ORIGINAL ARTICLE

Eastern Journal of Medicine

East J Med 25(1): 132-139, 2020
DOI: 10.5505/ejm.2020.57805

Forecasting for the number of individual per dentist in Turkey; Comparison of Box-Jenkins and Brown Exponential Smoothing Estimation Methods

Can Ateş

Van Yüzüncü Yil University Faculty of Medicine Department of Biostatistics

ABSTRACT

Oral and dental diseases and the fight against these diseases are a difficult and costly issue for our country and most of the world countries. Protective and informative dentistry practices may be realized with the prospective realistic planning of Dentist personnel trained at adequate number and Oral Dental Health services. Attaching importance to the protective services for development of health services are the leading among the issues, which the policy-makers are required to emphasize with caution.

The aim of this study is to model the series of number of individual per dentist personnel in Turkey between the years of 1951-2016 with Box-Jenkins and Brown Exponential Smoothing methods, and to provide these forecast models derived to guide the policy-makers.

Number of individual per dentist personnel is calculated prospectively in this study and values expected until 2023 are found with Box Jenkins and Brown Exponential Smoothing methods frequently used in making prospective forecasts. Calculations of these two models are compared in terms of decision-making criteria and it is concluded that Brown Exponential Smoothing model produces more coherent results than Box Jenkins model on behalf of making prospective forecasts.

Key Words: Box-Jenkins, Brown Exponential Smoothing, Number of individual per Dentist

Introduction

Forecasting studies are of great importance for planning in many areas such as health, economy-commerce, sports, environment, technology and politics (1-2-3-4). An important point discussed in this area is the integration of statistical and judgmental approaches. Green and Armstrong (2012) stated that the most reliable forecasts would be obtained by joint evaluation of these two approaches (5).

Soyiri ve Reidpath (2013), mentioned that forecasting models have a key role in the sector of medicine practice. They mentioned that health protection models can be used effectively in collaboration with different areas of expertise. And they reported this with an example of a system which actively used to identifying and reporting dates that may be risky for Chronic Obstructive Pulmonary Disease (COPD) patients and established by a forecasting unit within the United Kingdom Meteorological Office [6]. In this sense, Health forecasting can't be argued to be of great value when they provide sufficient warning for corrective action to be taken in a timely manner. Only in this way can healthcare decision makers be able to overcome complex problems such as provision of basic social care for early symptoms, staffing and facility utilization.

Many field experts in a clear way have presented impact of the oral and dental health on general health. Continuance of the general community's life healthily is associated with the increase of conscious level in subjects like being protected from diseases and early treatment in terms of oral and dental health as much as in the general health issues. In this sense, it will be possible to prevent the oral and dental diseases threatening the community health with the training and employment of effective Dentists who are been trained in this field.

World Health Organization (WHO) and FDI (Fédération Dentaire Internationale) and IADR (International Association of Dental Research) published the objectives they determined jointly for 2020 in the early 2000's. These objectives have been determined for not only being protected from tooth decay and controlling tooth decay but also preventing periodontal condition, mucosa lesions, pre-cancer and cancers, head-face traumas, pain by taking the life quality related with oral and dental health into account. In conclusion, it is been stated that objectives and standards related with oral and dental

***Corresponding Author:** Can Ateş, Van Yuzuncu Yil University, Faculty of Medicine, Department of Biostatistics, Campus, Van, Turkey
E-mail: can.ates@gmail.com, Phone: +90 532 543 42 83
Received: 01.11.2019, **Accepted:** 02.12.2019

health should be determined by the regional, national and local conditions and information and health systems, system competence and socio-economic environmental conditions will play role in establishment of this. Objectives setting out in this study are not recommended numerically, establishment of own health system of each country by its executives is accepted as a principle (7).

In this sense, our oral and dental health is deteriorating in parallel to the new changing living conditions by the developments particularly experienced in technology and industry in our country and world, health expenses used for treatment in this field are seriously increasing every year. Though, protective and informative dentistry practices may be realized with the prospective realistic planning of Dentist personnel trained at adequate number and Oral Dental Health services. In this study, series of number of patient per dentist personnel in Turkey between the years of 1951-2016 are modeled with Box-Jenkins and Brown Exponential Smoothing methods and derived estimation models are evaluated for the purpose of enabling the health departments and oral and dental health specialists to use in the prospective planning.

Materials and Methods

In this study, estimates derived by using autoregressive moving average (ARIMA- Auto Regressive Integrated Moving Average) and Brown Exponential Smoothing methods are evaluated in time-series analyses. SPSS, version 25.0 (SPSS Inc., Chicago, IL, USA) program is used for the analyses.

Data collection tools and process: Data of research is consisted of number of individual per dentist personnel in Turkey between the years 1951 and 2016. In table 1, number of individual per Dentist personnel by the years is shown (8).

Time-series is a series derived from the observations made at periodical time intervals. This series enables to develop a proper model and to make prospective estimations by using statistical methods (9). However, stationary series are required for estimating the values, which they will take prospectively by using the past values for any series. Since non-stationary series contain up-and-down values exhibiting variance at high level, margin of error in the possible estimates is quite high (10). Stationarity may be defined as "probabilistic process whose average and variance do not vary over time and covariance between two periods is based on distance only between two periods, not period for which this covariance is calculated" (11-12). Many tests are been used for searching the stationarity. Those that are most common among these methods are ACF (Autoregressive Correlation Function)and PACF (Partial Autoregressive Correlation Function) graphics and augmented Dickey Fuller (ADF) unit root test (13).

Box-Jenkins Method (ARIMA): This method that was developed by Box and Jenkins (1970) is constituted by combination of two different processes (14). While the first process expresses Autoregressive Model (AR), the second process expresses moving average (MA) process. Box-Jenkins method is stated with ARMA model that is the combination of these two models. However, the condition of existence of a stationary series is sought in Box-Jenkins method. It is commonly used due to ARIMA (Integrated Autoregressive Moving Average) model structure by taking the difference of series from d degree and adding to ARMA model for the stabilizing process (15).

The core of Box-Jenkins method is to select an ARIMA model containing the most favorable but limited parameter among the various model choices by depending on the nature of existing data. Presentation of these non-seasonal models as a whole is in form of ARIMA (p, d, q). In the models, the following is defined; p: autoregressive model (AR) degree, q: moving average model (MA) degree, d: Non-seasonal taking difference degree. ARMA model in the models is as shown in Equation (1) (14).

$$Y_t = \sum_{i=1}^{q} \beta_i \varepsilon_{t-i} + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \varepsilon_t \quad (1)$$

Once difference of non-stationary X_t time-series is subtracted, equation (2) is found.

$$\nabla X_t = X_t - X_{t-1} = X_t' \quad (2)$$

If $X_t{}'$ series is not still stationary, difference taking process is repeated and difference taking degree is found as d=2.

$$\nabla^2 X_t = \nabla(X_t') = X_t' - X_{t-1}' = X_t - 2X_{t-1} + X_{t-2} \quad (3)$$

If the series is not still stationary, difference taking process continues for d times until being stationary and ARIMA(p,d,g) model is found in general sense [16].

$$X_t = \nabla^d Y_t = (1 - B)^d Y_t \quad (4)$$

Seasonal Box-Jenkins models are generally expresses in form of ARIMA(p,d,q) (P,D,Q)s. Here, P is degree of seasonal auto-regression (SAR) model, D is the number of seasonal difference taking process, Q is the degree of seasonal moving average (SMA) model

Table 1. Number of İndividual per Dentist by Years

Year	Nr.of individual	Year	Nr.of individual	Year	Nr.of individual	Year	Nr.of individual	Year	Nr.of individual	Year	Nr.of individual
1951	22403.99	1962	18605.14	1973	8897.64	1984	6033.44	1995	5099.94	2006	3803.73
1952	22724.64	1963	16256.58	1974	9144.30	1985	6057.44	1996	4890.46	2007	3661.49
1953	19506.48	1964	17179.76	1975	7932.22	1986	6121.28	1997	4834.89	2008	3583.20
1954	23725.97	1965	16122.67	1976	7606.62	1987	6097.33	1998	4654.20	2009	3524.28
1955	24902.92	1966	14923.36	1977	7015.28	1988	5526.30	1999	4454.10	2010	3439.86
1956	23550.86	1967	14581.48	1978	6246.85	1989	5348.60	2000	4039.48	2011	3541.60
1957	23576.10	1968	14105.84	1979	6200.11	1990	5242.53	2001	4051.82	2012	3533.33
1958	21295.90	1969	11386.12	1980	6279.36	1991	5276.76	2002	4056.07	2013	3438.79
1959	20771.56	1970	10884.75	1981	6706.92	1992	5324.30	2003	3786.48	2014	3378.67
1960	19717.56	1971	10297.13	1982	6123.02	1993	5232.00	2004	3800.94	2015	3170.70
1961	20648.87	1972	9800.21	1983	6165.66	1994	5135.46	2005	3794.18	2016	2992.23

Table 2. Forecast Values of Number of Individual Per Dentist by Box Jenkins Models

Model		2017	2018	2019	2020	2021	2022	2023
	Forecast	2667	2368	2068	1768	1468	1168	868
Ind/Dentist	95% CL Low	738.65	-122.85	-888.34	-1589.54	-2247.67	-2874.19	-3476.22
	95% CL Upp	4595.11	4858.96	5024.45	5125.76	5183.99	5210.62	5212.76

Table 3. Box Jenkins Model Fit Criteria Table

	Model Fit statistics								Ljung-Box Q(18)		
Ind/Dentist	Stat. R^2	R^2	RMSE	MAPE	MAE	Max APE	Max AE	Normalized BIC	Stat.	DF	Sig.
	0.03	0.98	964.75	6.36	599.88	21.57	4003.15	13.936	23.54	16	0.049

and s is the period (11).

$$(1-\phi_1 B-\phi_2 B^2-\cdots.-\phi_p B^p)(1-\phi_1 B^s-\phi_2 E$$
$$B^s)^D Z_t=(1-\theta_1 B-\theta_2 B^2-\cdots.-\theta_q B^q)(1-\Theta_1$$

(5)

Brown Exponential Smoothing Method : It is the exponential smoothing method used in cases where the trend in series while making estimate. We encounter with trend in many actual data.

Cumulative model

$$x_t=a+b_t \quad (6)$$

$$x_t=a\varepsilon_t$$

$$M_t=\frac{(x_t)+(x_{t-1})+\cdots+(x_{t-N})+1}{N} \quad (7)$$

Equation of updated trend component is given in equation (8).

$$M_t=M_{t-1}\frac{(x_t)-(x_{t-N})}{N} \quad (8)$$

Equation of updated trend component is given in equation (9).

$$S_t(x)=\alpha(x_t)+(1-\alpha)S_{t-1}(x) \quad (9)$$

$$S_t(x)=\alpha(x_t)+(1-\alpha)[\alpha(x_{t-1})+(1-\alpha)S_{t-2}(\quad (10)$$

$$S_t(x)=\alpha\sum_{k_0}^{t-1}(1-\alpha)^k(x_{t-k})+(1-\alpha)^t(x_0)+ \quad (11)$$

Results And Discussion: Time-series analysis of number of patient between the years 1951 and 2016 is carried out for making a prospective estimate of number of individual per dentist. Time-series graphic showing number of individual per dentist personnel is presented in Figure 1.

Once Figure 1 is examined, it can be said that there are fluctuations and series decrease with trend. Existence of seasonality and trend in the series lead to the series not to be stationary. ACF and PACF graphics of series are given in Figure 2 for examining the stationarity. As is seen, since several delays stay out of confidence limits, it can be said that series is

Table. 4. Forecast values of number of individual per dentist by Brown exponential smoothing models

Model		2017	2018	2019	2020	2021	2022	2023
	Forecast	2973	2882	2791	2700	2609	2517	2426
Ind/Dentist	95% CL Low	1095.06	541.12	-77.27	-750.16	-1470.78	-2234.40	-3037.49
	95% CL Upp	4851.39	5223.00	5659.07	6149.62	6687.92	7269.21	7889.98

Table 5. Model fit criteria table of Brown model

	Model Fit statistics								Ljung-Box Q(18)		
Ind/Dentist	Stat. R^2	R^2	RMSE	MAPE	MAE	Max APE	Max AE	Normalized BIC	Stat.	DF	Sig.
	0.591	0.981	940.429	4.752	540.12	17.886	3384.099	13.756	21.279	17	0.214

not stationary. Partial stabilization is tried to be provided since differences among values of series will decrease by firstly taking logarithm of the series, however; since the series is not stationary, taking difference process is applied until it is stationary. It is concluded that series become stationary after difference is taken for once for the trend. ACF and PACF graphics showing number of individual per dentist as a result of difference taking process are given in Figure 3 and 4.

Once ACF and PACF graphics given in Figure 4 is examined, it is seen that two delays exceed confidence limit; the other two delays are close to confidence limit.

These conditions may be neglected and it can be said that series becomes stationary. Also, stationarity analysis of series is performed by using augmented Dickey Fuller (ADF) unit root test. It is said that series is not stationary by ADF test result prior to taking difference (t=-1,254;p=0.758), but, following the difference taking process, series becomes stationary (t=-11,258; p=0.001). While trying to create the proper model by utilizing from such processes, several different models are tried and it is seen that ARIMA (1,1,1) model is the most proper model for number of individual per dentist.

Once Table 2 is examined, forecast values until 2023 are seen. Number of individual per dentist personnel follows a decreasing trend in a way that is similar to past years. As is seen from Figure 5 where results of ARIMA (1,1,1) model are presented visually, number of individual per dentist in which a radical decrease is observed between 1954-1981 shows a decrease also between 1981–017, however; acceleration of this decrease reduces. The expected state also between 2017-2023 is that acceleration of number of individual per dentist will further increase and decrease. This condition shows paralelism with increase of numbers of Faculty of Dentistry opened recently and establishment of new and easily accessible centers for oral and dental health by Ministry of Health.

Goodness of fit criteria of derived models is evaluated in a comparative way with each other. R2 is a commonly known measure and goodness of fit benchmark of linear model, it is mostly called as determination coefficient. It varies between 0 and 1 and maximal values shows that data fit of model is good. Stationary R^2 is a measure comparing the basic model with stationary part of the model. It is preferred if there is any trend or seasonal pattern. RMSE is square root of average error means. It is used for expressing that how much the dependent series is different from the forecasted level. Minimal values shows that model forecast is better. MAPE shows average absolute percent error and is independent from units of series, thus, it can be used also in comparison of different series. MAE shows the average absolute error and is expressed with the own units of series. MaxAPE is the highest absolute percent error measure. It shows the highest error occurred among the forecasted values, it is expressed in percent, therefore, it is independent from the unit. It is a measure which can be used for the worst scenario practices among forecasts. MaxAE shows the highest absolute error and is expressed in the same unit with the dependent series. Normalized BIC, normalized Bayesyan information criteria, is the general measure of total fit of model. This measure is used for making comparison among different models once there are same series and minimal values show better model (17).

When Table 3 is examined, Box-Jenkins models for which number of individual per dentist is formed, are statistically significant (p=0.049). MAPE shows that series contain highly useable forecasts.

Under the light of these information, number of individual per dentist is forecasted with Brown method of exponential smoothing methods and forecasted values are given in Table 4. Forecasted

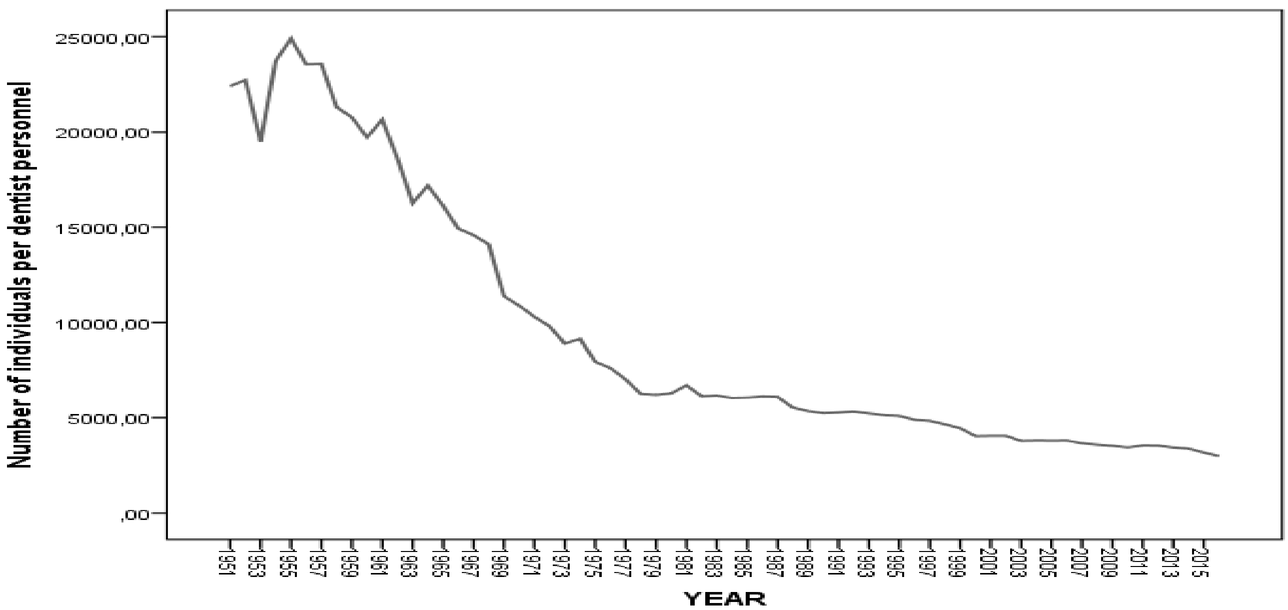

Fig. 1. Time-series graphic showing number of individual per dentist

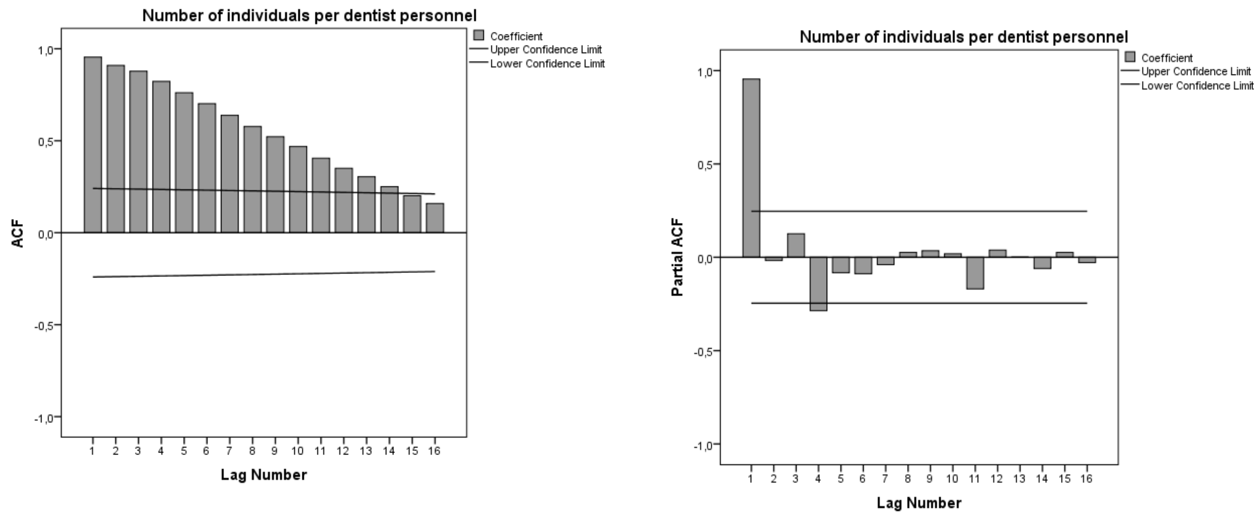

Fig. 2. ACF and PACF graphics showing number of individual per dentist

values of number of individual per dentist personnel for the forthcoming years are visually summarized in a longitudinal graphic in Figure 6. Similarly, again a decreasing trend is seen in the number of individual per dentist forecasted up to 2023.

While those marked in red are the values observed in past years, curve shown in blue line expresses the forecasting values before and after 2017. 95% confidence interval observed and expected is also given in the graphic for the values calculated with Brown model.

Once the forecasting values derived by Brown exponential smoothing model are examined, it is seen that decrease regarding the trend between the years 2017 and 2023 is less expected compared with Box Jenkins. Thus, the number of individual per dentist personnel expected for 2023 is calculated about 3 times more than the first model, it continues with a course that is more suitable to the trend between the years 1981-2017.

Once Table 3 and 5 are examined comparatively, it is observed that all fit statistics are better than Box Jenkins model regarding the Brown Exponential Smoothing method, notably MAPE value. In Box Jenkins model, MAPE value (6.360) found for (ARIMA(1,1,1)) is higher than Brown exponential smoothing model (4.752). In terms of MaxAE that we can evaluate the series with same unit and that is the indicator of the highest absolute error, it is forecasted as less faulty for Brown model (3384.09) than Box Jenkins (4003.15).

Attaching importance to the protective services for

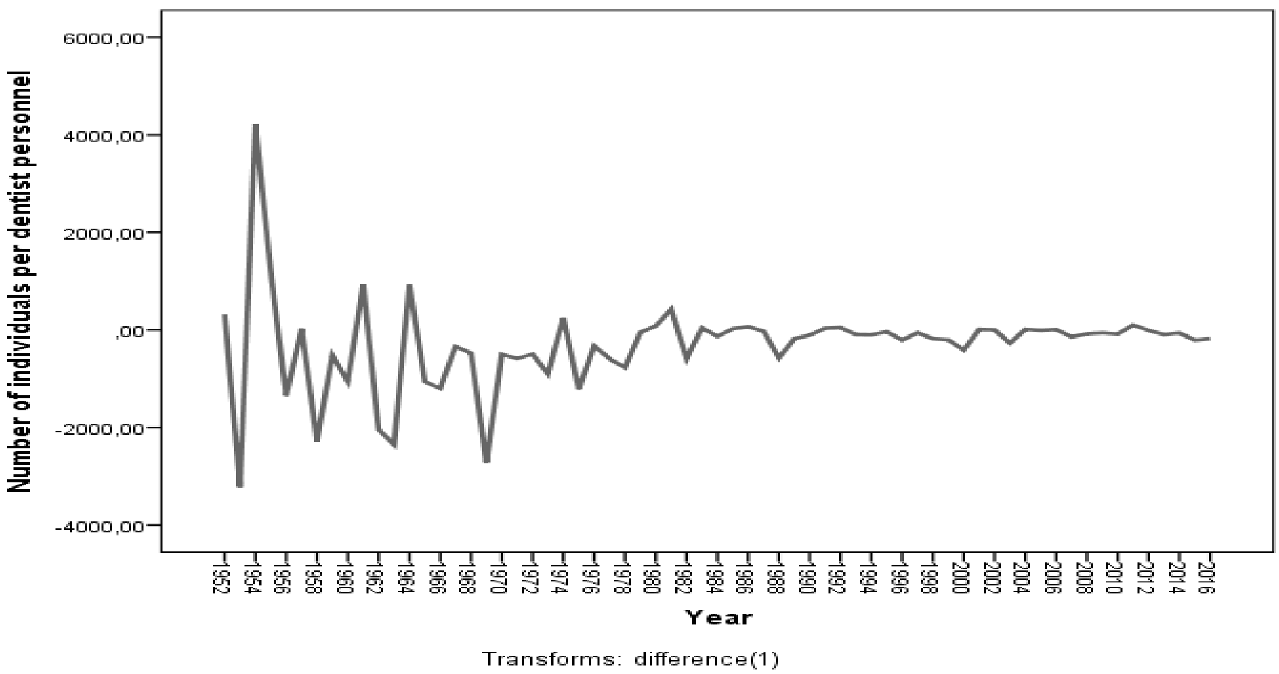

Fig. 3. Graphic of series whose difference is taken showing number of individual per dentist personnel

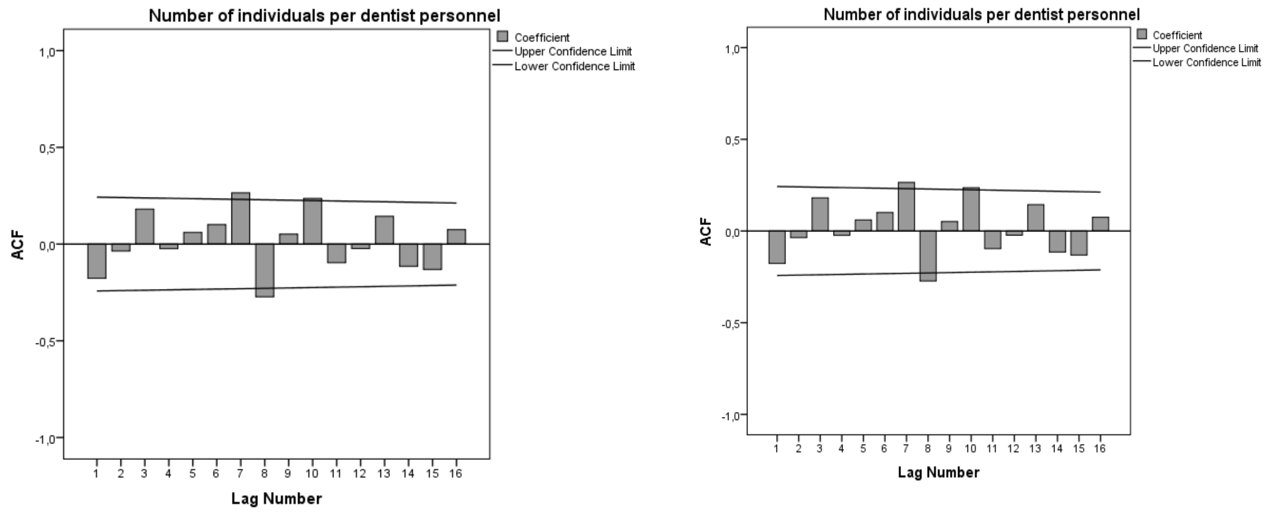

Fig. 4. ACF and PACF graphics of series whose difference is taken belonging to number of individual per dentist personnel

development of health services are the leading among the issues, which the policy-makers are required to emphasize with caution. Institutions and organization which direct the health policies all over the world and/or publish recommendations like World Health Organization (WHO), International Association of Dental Research (IADR), UN, International Federation of Dentistry (FDI) have made numerous emphasis for the increasing importance of oral and dental health services (ADS) among the preventable and contagious diseases from the past to the present day. Nevertheless, Oral and Dental Health Services (ADS) could not draw the necessary attention either in term of presentation and financial opportunities.

As is seen in the country samples, the main reason of this inadequate interest all over the world is caused from losses led by austerity policies sometimes as a result of global financial crises, as in Greece (18). However; it is also known that it has not a vital importance in the context of benefit provided by oral and dental health services' expenses spent for reducing DMFT score in the group of 12 years old [19]. As is in the sample of France, we may find the root cause of the problem as the inability of developing the protective and incentive policies in oral and dental health services before the state and absence of an integrative function of the head of dentistry in France in a similar with Turkey (French Chief Dental Officer) (20-21). The establishment of the organization in such way which will contain the

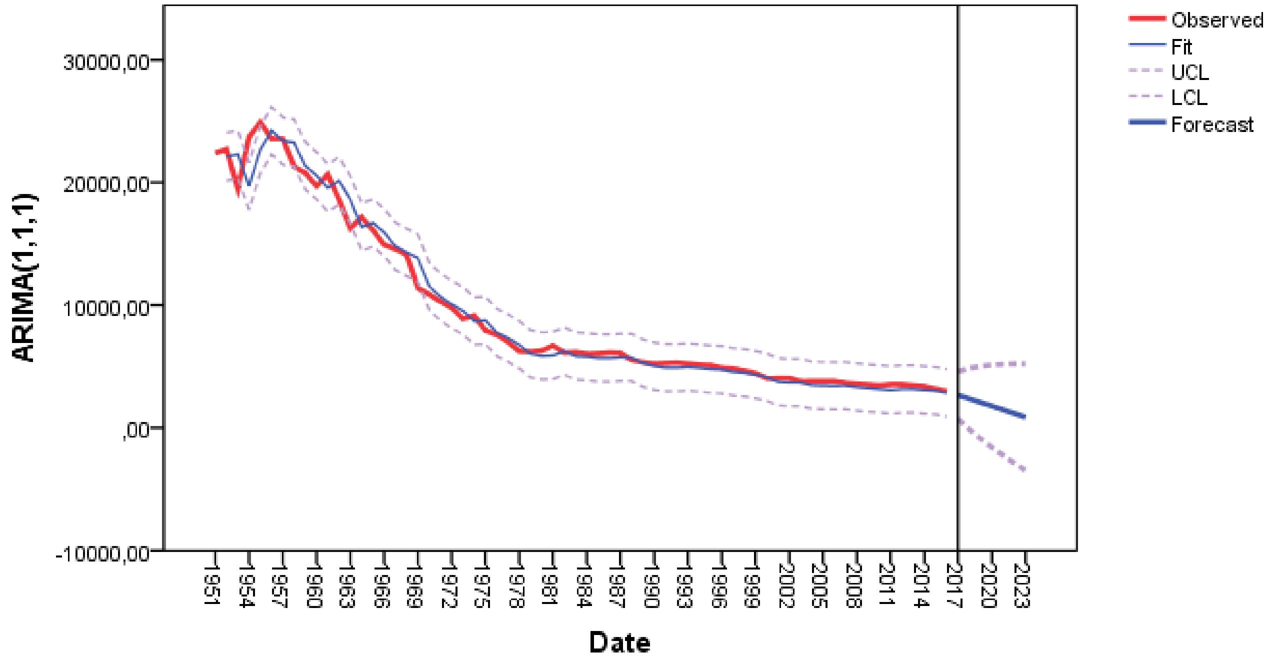

Fig. 5. Forecast graphic of Box Jenkins model for number of indiviual per dentist personnel by years

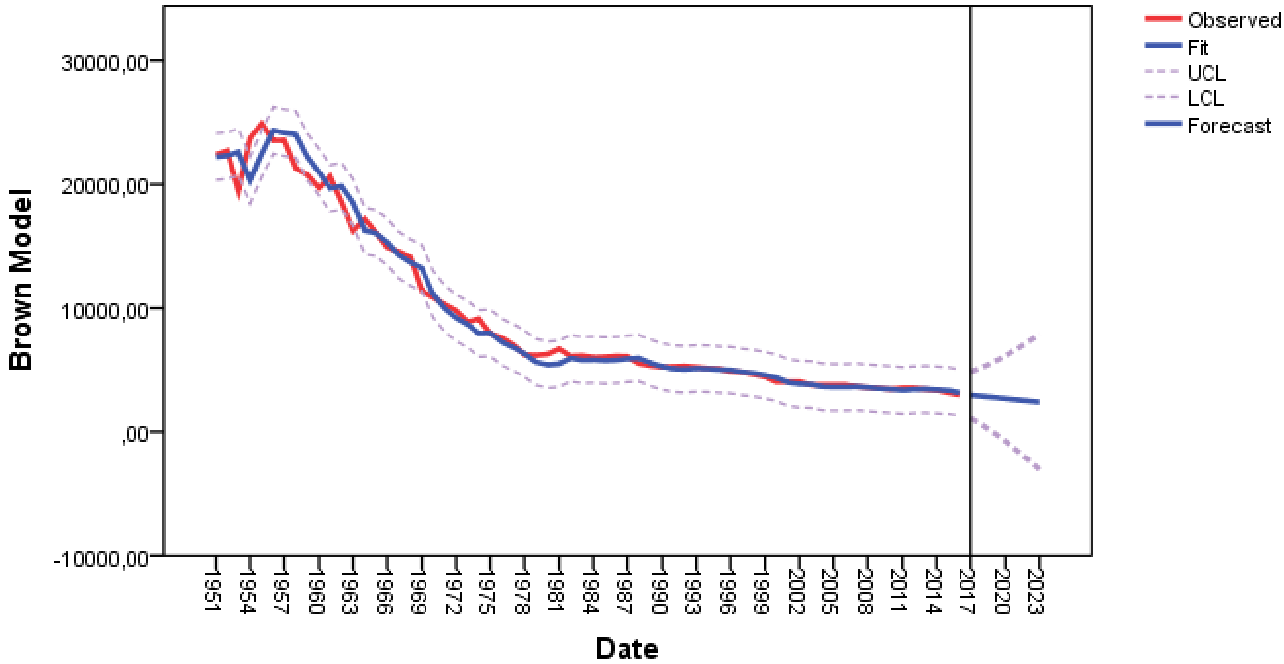

Fig. 6. Forecast graphic of Brown exponential smoothing model of number of patient per dentist personnel by the years

controlling of health expenses, including the cooperation of all shareholder groups of service within the system once the protective measures from diseases are taken (including private sector, as in Scandinavian country samples), appears as the most proper model (19).

Number of potential patient per dentist personnel, which can be used as an important health protection and development indicator for our country, is calculated prospectively in this study and values expected until 2023 are found with Box Jenkins and Brown Exponential Smoothing methods frequently used in making prospective forecasts. Calculations of these two models is compared in terms of decision-making criteria and it is concluded that Brown Exponential Smoothing model produces more coherent results than Box Jenkins model on behalf of making prospective forecasts.

While the importance of oral and dental diseases and struggle with these diseases could not be understood adequately in the world, the existing gap in this field in Turkey should be removed with the realistic state policies immediately. Oral and dental health that is required to be seen as a part of public health should be planned by the socio-economic condition of the society both in delivery of service and finance. While making these planning, epidemiological characteristics of Turkey should be taken into account along with the global health targets which international health organization established and it should be acted in cooperation with non-governmental organizations for common targets.

Acknowledgement: No funds were used during the publication of the article.

Conflict of Interest: The author declares that there is no conflict of interest in terms of financial or otherwise, in the process of the creation of this publication and afterwards.

Data Availability: The data set from which the results were obtained is presented both in the article and at the reference 2, as open access.

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