PalArch's Journal of Archaeology of Egypt / Egyptology

FORECASTING TECHNIQUE TO PREDICT PATIENT VOLUMES IN HOME HEALTHCARE SERVICE

Ghofran Ayed Almohamadi[1], *Marwan M. Lingga*[2]

[1,2] Effat College Of Business, Effat University Qasr Khuzam St.,Kilo. 2, Old Mecca Road.

P.O.Box 34689 Jeddah 21478 Saudi Arabia

Email: [1]gaalmohamadi@effatuniversity.edu.sa, [2]molingga@effatuniversity.edu.sa

Ghofran Ayed Almohamadi, Marwan M. Lingga. Forecasting Technique to Predict Patient Volumes in Home Healthcare Service -- Palarch's Journal of Archaeology of Egypt/Egyptology 18(15), 77-84. ISSN 1567-214x

Keywords: Forecasting Technique, Healthcare Service, Patient Volumes,

ABSTRACT

Health care is essential for the general welfare of society. It provides for the prevention, treatment and management of illnesses and the preservation of mental and physical well-being through the provision of medical and allied health services. Healthcare planning serves a critical role in the institution's capacity to prepare and execute plans to meet the needs of a constantly evolving healthcare system. Thus, in this work, forecasting technique to predict patient volumes in healthcare service in Jeddah were analyzed. This work was conducted based on quantitative research method. The study sample consisted of all hospitals providing home health care services in Jeddah. Three methods of forecasting have been used for comparison in this work. The forecasting methods compared are simple average moving method, double weighted average moving method, and simple exponential smoothing method. In addition, to determine the most accurate method, root mean square error (RMSE) analysis was carried out. The results have shown that simple moving average method had the best accuracy among the other forecasting methods.

CCS Concepts

• Information systems→Database management system engines • Computing methodologies→Massively parallel and high-performance simulations.

INTRODUCTION

Forecasting is a study of the anticipation of future opportunities [1]. It could include taking the verifiable information and anticipating it in the future with some kind of numerical model. There is only one prevalent strategy here and there. What works best in one firm under a lot of conditions could be a

complete misfit in another association, or even in an equivalent branch of a similar firm [2].

Forecasting is one of the first steps in the planning process [3]. The success of the plans depends on the accuracy of the forecasts, for example, in service industries such as hospitals, there are many plans that depend on the forecast, from capacity planning to overall planning, from layout decisions to daily schedules [4]. The error indicators could be used to determine the accuracy of the forecasts after the test of the many methods that fit the test data [4].

Healthcare services (HS) are essential for the general welfare of society [5]. It provides for the prevention, treatment and management of illnesses and the preservation of mental and physical well-being through the provision of medical and allied health services. Healthcare forecasting (HF) involves reliable data, knowledge and effective analytical tools to anticipate specific health issues or scenarios [6]. They also act as a critical component of the scheduling and forecasting system [6].

There are a number of previous works that reported predicting patient volumes. Liu et al. [7] presented a forecast model that enables lung function prediction in patients with scleroderma disease and found that the responsive data technique was able to retrieve patterns of three pulmonary function indicators and to help predict values in an excellent way. Calegari et al. [8] demonstrated work that predicted hospital emergency room visits using a variety of mathematical models and found that seasonal exponential smoothing (SS) was the best way to quantify patient volume in the emergency room. Zinouri et al. [9] presented the work on predicting the volume of surgical cases and found that, with the time series analysis, the number of surgical cases can be predicted and the hospital schedule planning system supported. Hertzum et al. [10] reported a work that predicts patient hourly visits to the emergency department and found that the forecasting model improved overall hospital planning and addressed the crowding issue. Capan et al. [11] demonstrated work on forecasting patient volume for the neonatal intensive care unit and found that the time series model showed good forecast accuracy and efficacy under different test conditions. Zhou et al. [12] examined a number of mathematical models for predicting the volume of hospital admissions and found that all model outputs were comparable to in forecasting inpatient admissions that helped hospital management plan accordingly. Ganguly and Nandi [13] presented a work that used the statistical method for forecasting and optimizing the staff scheduling process at the hospital and found that the scheduling process was improved with the implementation of the forecasting system.

Healthcare forecasting plays a key role in the organization's ability to plan and implement strategies to meet the demands of a rapidly changing health environment [14]. Every decision made by the leader is practically dependent on the accuracy of the information collected. The patient volume forecast study may allow hospital managers to adjust staff levels in the future. Patient volume forecasting has been extensively studied in healthcare services, but most of them focused on very specific conditions and knowledge, and very

minimal research has assessed the use of forecasting technique to predict patient volumes in healthcare services, especially in Saudi Arabia [14]. The problem is that hospital management experience fluctuations in the volume of patients that may be difficult to predict. Thus, this study was done to analyze forecasting technique to predict patient volumes in healthcare service in Jeddah.

METHODOLOGY

For this study, quantitative research method was used. The study sample consisted of all hospitals who provide home health care service in Jeddah. In this work, three forecasting methods were used. The methods are simple moving average method, double weighted moving average method, and simple exponential smoothing method. For the simple moving average method, this method involves calculating the average of observations and then employing that average as the predictor for the next period. The simple moving average method is highly dependent on n, the number of terms selected for constructing the average. The equation is shown as Equation 1 as follows:

Ft+1 = (Yt +Yt-1 +Yt-2 + ……+Yt-n+1)/n	(1)

Where: Ft+1 = the forecast value for the next period, Yt = the actual value at period, and t n = the number of term in the moving average.

For the double weighted moving average method, it requires determining two averages. The first moving average is computed; a second moving average is calculated. In addition, Five equations are used in the double moving average which are stated as follows:

Mt = Ft+1 = (Yt +Yt-1 +Yt-2 + ……+Yt-n+1)/n	(2)
M’t = (Mt + Mt-1 +Mt-2 + ……+Mt-n+1)/n	(3)
At = 2Mt - M ’ t	(4)
Bt = 1 2 n □ (Mt - M’t)	(5)
Ft+p = At + Bt p	(6)

Where: n = the number of period in the double moving average. Yt = the actual series value at time period, p = the number of period ahead to be forecast.

For the simple exponential smoothing method, it uses a weighted moving average of past data as the basis for a forecast. This method keeps a running average of demand and adjusts it for each period in proportion to the difference between the latest actual demand figure and the latest value of the average. The equation for the simple exponential smoothing method is shown as follows :

$F_{t+1} = \alpha Y_t + (1-\alpha) F_{t-1}$	(7)

where Ft+1 = the new smoothing value or the forecast value for the next period, α= the smoothing constant ($0 < \alpha < 1$), Yt = the new observation or

actual value of the series in period t, and Ft = the old smoothed value or forecast for period t.

In this study, the most appropriate forecasting method was selected on the basis of level of accuracy, and the accuracy method that used is root mean square error (RMSE). The equation for RMSE is stated as follows:

1 Σ□ □ n t Yt Ft n	(8)

where Yt = the actual value in time period, t Ft = the forecast value in time period, and t n = the number of periods.

In addition, this work has utilized the trend analysis plot. This plot displays the observations versus time. The plot includes the fits calculated from the fitted trend equation, the forecasts, and the accuracy measures

RESULT AND DISCUSSION

Descriptive Analysis

The descriptive statistics in Table 1 shows the basic number of beneficiaries in Jeddah. The data in Table 1 is used to forecast No of beneficiaries from 2020-2025. Figure 1 shows the trend plot. Based on Figure 1, the trend plot shows the original data, the fitted trend line, and forecasts. The trend model (in red) fits well to the current data (in black), revealing a general upward trend in number of beneficiaries.

Table 1. Basic Descriptive Statistics Of The Dataset

Year	No. of Hospitals	No of beneficiaries
2013	6	1596
2014	6	2222
2015	8	4304
2016	8	5069
2017	7	4271
2018	8.2	5951.5
2019	8.6	6771.2

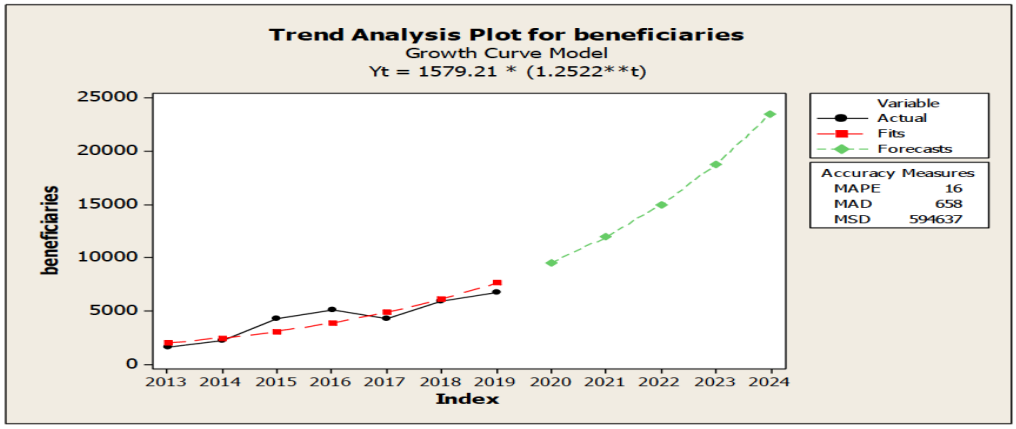

Figure 1. Trend Analysis Plot

Simple Moving Average Method.

This method involves calculating the average of observations and then employing that average as the predictor for the next period. Table 2 shows the result for this method.

Table 2. Simple Moving Average Method

Year	No of beneficiaries
2015	1909
2016	3263
2017	4686.5
2018	4670
2019	4470.5

Double Weighted Moving Average Method

Forecasting with a double weighted moving average requires determining two averages. Table 3 shows the result for this method.

Table 3. Double Weighted Moving Average Method

Year	No of beneficiaries
2015	1971.6
2016	3471.2
2017	4763
2018	4590.2
2019	4462.52

Simple Exponential Smoothing Method

The exponential smoothing method is a technique that uses a weighted moving average of past data as the basis for a forecast. Table 4 shows the result for this method.

Table 4. Simple Exponential Smoothing Method

Year	No of beneficiaries
2015	1590
2016	1591.8
2017	1780.86
2018	2537.802
2019	3297.1614

Evaluation Of Forecasting Methods

In this study, the most appropriate forecasting method was selected on the basis of level of accuracy, and the accuracy method that used is RMSE. Table 5 shows the RMSE values for all three forecasting methods. Based on Table 5, the result showed that the simple moving average method had the best accuracy; because it had small errors. It was therefore chosen as the most appropriate forecasting method for forecasting the number of beneficiaries of health services in Jeddah hospitals.

Table 5. Evaluation Of Forecast Methods

Method	RMSE
Simple moving average method	258.2
Double weighted moving average method	359.3
Simple exponential smoothing method	348.5

OVERALL DISCUSSION

In this study, three methods were used to predict patient volumes in healthcare service in Jeddah. The methods used are simple moving average method, double weighted moving average method, and simple exponential smoothing method. RMSE evaluation analysis was done to determine the most accurate method. Based on the results of RMSE analysis, the result showed that the simple moving average method had the best accuracy among the other forecasting methods. Thus, this method is the most suitable for predicting the number of beneficiaries of health services in Jeddah hospitals. The outcome of this work is inline with the work of Xu et al. [15] where it was confirmed that simple moving average is a good method for forecasting patient volumes. Futhermore, the study of Luo et al.[16] has also found that simple moving average method is accurate for predicting the volume of patient visiting the hospitals.

CONCLUSION

Healthcare forecasting plays a key role in the organization's ability to plan and implement strategies to meet the demands of a rapidly changing health

environment. As long as the productivity of healthcare organizations continues to increase, analysts will seek to apply relevant models to improve the performance of healthcare processes. In this study, three forecasting techniques were analyzed. The findings of this study have shown that simple moving average method had the best accuracy among the other forecasting methods. Thus, this method can be used to predict patient volumes in healthcare service in Jeddah. For future work, the authors recommend the use of other models of descriptive analysis to predict patient volumes in healthcare services.

REFERENCES

Petropoulos, F., Wang, X., & Disney, S. M. (2019). The inventory performance of forecasting methods: Evidence from the M3 competition data. *International Journal of Forecasting*, *35*(1), 251-265.

Yang, X., Pan, B., Evans, J. A., & Lv, B. (2015). Forecasting Chinese tourist volume with search engine data. *Tourism Management*, *46*, 386-397.

Ouyang, Q., & Lu, W. (2018). Monthly rainfall forecasting using echo state networks coupled with data preprocessing methods. *Water resources management*, *32*(2), 659-674.

Gopakumar, S., Tran, T., Luo, W., Phung, D., & Venkatesh, S. (2016, October). Forecasting patient outflow from wards having no real-time clinical data. In *2016 IEEE International Conference on Healthcare Informatics (ICHI)* (pp. 177-183). IEEE.

Abdelaziz, A., Elhoseny, M., Salama, A. S., & Riad, A. M. (2018). A machine learning model for improving healthcare services on cloud computing environment. *Measurement*, *119*, 117-128.

Ho, A. F. W., To, B. Z. Y. S., Koh, J. M., & Cheong, K. H. (2019). Forecasting Hospital Emergency Department Patient Volume Using Internet Search Data. *IEEE Access*, *7*, 93387-93395.

Liu, H., Del Galdo, F., & Houwing-Duistermaat, J. (2018). Prediction and forecasting models based on patient's history and biomarkers with application to Scleroderma disease. *arXiv preprint arXiv:1811.04290*.

Calegari, R., Fogliatto, F. S., Lucini, F. R., Neyeloff, J., Kuchenbecker, R. S., & Schaan, B. D. (2016). Forecasting daily volume and acuity of patients in the emergency department. *Computational and mathematical methods in medicine*, *2016*.

Zinouri, N., Taaffe, K. M., & Neyens, D. M. (2018). Modelling and forecasting daily surgical case volume using time series analysis. *Health Systems*, *7*(2), 111-119.

Hertzum, M. (2017). Forecasting hourly patient visits in the emergency department to counteract crowding. *The Ergonomics Open Journal*, *10*(1).

Capan, M., Hoover, S., Jackson, E. V., Paul, D., & Locke, R. (2016). Time series analysis for forecasting hospital census: Application to the neonatal intensive care unit. *Applied clinical informatics*, *7*(02), 275-289.

Zhou, L., Zhao, P., Wu, D., Cheng, C., & Huang, H. (2018). Time series model for forecasting the number of new admission inpatients. *BMC medical informatics and decision making*, *18*(1), 39.

Ganguly, A., & Nandi, S. (2016). Using statistical forecasting to optimize staff scheduling in healthcare organizations. *Journal of Health Management*, *18*(1), 172-181.

Alomi, Y. A., Alghamdi, S. J., & Alattyh, R. A. (2018). Forecasting the demand of clinical pharmacist workforce in future fifteen years (2016-2030) at all healthcare institutions in Saudi Arabia. *J Pharm Pract Comm Med*, *4*, S92-S96.

Xu, Q., Tsui, K. L., Jiang, W., & Guo, H. (2016). A hybrid approach for forecasting patient visits in emergency department. *Quality and Reliability Engineering International*, *32*(8), 2751-2759.

Luo, L., Luo, L., Zhang, X., & He, X. (2017). Hospital daily outpatient visits forecasting using a combinatorial model based on ARIMA and SES models. *BMC health services research*, *17*(1), 469.