Chin Med Sci J
September 2017

Vol. 32, No. 3
P. 152-160

CHINESE
MEDICAL SCIENCES
JOURNAL

ORIGINAL ARTICLE

Time Series Models for Short Term Prediction of the Incidence of Japanese Encephalitis in Xianyang City, P R China△

Rongqiang Zhang[1, 2], Fengying Li[3], Junli Liu[3], Meining Liu[3], Wenrui Luo[3], Ting Ma[3], Bo Ma[3], and Zhigang Zhang[1]*

[1]School of Public Health, Shaanxi University of Chinese Medicine, Xianyang, Shaanxi 712046, China
[2]Institute of Endemic Diseases, School of Public Health, Health Science Center, Xi'an Jiaotong University, Key Laboratory of Trace Elements and Endemic Diseases of National Health and Family Planning Commission, Xi'an 710061, China
[3]Department of Immunology, Center for Disease Control and Prevention of Xianyang City, Xianyang, Shaanxi 712046, China

Key words: Japanese encephalitis; time series models; incidence; prediction

Objective To construct a model of Seasonal Autoregressive Integrated Moving Average (SARIMA) for forecasting the epidemic of Japanese encephalitis (JE) in Xianyang, Shaanxi, China, and provide valuable reference information for JE control and prevention.

Methods Theoretically epidemiologic study was employed in the research process. Monthly incidence data on JE for the period from Jan 2005 to Sep 2014 were obtained from a passive surveillance system at the Center for Diseases Prevention and Control in Xianyang, Shaanxi province. An optimal SARIMA model was developed for JE incidence from 2005 to 2013 with the Box and Jenkins approach. This SARIMA model could predict JE incidence for the year 2014 and 2015.

Results SARIMA (1, 1, 1) $(2, 1, 1)_{12}$ was considered to be the best model with the lowest Bayesian information criterion, Akaike information criterion, Mean Absolute Error values, the highest R^2, and a lower Mean Absolute Percent Error. SARIMA (1, 1, 1) $(2, 1, 1)_{12}$ was stationary and accurate for predicting JE incidence in Xianyang. The predicted incidence, around 0.3/100 000 from June to August in 2014 with low errors, was higher compared with the actual incidence. Therefore, SARIMA (1, 1, 1) $(2, 1, 1)_{12}$ appeared to be

Received for publication December 21, 2016.
*Corresponding author Tel: 86-29-38185219, Fax: 86-29-38185219, E-mail: Zhangrqxianyang@163.com
△Supported by the Youth Project of Shaanxi University of Chinese Medicine (2015QN05).

reliable and accurate and could be applied to incidence prediction.

Conclusions The proposed prediction model could provide clues to early identification of the JE incidence that is increased abnormally (≥0.4/100 000). According to the predicted results in 2014, the JE incidence in Xianyang will decline slightly and reach its peak from June to August.

Chin Med Sci J 2017; 32(3):152-160. DOI: 10.24920/J1001-9294.2017.036

JAPANESE encephalitis (JE), a member of the genus flavivirus, is a mosquito-borne disease caused directly by the JE virus.[1-4] JE is an acute infectious disease with a high mortality rate of around 25%.[5] The mortality rate of children is generally much higher. Estimated 67 900 cases develop each year in Asia; about half of the cases occur in China.[3] If the virus reaches the central nervous system, it is likely to cause lifelong neurological defects, such as deafness, hemiparesis and emotional problems.

Since JE severely threatens people's health, it is highly crucial to identify a JE outbreak early in order to better plan for control and intervention. The seasonality of JE incidence makes it possible to use the existing data more efficiently and effectively. There have been many retrospective studies using surveillance data to predict the number of cases or incidence in the near future, taking tuberculosis and Hand, Foot, and Mouth Disease for example.[6-8] Until now, no studies have been conducted in Xianyang, China to forecast the incidence of JE and help understand the possibility of an epidemic or provide valuable clues for prevention.

There are many models available that can be used to forecast infectious diseases. These include general regression models, Markov chain models, Seasonal Autoregressive Integrated Moving Average (SARIMA), Grey models, etc.[9-10] Due to the strong seasonality of JE, SARIMA model is the most appropriate model. SARIMA model is a statistical method and prediction approach that is particularly useful if there is time dependence in each observation. It is assumed that each observation in the time series correlates with previous ones, which makes it possible to model a temporal structure and obtain a more reliable prediction, particularly for seasonal infections. In recent years, SARIMA models have been successfully employed to predict the incidence or death trends of malaria[11] and pneumonia[12] or daily patient numbers.[13-14]

The principal objective of our study was to construct a SARIMA model by which the reported JE incidence in Xianyang, Shaanxi, China could be predicted. The findings of this study will be useful for forecasting JE epidemics and providing valuable reference information for JE control and prevention in Xianyang City and even throughout China.

MATERIALS AND METHODS

Study area

Xianyang City is located in the hinterland of Guanzhong Plain in Shaanxi province, China, adjacent to Gansu province, with a population of about 5.4 million. Situated at 107°38′ to 109°10′ east longitude and 34°11′ to 35°32′ north latitude, Xianyang enjoys a semi-humid tropical climate with good sunshine and rainfall. The geographical features of Xianyang include mountains, hills, plains and gullies. In mountainous regions, some villages can only be reached by foot.

JE diagnosis

JE is a disease that is legally mandated for reporting in China. All reported JE cases in this study were confirmed according to the WHO's criteria.[5] Specifically, laboratory diagnosis of JE virus infection should be performed by using a JE virus-specific IgM-capture ELISA. JE virus-specific IgM can be measured in serum by 7 days after the onset. A ≥4-fold rise of JE virus-specific neutralizing antibodies in the serum of acute phase, compared to the convalescent phase, may be used to confirm recent infection.

To ensure diagnostic reliability, confirmatory serological testing was performed on all patients with suspected JE by detecting specific measles IgM antibodies with a commercially available ELISA kit (Yanhui Biotechnology Company, China), according to the manufacturer's instruction. Patients with a ≥4-fold rise of JE virus-specific neutralizing IgM of the acute phase, compared to the convalescent phase, may be diagnosed as JE.

Data collection and management

Monthly incidence data on JE for the period from Jan 2005 to Sep 2014 were obtained from a passive surveillance system at the Center for Diseases Prevention and Control in Xianyang, Shaanxi province. The well-established Disease Prevention and Control Information System could ensure the integrity, accuracy and reliability of the data used in this study. The population information was obtained from the Statistical Yearbook of Shaanxi Province from 2005 to 2014.