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Forecasting Schizophrenia Incidence Frequencies Using Time Series Approach

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Abstract

Background: Learning the prevalence of schizophrenia has main insinuations for both health service preparation and risk factor epidemiology. The aims of this research in order to systematically classify and collate studies explaining the prevalence of schizophrenia, to sum up the findings of these studies, also to survey selected factors that may influence occurrence approximates.

Methods: This historical cohort study was done on schizophrenia patients in Farshchian psychiatric hospital from April 2008 to April 2016. To analyze the data, the Holt-Winters Exponential Smoothing (HWES) method was applied. All the analyses were done by R.3.2.3. software using the packages "forecast" and "tseries." The statistical considerable level was simulated as 0.05.

Results: Our investigation shows that a constant frequency of schizophrenia incidence happens every month from August 2008 to February 2015 while a considerable increase occurs in March 2015. The high frequency of schizophrenia incidence remains constant to the end of 2015 and a decrease is shown in 2016. Also, data demonstrate the development of schizophrenia in the next 24 months with 95% CI.

Conclusion: Our study showed that a significant increase happens in the frequency of schizophrenia from 2016. Although the development is not constant and the same for all months, the amount of increase is considerably high compared to before 2016.

Keywords: Schizophrenia; Holt winter; Time series; Exponential smoothing; Modeling

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Introduction

Schizophrenia is a disabling number of brain disorders characterized by symptoms such as hallucinations, delusions, disorganized interaction, poor planning, reduced incentive, and blunted influence.[1] Schizophrenia is associated with deficits in various cognitive processes that result in disorders of complex thinking and ideation, resulting in difficulty in dealing with 'psychological and social challenges in daily life.[2] Schizophrenia is a devastating psychiatric disorder that affects approximately 1% of the population.[3] For several years, it was believed that the prevalence of schizophrenia varied little between sites.[4,5] It is, in fact, the case that the estimates of the prevalence of schizophrenia are seen as a multiplicity of variations.[1,6-8] Major advancements have been made in our understanding of the epidemiology of schizophrenia. We now understand that the illness is somewhat more common and severe in young men, and that the occurrence may differ geographically and temporally. Risk factors have been elucidated; biological risks include a family history and ancestors of the complaint, advanced paternal age, obstetric difficulties, and abuse of drugs such as stimulants and cannabis. Furthermore, new research has also recognized social risk factors such as being born and brought up in a city, migration, and certain types of childhood difficulty such as physical misuse and bullying, as well as social separation and opposing events in adult lifetime. To conclude, the epidemiological evidence suggests that schizophrenia is a multifactorial disorder in which genes connect to the other person and with environmental factors to push individuals more than a threshold into expression of the disorder.[9] Studies that estimate the occurrence of schizophrenia are required to be able to recognize gradients across time and/or place.

These gradients allow us to generate prospect risk factors that may underlie difference in the disorder. However, studies that statement the prevalence of a disorder are also important. Estimating the amount of a population afflicted with schizophrenia is central to health service planning[1] Assessing the stochastic process of a variable over time is of interest in lots of medical problems.[10-12] Time series observations, as stochastic processes, are sequence of measurements of a special variable collected along with time. Lots of statistical methods have been introduced to analyze these types of data. Modeling and forecasting the development of a variable is a key characteristic of time series modeling approaches. Forecasting future conditions of variables cause a considerable reduction in costs and risks.[13] The procedure of forecasting a future state of variable is carried out using present and previous conditions of the variable.[14]

Techniques to analyze these types of data can be determined based on some characteristics of time series such as stationary and/or seasonal observations.[15] Holt-Winters exponential smoothing (HWES) method is frequently used compared to other time series analysis methods thanks to its' efficacy.[13,16]

The purpose of this investigation is to assess monthly frequency of schizophrenia in Hamadan province from 2008 to 2016. Modeling and forecasting are carried out using HWES method.

Materials and Methods

Data

This historical cohort study was done on schizophrenia patients in Farshchian psychiatric hospital from April 2008 to April 2016. Patients according to psychiatrist diagnosed base on DSM-IV criteria were hospitalized. Also, data collection based on a checklist was developed by the investigators. To analyze the data, the HWES method was applied. All the analyses were done by R.3.2.3. software using the packages "forecast" and "tseries." The statistical considerable level was simulated as 0.05.

Statistical Analysis

Holt-Winters Exponential Smoothing

Time series data are stochastic processes in which the response variable, "*y*," is recorded on several occasions "*t*."[17] A time series can be seasonal as well as stationary. Seasonal trend is described as the tendency of time-series data to display behavior that reiterates itself every L periods. In a stationary time series, some properties such as mean and variance are constant over time. Several modeling approaches can be utilized according to stationarity and seasonality of the observation that is moving means method, linear regression with time, exponential smoothing.[15] These models can be compared based on their goodness of fit and the accuracy of parameter estimations.

Exponential smoothing methods include single, double and triple (Holt-Winter) approaches and they can be used according to presence/absence of trend and seasonality. The HWES is applied when the series shows trend as well as seasonality. The HWES method models and forecasts the future condition of response variable by weighting the present and previous observation. This method allocates exponentially reducing weights as the prior surveillance get older.[15] An additive or multiplicative seasonality in time series observations requires additive or multiplicative HWES approach, respectively.

An additive HWES takes the additive change in seasonal development of variable into account. An estimated amount is added to the beginning of the next period. The model includes "y_{t+h}" as the frequency of Schizophrenia at "*t+h*" (the time of processes), "*p*" as period length, (at,b_t) as the permanent and trend of time series, as *S* the additive seasonal factor and ε_t as the random error component.

$$y_{t+h} = a_t + hb_t + S_{t-p+1} + \epsilon_t$$

Where

$$a_t = \alpha\left(y_t - S_{t-p}\right) + (1-\alpha)\,(a_{t-1} + b_{t-1})$$

$$b_t = \beta(a_t - a_{t-1}) + (1-\beta)b_{t-1}$$

$$S_t = \gamma(y_t - a_t) + (1-\gamma)\,S_{t-p}$$

After the parameters in the model are estimated, one can forecast the response variable at any desired future time point by replacing the coefficients. All the analyses were done by statistical programming R.3.2.3. Software using "forecast" and "tseries" packages. The statistical significance level was simulated as 0.05.

Results

This investigation assesses the frequency of schizophrenia in Hamadan province, west of Iran, from August 2008 to February 2016. According to Figure 1, a constant frequency of schizophrenia incidence happens every month from August 2008 to February 2015 while a considerable increase occurs in March 2015. The high frequency of schizophrenia incidence remains constant to the end of 2015 and a decrease is shown in 2016.

The additive HWES method was performed to model the frequency of schizophrenia incidence. The dashed line in Figure 1 shows the estimated frequencies by the HWES. The model is as follows.

$$y_{t+h} = a_t + hb_t + S_{t-p+1}$$

Where

$$a_t = 0.43\left(y_t - S_{t-p}\right) + 0.57\,(a_{t-1} + b_{t-1})$$

$$b_t = 0.03(a_t - a_{t-1}) + 0.97b_{t-1}$$

$$S_t = 0.35(y_t - a_t) + 0.65\,S_{t-p}$$

The level, trend and seasonal components are estimated

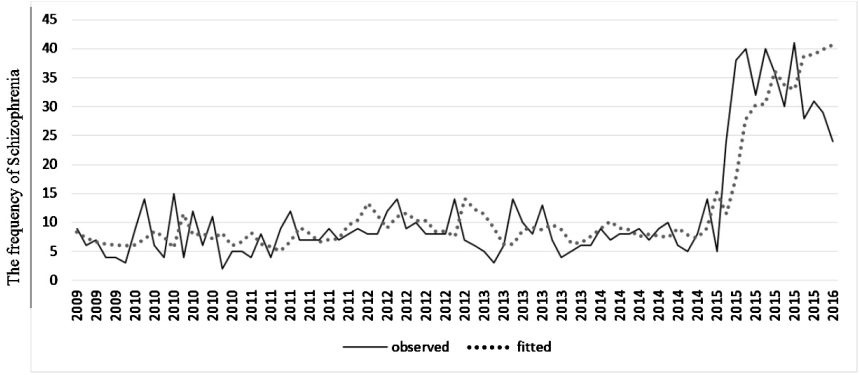

Figure 1. The Development of Schizophrenia Frequency (Dashed line=estimated frequencies resulted by the HWES, line=Observed frequency).

and shown in Table 1 while the period is 12 months (p=12). The estimated HWES model was applied to forecast the Schizophrenia incidence frequencies for the next 24 months after February 2016. The frequencies as well as a 95% CI are exposed in Table 2. In addition, Figure 2 demonstrates the development of schizophrenia in the next 24 months with 95% CI. According to Figure 2, a constant behavior of schizophrenia incidence frequencies occurs from March 2016 to February 2017 with an average of 41 frequencies each month. An increase happens in March 2017 and ends in October 2017 with an average of 54 schizophrenic patients each month. The schizophrenia incidence frequencies decreased after November 2017.

Discussion

The history of the epidemiological study of schizophrenia is as old as the diagnostic concept itself. The worldwide incidence of schizophrenia reported according to DSM standard, and modified for age, mean occurrence is 0.11 (range 0.07–0.17) per 1000 inhabitants per year.[16] Estimations of the lifetime frequency of schizophrenia range from 0.4% to 1.4%. The first age of onset and the persistent illness course may demonstrate these respectively high characters. Patients with schizophrenia may also have limited usage of and lower quality of healthcare services contrasted with the public population.[18] It really is clear that our knowledge of rate of recurrence of the disorder has improved substantially during the past few decades with evidence recommending that some previously organized views about its occurrence were not

Table 1. The Estimation of Level, Trend and Seasonal Components of Time Series HWES Model

Coefficients	Estimates
a	39.129
b	0.738
s1	1.051
s2	1.093
s3	1.258
s4	1.061
s5	0.998
s6	1.169
s7	0.947
s8	0.953
s9	0.726
s10	0.775
s11	0.712
s12	0.649

Table 2. A 24 Months Forecasting of Schizophrenia Using the HWES Model

Date	Point Forecast	95% CI
16-Mar	41.938	35.545-48.330
16-Apr	44.384	36.467-52.301
16-May	52.014	42.093-61.935
16-June	44.659	34.717-54.601
16-July	42.742	32.099-53.385
16-Aug	50.929	37.733-64.125
16-Sep	41.996	29.865-54.127
16-Oct	42.937	29.697-56.178
16-Nov	33.239	21.610-44.868
16-Dec	36.075	22.737-49.414
17-Jan	33.661	20.233-47.089
17-Feb	31.150	18.080-44.219
17-Mar	51.264	28.953-73.576
17-Apr	54.075	29.992-78.158
17-May	63.167	34.705-91.629
17-June	54.067	28.774-79.360
17-July	51.591	26.713-76.468
17-Aug	61.295	31.454-91.135
17-Sep	50.401	24.894-75.908
17-Oct	51.389	24.791-77.988
17-Nov	39.676	17.997-61.356
17-Dec	42.951	19.036-66.865
18-Jan	39.976	16.928-63.024
18-Feb	36.904	15.172-58.636

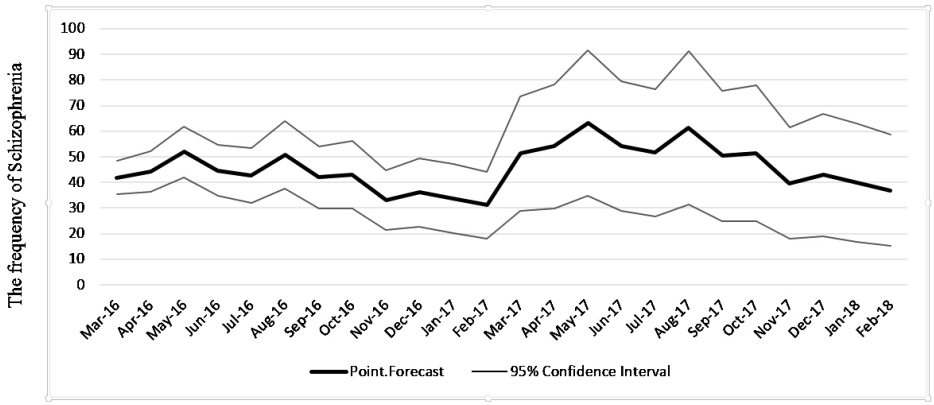

Figure 2. Forecasting 24 Next Months of Schizophrenia Frequency From March 2016 to February 2018.

exactly appropriate. Still, there remain important gaps in the literary works that can only be filled with more population-based studies using widely conventional and validated ascertainment tools.[18] Nevertheless, it should be mentioned that the boundaries chosen for epidemiological studies (e.g., health districts, towns, states, or nations) might not exactly be optimal for the detection of differences of the disorder within or between various populations. Studies that estimate occurrence of schizophrenia are essential in order to identify gradients across time and/or place. These gradients allow all of us to create prospect risk factors that may underlie different versions in the disorder. On the other hand, studies that report the prevalence of the disorder are also important.[1] Generally, epidemiologic research has built a powerful knowledge base over the past quarter hundred years, and this knowledge foundation will continue to make contributions to public well-being efforts at prevention of schizophrenia in the coming decades.[19] We used HWES method to model and forecast the schizophrenia incidence frequencies using the data from 91 months from 2008 to 2016. Lots of studies have used the HWES method with both additive and multiplicative approaches to analyze time series data in medical areas.[20-23] Limitations of this study are that the study was done according to the patient's records in hospital and we did not have access to information before 2008.

Our study showed that a significant increase happens in the frequency of schizophrenia from 2016. Although the development is not constant and the same for all months, the amount of increase is considerably high compared to before 2016. The HWES method can be used as an appropriate statistical tool to analyze and forecast such data.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

Ethical Statement

The research was approved by Hamadan University of Medical Sciences Local Ethical Committee (No. 94047091977).

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