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Modelling The Attendance of Patients to KlinikRawatanKeluargaPergigian (KRKG)Hospital UniversitiSains Malaysia (Hospital USM) with the Seasonal ARIMA Model

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Abstract— The present study aims to determine the trend of patient attendance pre- and post-COVID-19 pandemic at the outpatient dental clinic of Hospital UniversitiSains Malaysia (Hospital USM), Kelantan, Malaysia. This is a retrospective study. This paper, in retrospect, reviews the total number of patients seeking treatment at the dental outpatient clinic, Hospital USM, with interest in the trends of patient attendance from 2017 (pre-pandemic) to 2020 (post-pandemic of COVID-19). Data were collected from the monthly total patient registry from the dental services department of Hospital USM. The IBM SPSS Version 26.0 was used for trend analysis. Meanwhile, the Minitab software determines the trendline of patient attendance and the Seasonal ARIMA analysis predicts the patient attendance for the following year. The analysis found that the year 2020 decreased in trend due to the global coronavirus pandemic. According to the seasonal trend from 2017 to 2020, the SARIMA $(0,0,0)$ $(1,1,1)_{12}$model was selected. For 2021, the prediction value is performed monthly. This 30-day period is essential for further preliminary actions by the Hospital USM in planning the strategy to handle patients efficiently during the COVID-19 post-pandemic.The patient attendance is represented in the Seasonal Autoregressive Integrated Moving Averages (SARIMA). The coefficient for SARIMA was significant, indicating that this proposed model is a superior method.

Keywords: COVID-19, Seasonal ARIMA, dental attendance, dental clinics, health behaviour

1. Introduction

The world was devastated by the emergence of a novel coronavirus, also known as SARS-CoV-2. A virus which was believed to originate from Wuhan, China, since the end of December 2019 [1, 2].In months, the virus has led to a global outbreak, urging the World Health Organization (WHO) to announce a pandemic [1].

In Malaysia, the first half of March 2020 saw the first 41 cases from COVID-19 [3],which led to a Movement Control Order, effective on March 18, 2020 [4].The limitation of movement of essential and non-essential services forced many sectors to fine-tune their jobs to minimize direct contact. However, not all sectors were able to change working patterns, in particular, health care services. Dentistry is categorized under the health care sector.

On May 18, 2020, the Oral Health Division from the Ministry of Health, Malaysia announced that all elective dental treatment must be postponed immediately. Only urgent dental needs that meet the criteria of emergency dental cases are allowed to be attended after strict patient triage [5].Understandably, restrictions were placed due to the operational nature of dental practices such as near-proximity to Oro-nasal regions involving saliva and blood contaminants, creation of aerosol, and droplet contacts. These situations are considered probable transmission routes for COVID-19 [6].Even before this guideline was enforced, many dental clinics independently decided to halt their premises in concern of an increased risk of affection or transmission of COVID-19.

KlinikRawatanKeluargaPergigian (KRK-G) is an outpatient dental clinic which is part of a tertiary hospital, Hospital UniversitiSains Malaysia (Hospital USM), situated in Kubang Kerian, Kelantan, Malaysia. KRK-G is a primary dental care department, which operates during weekdays between the hours of 8.00 am–1.00 pm as walk-in for adults only and from 2.00pm – 5.00pm for appointment basis. Dental services in this hospital provides a variety and comprehensive dental treatment through dental specialist's clinics namely Restorative Dentistry, Orthodontics, Oral Pathology, Oral and Maxillofacial Surgery and Peadiatric Dentistry.

The current article is to determine the trend of patient attendance pre- and post-COVID-19 pandemic at the outpatient dental clinic. The article explores modelling of dental patient attendance for prediction of patients for the following years.

2. Material and Methods

The study was carried out retrospectively by examining the dental records of KlinikRawatanKeluargaPergigian (KRKG), UniversitiSains Malaysia (USM), Kelantan, Malaysia from January 2017 to October 2020. All related variable is being collected and summarized in Table 1.

Table 1: Attendance of Patients to KlinikRawatanKeluargaPergigian (KRKG) From the Year 2017 till the Year 2020

Month	The Year 2017	The Year 2018	The Year 2019	The Year 2020
January	805	1022	946	878
February	816	842	847	789
March	890	753	856	554
April	902	926	955	205
May	925	680	552	265
June	438	594	580	581
July	1040	1034	1015	689
August	955	801	775	697
September	692	711	710	819
October	778	863	1059	516
November	768	569	672	-
December	955	965	952	-

3. Methodology

In this paper, we used two main methodology approach, which was divided into Phase I and Phase II of data analysis. The detail of the analysis is given as follows.

3.1 Part I: Linear Trend Analysis

The aim of the linear trend analysis is to impose a line of best fit to time series data [7, 8].Linear trend is a simplistic forecasting technique that can be used for prediction purposes. A general linear trend pattern can be described by the equation as follows:

$$T_t = \alpha + \beta t + \varepsilon_t \quad (1)$$

where

$T_i$is the value of the dependent variable (or the trend value) at time t,

α and β are known intercept and slope parameters respectively, to be estimated, and

ε_i is the error term usually assumed identically, independently, and normally distributed with mean zero and variance σ_e^2.

3.2 Part II: Seasonal ARIMA

Box-Jenkins methods is the best model to forecast the trend of time series data, which is based on a special linear statistical model known as ARIMA (Autoregressive Integrated Moving Averages) [8].ARIMA is one of the most widely used with trends, but it does not support time series with seasonal components. An extension to ARIMA that supports the direct modeling of the seasonal trend of the series is called SARIMA. To handle the case with the seasonal component, the SARIMA method is being applied. In this paper, the Seasonal ARIMA (known as SARIMA) procedure was selected with seasonal difference order 1. In general, the seasonal difference of order D as

$$\nabla_h^D X_t = \left(1 - B^h\right)^D X_t \quad (2)$$

where D =1, 2 ... Usually D = 1 is sufficient to obtain seasonal stationarity. This leads to a very general seasonal autoregressive integrated moving average (SARIMA) model written as follows

$$\Phi\left(B^h\right)\varphi\left(B\right)\nabla_H^D \nabla^d X_t = \alpha + \Theta\left(B^h\right)\theta\left(B\right)Z_t \quad (3)$$

And denoted by ARIMA (p, d, q) × (P, D, Q) $_h$. The obtained model from the analysis is SARIMA(0, 0, 0) × $(1, 1, 1)_{12}$. Using the formula in (2), the equation for the SARIMA estimation can be shown as

$$(1 - B^{12})\, X_t = (1 + \Theta B^{12})\, (1 - \Phi B^{12}) Z_t$$

when expanded, we get the following form

$$X_t - B^{12}X_t = [1 - \Phi B^{12} + \Theta B^{12} - \Theta\Phi B^{24}]\, Z_t$$
$$X_t - B^{12}X_t = Z_t - \Phi B^{12} Z_t + \Theta B^{12} Z_t - \Theta\Phi B^{24} Z_t$$

Therefore, the final model for estimation can be summarized as

$$X_t = B^{12}X_t + Z_t - \Phi B^{12} Z_t + \Theta B^{12} Z_t - \Theta\Phi B^{24} Z_t \quad (4)$$

4. Results

The analysis was divided into two phases, Phase I and Phase II. In Phase I, data was analysed based on the trend analysis according to year, starting from the year 2017 till the year 2020. Meanwhile, in Phase II data was analyzed through the nonlinear modeling procedure using Seasonal ARIMA.

4.1 Part I: Linear Trend Analysis

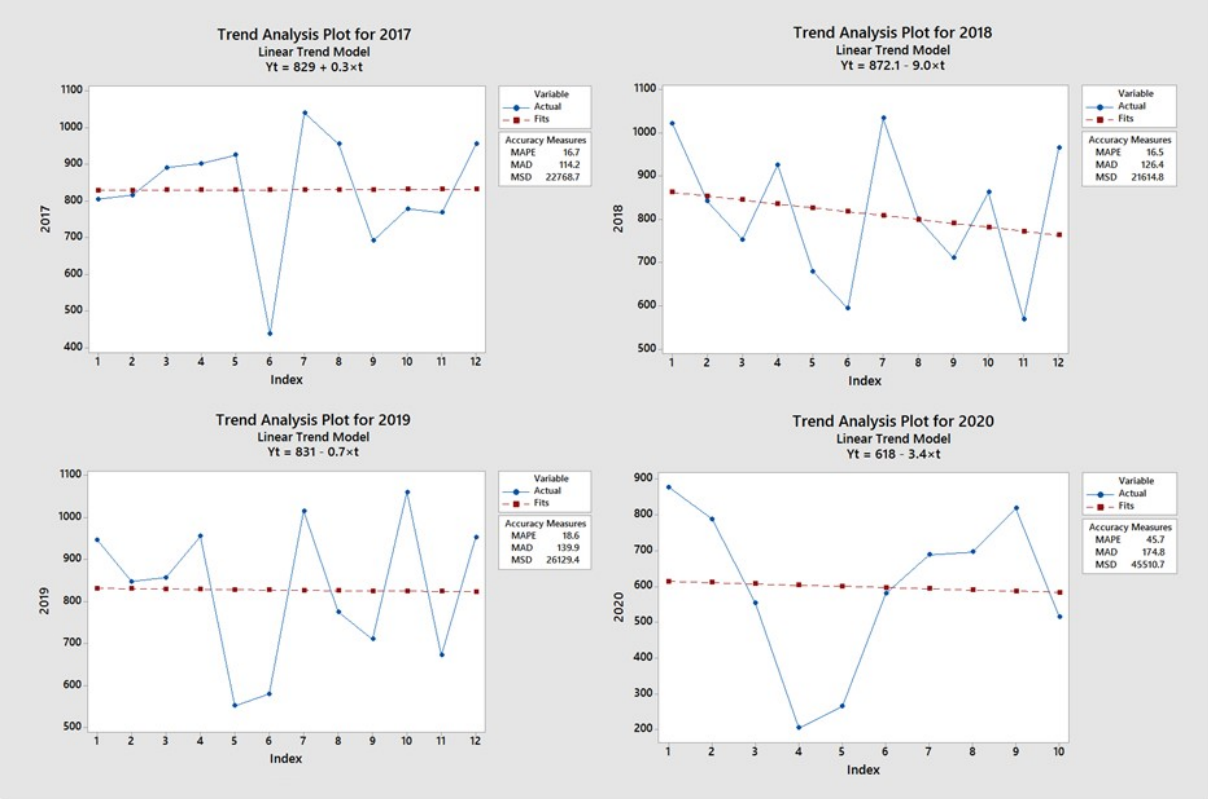

Figure 1: Trend analysis for the year 2017 until year 2020

Figure 1 shows the Trend analysis for the year 2017 until year 2020 had shown that there is a statistical significance of nonlinear trends was identified using the linear trend model. The linear model does not seem to be adequate for the prediction purposes.The overall trend for the attendance of patients to KRKG is upward and downward trends. This does not support the linear trendline for the modeling purpose. The value of Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), and Mean Square Deviation (MSD) is higher, this indicates that the fitting of trendline for each year is not adequate. It was observed that the nonlinear modeling perhaps much better to represent the trend of this time series values.

4.2 Part II: Seasonal ARIMA

In this phase, all the data was combined in single data with the seasonal trend. By plotting the data, the seasonal characteristic can be seen clearly at every twelvemonth. By differencing once and considering the model of SARIMA $(0,0,0)(1,1,1)_{12}$, it was found that the coefficient for Seasonal Autoregressive and Seasonal Moving Averages was found to be significant and adequate for the prediction purposes. From the model obtained, the projection of the value is being estimated up to twelve observations. Figure 2 shows the forecasting value for the year 2021.The trend for the year 2021 seems to be slightly lower compared to the year 2017, the year 2018, and the year 2019 but slightly higher compared to the year 2020.

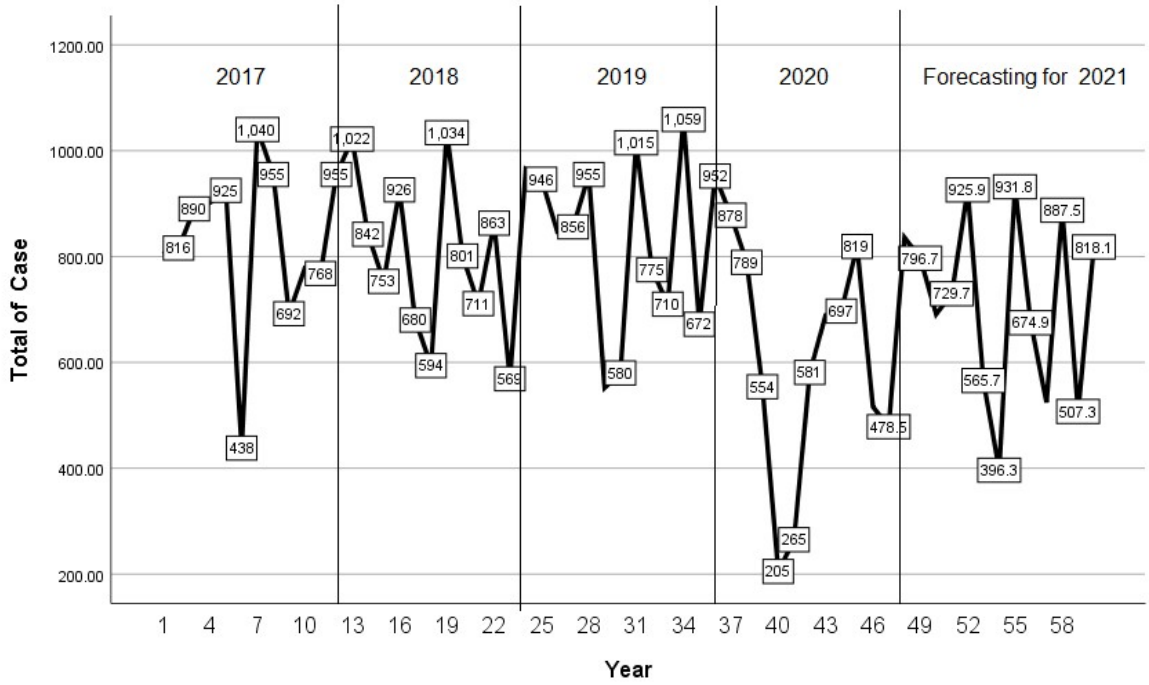

Figure 2: Trend analysis for the year 2017, 2018, 2019, 2020 and the prediction for the year 2021 using SARIMA $(0,0,0)(1,1,1)_{12}$

Figure 2 shows the trends from the year 2017 to the year 2020 and the forecasting part for the year 2021 using the model SARIMA $(0, 0, 0) \times (1, 1, 1)_{12}$. Using model SARIMA $(0, 0, 0) \times (1, 1, 1)_{12}$ the value of forecasting value is given as follows.

				95% Limits	
Period	Year	Num	Forecast	Lower	Upper
November	2020	47	478.45	188.54	768.36
December	2020	48	835.82	545.92	1125.73
January	2021	49	796.71	506.80	1086.61
February	2021	50	690.93	401.02	980.83
March	2021	51	729.74	439.84	1019.65
April	2021	52	925.89	635.98	1215.80
May	2021	53	565.66	275.76	855.57
June	2021	54	396.30	106.39	686.20
July	2021	55	931.80	641.90	1221.71
August	2021	56	674.93	385.02	964.83
September	2021	57	524.26	234.36	814.17
October	2021	58	887.54	597.63	1177.45
November	2021	59	507.27	190.72	823.82
December	2021	60	818.12	501.58	1124.67

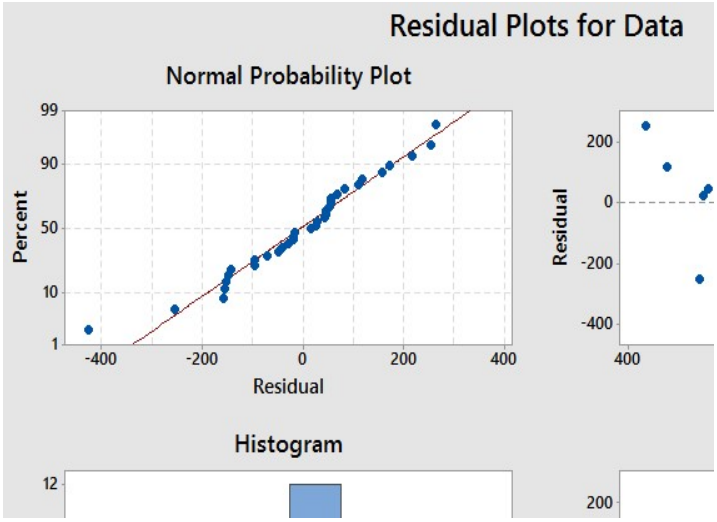

Figure 3: Residual plot for the model adequacy

Figure 3 shows the residual plots for data. A residual plot is a graph that is used to examine the goodness-of-fit in the Seasonal ARIMA model. Examining residual plots helps to determine the assumptions are being met or not. If these assumptions are satisfied, then the proposed model will produce unbiased coefficient estimates with the minimum variance. It was observed that i) **Histogram of residuals:** Data are not skewed, and no outliers exist in the data. ii) **Normal probability plot of residuals:** assumption that the residuals are normally distributed is met. iii) **Residuals versus fits:** assumption that the residuals have a constant variance is met. iv) **Residuals versus the order of data:** the residuals are uncorrelated with each other.

5. Summary and Discussion

This current paper is applied Seasonal Autoregressive Integrated Moving (SARIMA) to determine the trend of patient attendance pre-pandemic and post-COVID-19. SARIMA is the best model to handle the presence of a seasonal pattern. Pre-processing data is applied by using regular differencing (d=1) to convert non-stationary series to stationary series. Data from the year 2017-2020 were used by researchers in this study. Referring to Figure 2, SARIMA $\sqrt{(0,0,0)(1,1,1)_{12}}$ the model can be considered as the power of effective forecasting the trend of patient attendance pre-pandemic and post-COVID-19 for the year 2021. The sample forecast data from the year 2017 to 2020 follows closely the actual data.

Any country's dental visiting is influenced by their economic factors [9].The increasing price of dental treatment may delay the poor income group from seeking their dentist. The richer group may have knowledgeable reasons such as cosmetic for dental treatment. The role of government is important in helping the citizen in getting their oral care. The presence of pre-condition of any health disease may increase the knowledge about dental care. A condition such as pre-diabetic group which affects the teeth prompts a patient to seek their dentist for early care [10].Awareness of the disease complications is the important reason that increases dental visiting. The poor hygiene of the oral region may prompt the medical doctor to refer their dental patient [10].The role of the dentist in preventing damage to the oral region in any disease is important in preventing further complications [11].Besides that, any disease group also needs more knowledge and awareness about the impact of their disease on the teeth and mouth.

In other conditions such as dental trauma, the patient is forced to be attended by the dentist [12].The facial and dental emergency visits due to trauma are crucial in maintaining the patient's appearance. Nevertheless,

patients may experience psychological disturbances such as anxiety which influences dental visiting [13].Future reduction of anxiety toward dental procedures such as needle phobia and teeth drilling is very important [14].

However, the dental checkup is influenced by factors such as COVID 19 pandemic which marks the reduction for dental visiting (Figure 1). This may be due to fear of the virus which delays the reason for oral checking. A trend like this year's reduction is predicted to continue in the future (Figure 2). In this pandemic, the health condition of the patient is monitored first which includes the changes in the protocol of dental, which influence the decision for reschedule or acceptance for treatment [15].Moreover, protection measures by the dentist influence the perception of the patient such as usage of disposable coat, disposable mask, and preparing alcohol gel in the reception area [16].Conversely, a proper protocol gives more confidence in the patient to visit the dental clinic.

6. Conclusion

The trend of pre-and post-COVID 19 showed a reduction in the number of patients attending the outpatient dental clinic of the Hospital USM. The future trend is predicted toward a lower trend than the pre-COVID period.

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