However, additional data from other parts of the country with longer duration are needed to visualize the reliable trend of suicide and identify seasonality of suicide across the country.

Keywords: *Exponential smoothing state space model, forecast, suicide, time series*

Mehran Rostami, Abdollah Jalilian[1], Jalal Poorolajal[2], Behzad Mahaki[3]

Deputy for Treatment, Kermanshah University of Medical Sciences, Kermanshah, Iran, [1]Department of Statistics, Razi University, Kermanshah, Iran, [2]Department of Epidemiology, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran, [3]Department of Biostatistics, School of Health, Kermanshah University of Medical Sciences, Kermanshah, Iran

Introduction

The suicide rates vary substantially among different countries and regions.[1] Over 800,000 completed suicide deaths occurred worldwide annually.[1] In Iran, the estimated rate of completed suicide for both sexes was about 5 per 100,000 population.[2] Due to the ethnic diversity and socioeconomic heterogeneity in Iran, there is a substantial difference in suicide rates across the country. Recent data show that Kermanshah province, the most populated western province of Iran, with 13.74/100,000 population has the second highest suicide mortality rate in the whole country.[2] Thus, detailed analysis of the suicide mortality rate in the Kermanshah province is of great importance.[3,4]

Determining the temporal and seasonal trends of disease helps identify different spatial patterns over time and improves our understanding of the environmental, social, and economic risk factors affecting the distribution of disease.[5-9]

Time series analysis of suicide mortality has gained attention in the past two decades. It can be used to identify any persistent pattern in the suicide time series, such as an upward or downward movement (trend) or a pattern that repeats periodically (seasonal variation). For instance, some studies have reported constant levels of suicide rates over time[10] while other studies have reported either downward or upward trends.[11-13] Moreover, a statistical model for a time series analysis of suicide rates can describe the underlying generating process of the data by a set of assumptions and relationships and reveal the complex etiology of suicide.[14,15] The model can be used to obtain forecasts of future suicide rates and the corresponding prediction intervals with a given level of confidence.[16]

The main purpose of this study was to conduct a time series analysis on the monthly completed suicide rates in Kermanshah province, from March 2006 to September 2013. The study tries to find an appropriate time series model that can adequately explain variations in the monthly suicide rates and detect any statistically significant feature in the data.

How to cite this article: Rostami M, Jalilian A, Poorolajal J, Mahaki B. Time series analysis of monthly suicide rates in West of Iran, 2006–2013. Int J Prev Med 2019;10:78.

Address for correspondence:
Dr. Behzad Mahaki, Department of Biostatistics, School of Health, Kermanshah University of Medical Sciences, Kermanshah, Iran. E-mail: behzad.mahaki@gmail.com

Access this article online
Website: www.ijpvmjournal.net/www.ijpm.ir
DOI: 10.4103/ijpvm.IJPVM_197_17
Quick Response Code:

The study period of 2006–2013 was chosen because the suicide mortality data were available to the authors only for these years at the time of conducting the study.

Methods

Ethics statement

This study is based on the digital file of completed suicide mortality records obtained from Kermanshah's provincial forensic medicine organization (FMO). The data were anonymized and de-identified before usage, and hence, no informed consent was required for this work. Furthermore, other aspects of ethical issues have been completely observed by the authors. The study protocol was reviewed and approved by the Research Committee of Hamadan University of Medical Sciences (No. 9107252601).

Data source and preparation

According to Iranian law, all deaths due to suspicious causes must be referred to the FMO centers and examined by forensic pathologists to determine the cause of death. The monthly frequencies of completed suicide mortality in Kermanshah province were extracted from suicide records registered in the digital file of the FMO mortality records that occurred from March 21, 2006, to September 22, 2013. Deaths of nonresidents of Kermanshah province were excluded from the study. The frequencies were converted to rates per 100,000. For this purpose, the number of completed suicide mortality in each month was multiplied by 100,000 and then considered as the numerator and the estimated population in the same year that reside in the province as the denominator. Estimates of yearly population were obtained from the Statistical Center of Iran.

A sequence of 90 monthly completed suicide rates, $y_1, y_2, \ldots, y_{90}$ was obtained and formed a time series [Figure 1, upper panel]. The Box-Cox transform was applied to the series to stabilize the data variance.[17,18] The presence of a stochastic trend (unit root effect) was examined by the augmented Dickey–Fuller unit root test[18] and seasonality were assessed by estimated spectral density function of the series.[17] Seasonality is the component of time series behavior that repeats on a regular basis, such as 1 year.[17,18]

Exponential smoothing state-space models

The observed time series of monthly suicide rates $\{y_t\}_{t=1}^{90}$ was decomposed into three components: Trend or the long-term direction of the series, T_t, Seasonality or a pattern that repeats with a known periodicity, S_t, and random errors, ϵ_t, with constant variance σ^2.[17,18] There were five different choices for the trend term: a simple level (no trend), $T_t = \ell$, an additive trend $T_t = \ell + bt$ with slope b, a damped additive trend $T_t = \ell + b(\varphi + \varphi^2 + + \varphi^t)$ with damping parameter $0 < \varphi < 1$, a multiplicative trend $T_t = \ell b^t$ and a damped multiplicative trend $T_t = \ell b(\varphi + \varphi^2 + \ldots + \varphi^t)$. For the seasonal term S_t, three different types of no seasonality, additive seasonality, and multiplicative seasonality were possible. In addition, it was possible for the error term to be included either additively or multiplicatively.[16] Thus, there were 30 different formulations for T_t, S_t and ϵ_t; from a purely additive model $y_t = T_t + S_t + \epsilon_t$ to a purely multiplicative model $y_t = T_t \times S_t \times \epsilon_t$ and other combinations, such as $y_t = (T_t + \epsilon_t) \times S_t$. Each of these 30 potential models corresponds to an exponential smoothing state-space model.[16] For example, a model with no trend ($T_t = \ell$), no seasonality and additive error corresponds to simple exponential smoothing, while a model with additive trend, multiplicative seasonality, and additive error corresponds to the Holt–Winters' multiplicative smoothing method.[18]

To find the best-fitting model for the monthly suicide data, all 30 exponential smoothing state-space models with different types of trend, seasonality, and error were fitted to the data. The unknown parameters of the models were estimated by maximum likelihood method and the model with the smallest value of the Akaike information criterion (AIC) and the Schwarz's Bayesian information criterion (BIC) was selected as the best-fitting model among competing models. Then, the model residuals were obtained by subtracting the observed values from the expected values from the best-fitting model. If the fitted model adequately explains all statistically significant features of the data, the model residuals are expected to have no significant feature, including trend, seasonality, serial correlation, and variance heteroscedasticity. The serial correlation of the model residuals was checked using portmanteau Ljung–Box Q-test for white noise (goodness-of-fit statistic) and autocorrelation function (ACF) plot of residuals. The Shapiro–Wilk test was used to investigate the normality assumption of the model residuals. The autoregressive conditional heteroscedasticity -lagrange multiplier (ARCH-LM) test was performed for ARCH effect in the model residuals. Finally, the best-fitting model was used to obtain the 6 months ahead out-of-sample predictions and their corresponding prediction intervals for the monthly suicide rates in the Kermanshah province from October 2013 to March 2014. All analyses were performed at 0.05 significant levels using the R package "forecast" developed under the statistical programing language R.

Results

The power parameter of the Box-Cox transform was estimated to $\hat{\theta} = 0.838$ which suggested no variance stabilizing transform. The augmented Dickey–Fuller unit root test rejected (with Z (t) = −5.392 and approximate $P = 0.010$) the null hypothesis of the presence of a stochastic trend. Thus, there was no need for differencing. Most of the suicide cases happened in August. The peak of the estimated spectral density function at frequency 1 indicated a 1 year (12 month) cycle or seasonality in the data [Figure 1, middle and lower panel].

The best-fitting model among all competing exponential smoothing state space models, was the model with no trend (constant level), additive seasonality and multiplicative error (with AIC = 208.45 and BIC = 243.45). As suggested by the estimated spectral density function, the presence of the seasonal component in the model was tested using likelihood ratio test and accepted (with $X^2 = 33.63$ and $P < 0.001$). The best-fitting model can be expressed regarding the three equations:

Observation $y_t = \ell_{t-1} + S_{t-12} + (\ell_{t-1} + S_{t-12})\,\epsilon_t$

Level $\ell_t = \ell_{t-1} + \alpha\,(\ell_{t-1} + S_{t-12})\,\epsilon_t$

Seasonal $S_t = S_{t-12} + \gamma\,(\ell_{t-1} + S_{t-12})\,\epsilon_t$

where ℓ_t is the series level at time t, S_t is the seasonal component at time t, and $0 < \alpha < 1$ and $0 < \gamma < 1-\alpha$ are smoothing parameters. Figure 2 shows the observation, exponentially smoothed level and exponentially smoothed seasonal component. Furthermore, estimates of the parameters of the best-fitted model are summarized in Table 1.

The uncorrelatedness, normality, and homoscedasticity of the model residuals were tested to assess the adequacy of the best-fitting model. The standardized model residuals, sample ACF of the model residuals, and *P* of the portmanteau test for the first 10 lags are plotted in Figure 3. The ACF of the model residuals were inside the 95% confidence limits, and *P* of the portmanteau tests were >0.05 for the first 10 lags, indicating no serial correlation in the model residuals [Figure 3]. The Shapiro–Wilk test confirmed the normality assumption of the model residuals (W = 0.981, *P* = 0.222). The ARCH-LM test was performed on the residuals of the fitted model did not reject the null hypothesis of stability of the residuals variance ($\chi^2 = 6.985$, approximate $P = 0.973$). Therefore, the overall goodness-of-fit of the best fitting model was evaluated. Finally, the model was employed to forecast up to 6 months ahead out-of-sample predictions for the monthly suicide rate in the Kermanshah province from October 2013 to March 2014. Figure 4 shows the transformed monthly suicide rates, expected values from the model (in-sample predictions) and out-of-sample predictions and their corresponding 80% and 95% prediction intervals. Although some discrepancies can be seen, observation and the expected values from the model follow the same pattern, which means the model is successful in describing the time-series dynamics of the data. The 6 months ahead out-of-sample predictions for the monthly suicide rates and their corresponding prediction intervals are summarized in Table 2.

Discussion

Suicide is not only a global public health problem but also it has had a worldwide increasing trend during the last

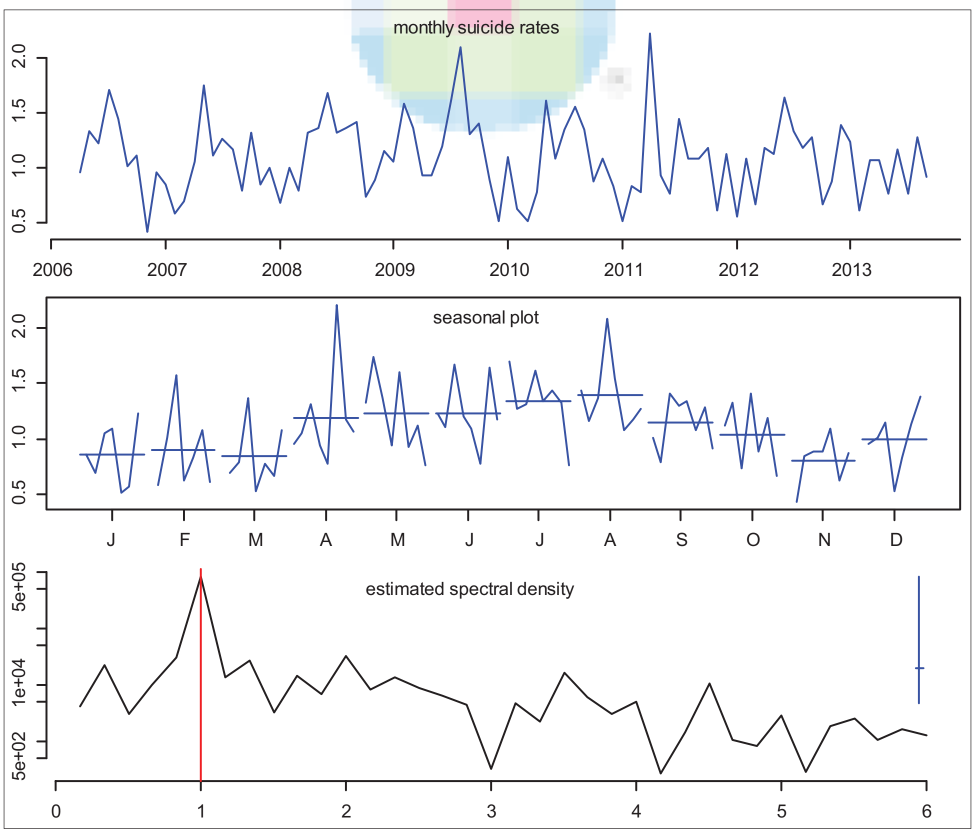

Figure 1: Upper panel: Time series plot of the monthly completed suicide rate. Middle panel: the month plot of suicide rates. Lower panel: The estimated spectral density function of the suicide rates

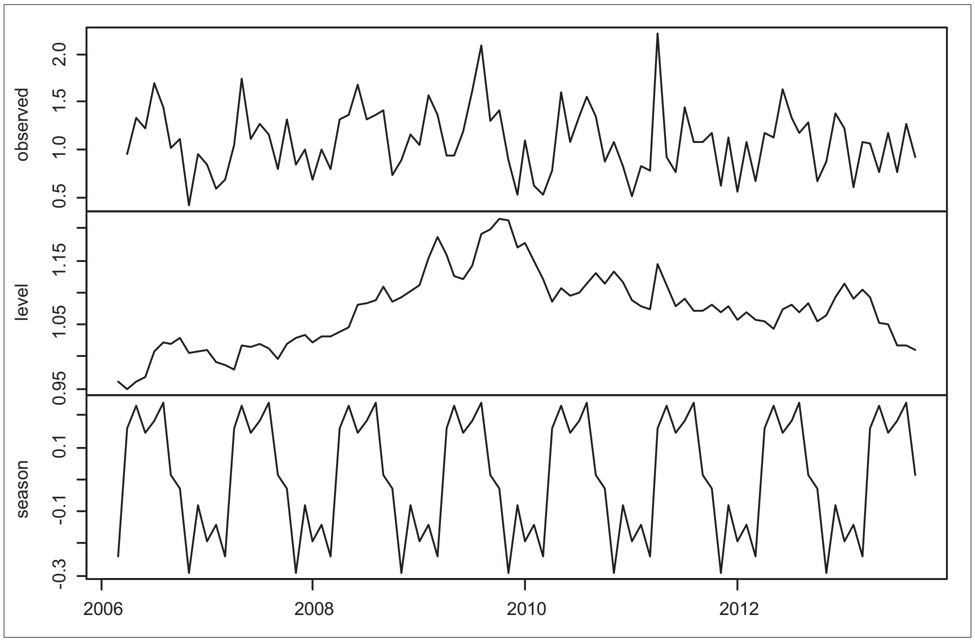

Figure 2: The observed (upper panel), exponentially smoothed level (middle panel), and exponentially smoothed seasonal component (lower panel) of the monthly suicide rates obtained from the best-fitting exponential smoothing state-space model

Table 1: Estimates of parameters of the exponentially smoothing model with no trend, additive seasonal component and multiplicative error fitted to the monthly suicide rates of Kermanshah province, 2006-2013

Log likelihood = -90.23		**AIC = 208.45**		**BIC = 243.45**	
		Estimated model parameters			
$\alpha = 0.0711, \hat{\gamma} = 0.0001$				$1 = 0.9615, \hat{\sigma} = 0.2687$	
$\hat{S}_1 = -0.2397$	$\hat{S}_2 = -0.1416$	$\hat{S}_3 = -0.1915$	$\hat{S}_4 = -0.0804$	$\hat{S}_5 = -0.2915$	$\hat{S}_6 = -0.0263$
$\hat{S}_7 = 0.0131$	$\hat{S}_8 = 0.2404$	$\hat{S}_9 = 0.1853$	$\hat{S}_{10} = 0.1440$	$\hat{S}_{11} = 0.2305$	$S_{12} = 0.157$

Table 2: The six months ahead out-of-sample predictions for the monthly suicide rates in the Kermanshah province from October, 2013 to March 2014, along with the corresponding 80% and 95% prediction intervals

Month	Forecast	Lower 80% prediction bound	Upper 80% prediction bound	Lower 95% prediction bound	Upper 95% prediction bound
Oct-2013	0.9837693	0.6450389	1.3224997	0.4657259	1.501813
Nov-2013	0.7186044	0.4699217	0.9672872	0.338277	1.098932
Dec-2013	0.9297288	0.6081189	1.2513387	0.4378689	1.421589
Jan-2014	0.818639	0.5341004	1.1031777	0.3834747	1.253803
Feb-2014	0.8685167	0.5662418	1.1707915	0.4062272	1.330806
Mar-2014	0.7704304	0.5006216	1.0402391	0.3577935	1.183067

decades,[1] as well as in Iran.[19] Iran's western provinces have higher suicide rate compared to the other provinces of the country.[2] For example, during the past decade, Kermanshah had the highest cumulative frequency of completed suicide among the Iranian provinces.[20] The present study was carried out aiming at exploring an appropriate time series methodological approach to models of completed suicide rate in the most populated western province of Iran over the period from March 2006 to September 2013.

We smoothed the time series data to identify of the underlying patterns more obvious.[16-18] According to our result, we had no significant trend but seasonal variations in the suicide rates that were identified. Nazari Kangavari *et al*.[20] fitted ARIMA, exponential smoothing, and linear component models to the time series of monthly suicide rates in Kermanshah province, as well as Ilam, Lorestam and Kohgiluyeh-va-BoyerAhmad provinces. They found that the exponential smoothing with no trend, additive seasonality, and multiplicative error was the best-fitting model (lowest mean absolute error) for series of Kermanshah province. This is in line with the best-fitting exponential smoothing state space model in

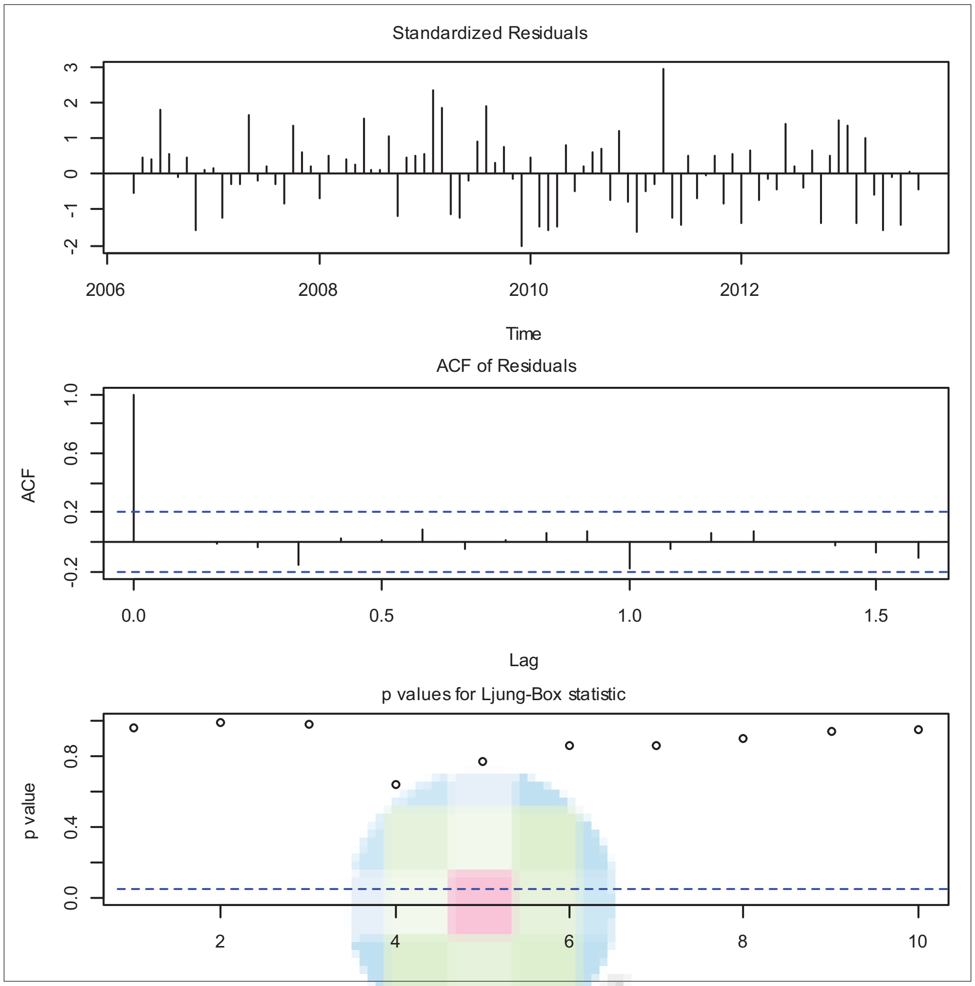

Figure 3: Standardized residuals of the best-fitting model (upper panel), autocorrelation function of the model residuals (middle panel), and *P* values of the portmanteau goodness-of fit test for the first 10 lags (lower panel)

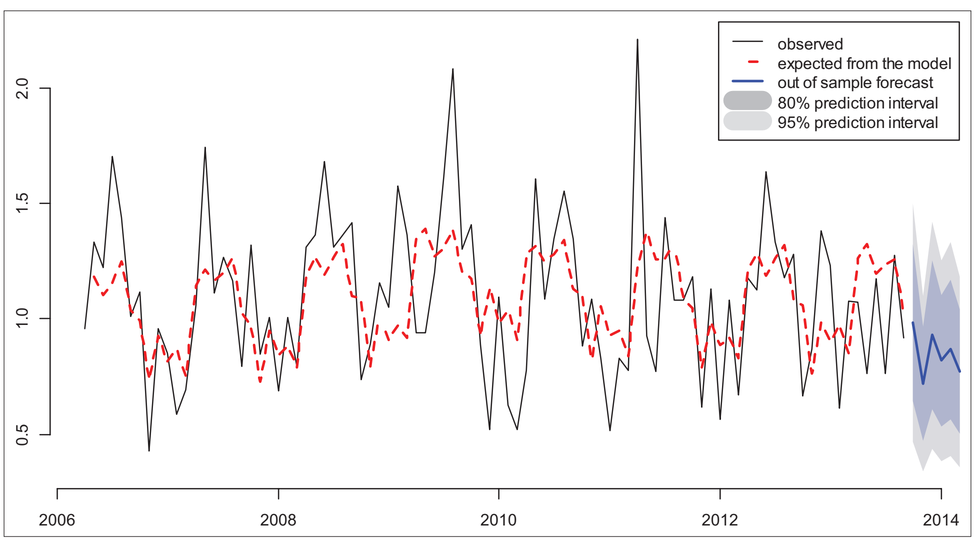

Figure 4: The observed, expected values form the best-fitting model, 6 months ahead out-of-sample predictions, and prediction intervals of the monthly suicide rates in Kermanshah province

our work. Exponential smoothing state-space models refer to a particular approach of time series techniques applied for a short-term forecasting which assumes that heaviest weight for more recent periods and smaller weight for the past periods. This statistical approach is also useful for estimating unknown coefficients from a time series and monitoring forecast errors.[16] This framework is expanded in Hyndman *et al*.[21] and shows how models can be automatically selected for a given time series data. Those showed that all exponential smoothing methods (including nonlinear methods) were optimal forecasts from innovation state-space models.[16,21]

National time trend analysis of major causes of disability-adjusted life-years showed increasing trend in suicide between 1990 and 2010,[19] this finding was concordant with another time trend study of suicide mortality in Iran.[2] Despite the fact that attempted suicide trend in rural areas of Kermanshah province was decreasing during 2000–2006;[22] the incidence rate of completed suicide in Kermanshah province was slightly increasing trend during 2006–2011,[23] but we found no statistically significant trend variations in this time series over the study period, and hence, we fitted an exponential smoothing state-space model to data with the constant level. In other part of the country, for example, the time trend of suicide incidence in the southwest of Iran was decreasing for women and was increasing for men over the captured period, however these trends were not statistically significant.[24] In Tehran, capital of Iran, the trend of deliberate self-poisoning was increasing during 2006–2011.[25] Future studies with long-time period could also reveal significant trend behaviors in an Iranian suicide data.

Study of seasonality pattern of suicide in Iran has been received little attention. During the period of study, a significant seasonal variation was detected in completed suicide cases with a peak in August (more detailed can be obtained from the Figure 1, middle panel). This finding was in line with a recent study in four most suicide prevalent provinces that the highest suicide rate happened in July and August.[20] In addition, in Iran, the highest and the lowest number of completed suicides happened in warm and cold seasons, respectively and the difference between these two seasons was statistically significant.[26] For example, in Mazandaran province, seasonal pattern of attempted suicide cases recorded by emergency wards of all hospitals were examined, which the results showed the highest rates of attempted suicide were in June and November, and the lowest rate was in the winter.[27] Other studies that examined suicide seasonality pattern in Ilam province showed that significant suicide seasonality was observed with one peak in the spring and one in the autumn.[28,29] Furthermore, another study reported the relationship between completed suicide and seasons of the year in south of Iran.[30] In Italy, Preti and Lentini[31] fitted the exponentially smoothing state-space model to monthly number of suicides from 1969 to 2003 and found significant trend and seasonality in the suicide data. In addition, this statistical model has been used to evaluate the trend of body mass index in Australia;[32] breast cancer mortality in Australia,[33] and in the United States and England.[34]

Limitations and strengths

This study had several limitations. First, like any other studies addressing suicide rate, there was the possibility that the number of the completed suicide had been underreported. Second, to avoid potential sparse data biases, we ignored gender-based time series model-building and forecasting. Third, due to restrictions in data availability, we analyzed the short period of seven and half years in our study. Despite its limitations, one of the most strengths of the present study is that it is the first study in Iran which uses exponential smoothing approaches to mathematical modeling the completed suicide rate. Other most strengths of this analytical study was using a state-space approach to forecast suicide mortality which allows the possibility of a seasonal component, thereby providing greater accuracy when forecasting completed suicide mortality. Finally, we have presented a better alternative modeling and forecasting approach to the classic time series models such as an ARIMA (p, d, q) model.

Conclusions

Since suicide is a multidimensional and complex problem, all governments and individuals of society are required to cooperate with one another to tackle this issue. Therefore, fulfilling various studies to clarify whole aspects of suicide in western provinces of the country seems necessary. Regardless of these issues, we found no statistically significant trend in the suicide rate and provided an appropriate time series model for monthly suicide rate for the study period. In overall, exponential smoothing state space model provides a useful statistical approach for the purpose of analyzing the rates of suicide mortality. This approach enables to detection of statistically significant variations hardly detectable through classic time series models. However, additional data from other parts of the country with longer duration are needed to estimate the general trend of suicide in Iran and identify seasonality of suicide across the country.

Acknowledgments

The authors would like to appreciate the Iranian Legal Medicine Research Center as well as the personnel of the Kermanshah provincial forensic medicine organization who collaborate with us for preparing the data.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Received: 28 May 17 **Accepted:** 24 Jan 18
Published: 17 May 19

References

1. World Health Organization. Preventing Suicide: A Global Imperative. Geneva, Switzerland: WHO Press;

2014. Available from: http://www.apps.who.int/iris/bitstream/10665/131056/1/9789241564779_eng.pdf?ua=1&ua=1. [Last accessed on 2017 Mar].
2. Kiadaliri AA, Saadat S, Shahnavazi H, Haghparast-Bidgoli H. Overall, gender and social inequalities in suicide mortality in Iran, 2006-2010: A time trend province-level study. BMJ Open 2014;4:e005227.
3. Rostami M, Jalilian A, Ghasemi S, Kamali A. Suicide mortality risk in Kermanshah province, Iran: A county-level spatial analysis. Epidemiol Biostat Public Health 2016;13:e11829-1.
4. Rostami M, Jalilian A, Rezaei-Zangeneh R, Salari A. Factors associated with the choice of suicide method in Kermanshah province, Iran. Ann Saudi Med 2016;36:7-16.
5. Jafari-Koshki T, Arsang-Jang S, Mahaki B. Bladder cancer in Iran: Geographical distribution and risk factors. Int J Cancer Manag 2017;10:e5610.
6. Mahaki B, Mehrabi Y, Kavousi A, Schmid VJ. Joint spatio-temporal shared component model with an application in Iran cancer data. Asian Pac J Cancer Prev 2018:19:1553-60.
7. Rastaghi S, Jafari-Koshki T, Mahaki B. Application of bayesian multilevel space-time models to study relative risk of esophageal cancer in Iran 2005-2007 at a county level. Asian Pac J Cancer Prev 2015;16:5787-92.
8. Rastaghi S, Jafari-Koshki T, Mahaki B, Bashiri Y, Mehrabani K, Soleimani A. Trends and risk factors of gastric cancer in Iran (2005-2010). Int J Prev Med 2018. doi:10.4103/ijpvm.IJPVM_188_17. [In Press].
9. Ahmadipanahmehrabadi V, Hassanzadeh A, Mahaki B. Bivariate spatiotemporal shared component modeling: Mapping of relative death risk due to colorectal and stomach cancers in Iran provinces. Int J Prev Med 2018. doi: 10.4103/ijpvm.IJPVM_31_17. [In Press].
10. Młodozeniec A, Brodniak WA, Polewka A, Bembenek A. Seasonality of suicide in poland. Analysis of the main statistical office data for the years 1999-2003. Psychiatr Pol 2010;44:61-9.
11. Brzozowski FS, Soares GB, Benedet J, Boing AF, Peres MA. Suicide time trends in Brazil from 1980 to 2005. Cad Saude Publica 2010;26:1293-302.
12. Lin JJ, Lu TH. Suicide mortality trends by sex, age and method in Taiwan, 1971-2005. BMC Public Health 2008;8:6.
13. Rocchi MB, Sisti D, Cascio MT, Preti A. Seasonality and suicide in italy: Amplitude is positively related to suicide rates. J Affect Disord 2007;100:129-36.
14. Razvodovsky YE. Beverage-specific alcohol sale and suicide in Russia. Crisis 2009;30:186-91.
15. Shahtahmasebi S. Suicide research and adolescent suicide trends in New Zealand. ScientificWorldJournal 2008;8:287-302.
16. Hyndman R, Koehler AB, Ord JK, Snyder RD. Forecasting with Exponential Smoothing: The State Space Approach. Berlin: Springer Science & Business Media; 2008.
17. Chatfield C. The Analysis of Time Series: An Introduction. 6th ed. Boca Raton: Chapman and Hall/CRC Press; 2013.
18. Montgomery DC, Jennings CL, Kulahci M. Introduction to time series analysis and forecasting. Hoboken, NJ, USA: John Wiley and Sons, Inc.; 2015.
19. Naghavi M, Shahraz S, Sepanlou SG, Dicker D, Naghavi P, Pourmalek F, *et al.* Health transition in Iran toward chronic diseases based on results of Global Burden of Disease 2010. Arch Iran Med 2014;17:321-35.
20. Nazari Kangavari H, Shojaei A, Hashemi Nazari SS. Suicide mortality trends in four provinces of Iran with the highest mortality, from 2006-2016. J Res Health Sci 2017;17:e00382.
21. Hyndman R, Koehler AB, Snyder RD, Grose S. A state space framework for automatic forecasting using exponential smoothing methods. Int J Forecasting 2002;18:439-54.
22. Barkhourdar N, Jahangiri K, Barkhourdar N. Trend and factors influencing suicides in rural areas of Kermanshah during 7 years (2000-2006). JMCIRI 2009;27:219-25.
23. Poorolajal J, Rostami M, Mahjub H, Esmailnasab N. Completed suicide and associated risk factors: A six-year population based survey. Arch Iran Med 2015;18:39-43.
24. Najafi F, Hasanzadeh J, Moradinazar M, Faramarzi H, Nematollahi A. An epidemiological survey of the suicide incidence trends in the Southwest Iran: 2004-2009. Int J Health Policy Manag 2013;1:219-22.
25. Hassanian-Moghaddam H, Zamani N, Rahimi M, Shadnia S, Pajoumand A, Sarjami S, *et al.* Acute adult and adolescent poisoning in Tehran, Iran; the epidemiologic trend between 2006 and 2011. Arch Iran Med 2014;17:534-8.
26. Shojaei A, Moradi S, Alaeddini F, Khodadoost M, Ghadirzadeh MR, Khademi A, *et al.* The association between completed suicides and season of the year in an Iranian population. Iran J Public Health 2013;42:293-7.
27. Moqaddasi Amiri M, Ahmadi Livani A, Moosazadeh M, Mirzajani M, Dehghan A. Seasonal pattern in suicide in Iran. Iran J Psychiatry Behav Sci 2015;9:e842.
28. Veisani Y, Delpisheh A, Sayehmiri K, Moradi G, Hassanzadeh J. Seasonality and time patterns in attempted suicide in ilam province of Iran: An appraisal of current data of 2010-2014. Med J Islam Repub Iran 2017;31:11.
29. Veisani Y, Delpisheh A, Sayehmiri K, Moradi G, Hassanzadeh J. Seasonality in violent and nonviolent methods of suicide attempts: A cross-sectional study on systematic registry data. Acta Med Iran 2017;55:507-13.
30. Haghighi H, Golmirzaee J, Mohammadi K, Moradabadi AS, Dadipoor S, Hesam AA, *et al.* Investigating the relationship between the demographic variables associated with suicide in different seasons, among suicidal people in the Shahid Mohammadi Hospital, Bandar Abass, Iran. J Educ Health Promot 2015;4:3.
31. Preti A, Lentini G. Forecast models for suicide: Time-series analysis with data from Italy. Chronobiol Int 2016;33:1235-46.
32. Hendrie GA, Ullah S, Scott JA, Gray J, Berry N, Booth S, *et al.* Past and projected trends of body mass index and weight status in South Australia: 2003 to 2019. Aust N Z J Public Health 2015;39:536-43.
33. Erbas B, Hyndman RJ, Gertig DM. Forecasting age-specific breast cancer mortality using functional data models. Stat Med 2007;26:458-70.
34. Erbas B, Akram M, Gertig DM, English D, Hopper JL, Kavanagh AM, *et al.* Using functional data analysis models to estimate future time trends in age-specific breast cancer mortality for the United States and England-Wales. J Epidemiol 2010;20:159-65.