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Forecasting of Paracetamol Demand in UMMC Pharmacy

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ABSTRACT

Pharmaceutical inventory management is a critical operation in healthcare centres. This is due to the fact that most pharmaceutical products are perishable. Managing the inventory of perishable items can be a complicated process as the healthcare industry needs to maintain a high level of services. In order to manage the inventory of pharmaceutical products, it is important to forecast the demand, which will enable the distribution to be planned and scheduled effectively. In this research, we focus on one fast moving medicine which is paracetamol that commonly used to treat fever and pain across all ages group of patients. Data is obtained from University Malaya Medical Centre (UMMC) for the year 2017-2020. Before applying the forecasting techniques, the data pattern needs to be identified. Among the five forecasting techniques are Additive Decomposition Method, Multiplicative Decomposition Method, Simple Exponential Smoothing and Adaptive Response Rate Exponential Smoothing. The performance of these techniques was evaluated based on four error measurements; (i) Mean Absolute Deviation, (ii) Mean Squares Error, (iii) Mean Percentage Error and Mean Absolute Percentage Error. Multiplicative Decomposition method displays the lowest values of error measurements which indicates the greatest accuracy and implies the suitability for this research. The data predicts that the demand for paracetamol will likely continue to move downwards over the next five years.

Keywords: pharmaceutical, perishable, inventory, medicine, sustainable healthcare management

INTRODUCTION

Sustainable management of the healthcare industry is critical in ensuring the wellbeing of the human race. This issue has come into the limelight in the year 2020, where we see the collapse of healthcare system in some countries due to the sudden spike in demand for healthcare services during the inception of the COVID-19 pandemic. Although this pandemic is an unprecedented event, future pandemic should be expected to occur more frequently due to rapid changes in the environment, development, deforestation, and lifestyle. Thus, the development of an agile and sustainable healthcare management should become a priority.

Among the important factors of healthcare management is pharmaceutical products inventory management. [1] developed a model that enables more synchronization between an inventory system and its operation feeders. Their main intention is to minimize operation costs, while simultaneously providing lean services and reducing wastage of resources. Similarly, [2] also modelled an efficient inventory

management, though his work is specifically focused on resources for the COVID-19 pandemic. [3], [4], and [5] have utilized the digitalization era and used the internet of things (IoT) to ensure that product inventory can be accessed and monitored in real time. This effort will improve the speed of response for replenishing medicine stock.

Nevertheless, wastage of resources is a big issue in inventory management. Pharmaceutical sources of waste include expired drugs, drugs discarded by patients, and manufacturing waste. These wastes may be non-hazardous, hazardous even cytotoxic. Pharmaceutical wastes cannot be disposed of freely in landfills, and need to go through proper standardized method of disposal. A report by UK Water Industry Research in 2014, found that the presence of common drugs in most of its 160 sewage treatment plants under study, with concentrations high enough to affect the ecosystem [6]. In Brazil, [7] also found that the presence of diclofenac and paracetamol in sewage water treatment as well as in the Beberibe river, where the concentration is the highest during draughts. This issue is shared globally including in Mexico [8] India [9] 2021, USA [10] and China [11] to name a few.

As paracetamol is a common drug and readily available in the market, it is natural to investigate closely on the demand for this particular drug. [12] proposed a supply chain management particularly for this drug, while [13] predicted the need for two popular drugs, i.e., captopril and paracetamol in a hospital in Indonesia.

By monitoring the actual demand for this drug, only the required amount of stocks would be prepared at any given time. This practice will ensure the reduce of medical waste, thus enable better resource allocation, reduce the cost of product procurement, and improve the sustainability of medical waste management to improve the overall ecosystem on earth. In this study, we aim to improve understanding of demand for paracetamol in UMMC Pharmacy for better management in their generic drugs inventory, in particular paracetamol.

METHODOLOGY

Data Collection

A set of data of paracetamol tablet demand from the year 2017 to 2020 was collected for this study. Data was obtained from University Malaya Medical Centre (UMMC). It represents the stock movement of tablet paracetamol kept by Pharmacy Main Store of UMMC.

Forecasting Techniques

Four forecasting techniques for stationary pattern were used. The techniques are Additive Decomposition Method, Multiplicative Decomposition Method, Simple Exponential Smoothing (SES) and Adaptive Response Rate Exponential Smoothing (ARRES). To evaluate the performance of the techniques, four error measurements were used which are (i) Mean Absolute Deviation (MAD), (ii) Mean Squares Error (MSE), (iii) Mean Percentage Error (MPE) and (iv) Mean Absolute Percentage Error (MAPE).

RESULT AND DISCUSSION

Data Pattern

By using Microsoft Excel, plot *yt* (Total Demand of tablet) versus *t* (Time) was used to determine the pattern of tablet paracetamol demand (Figure 1). Figure 1 shows the stock movement which is not in a fixed frequency. The plot displays movement of rises, and falls from January 2017 until July 2020 indicates that the data has a stationary pattern.

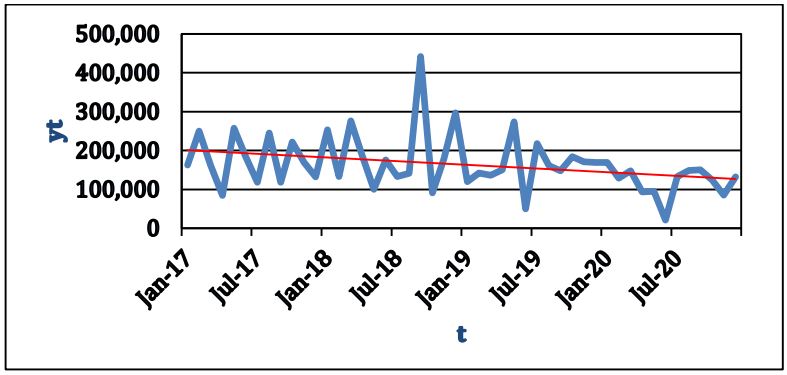

Figure 1: Line Graph of Actual Total Demand versus Time

Autocorrelation

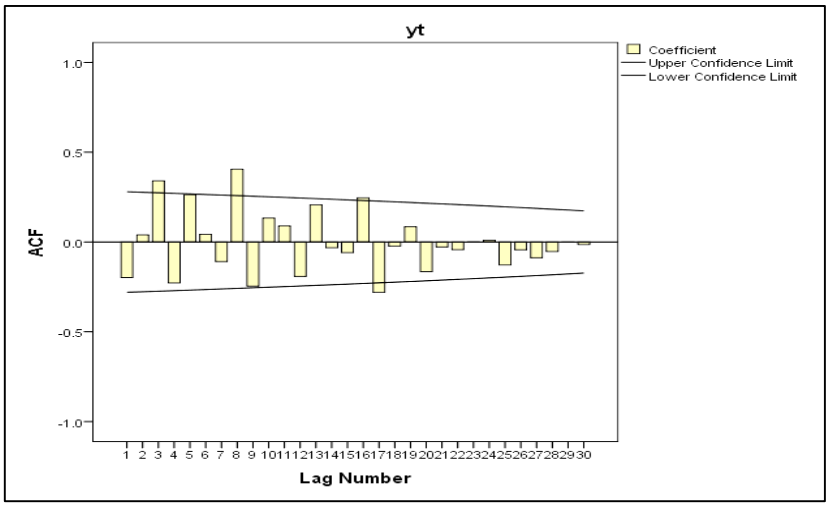

Figure 2: Autocorrelation Function Plot

Based on Figure 2, the autocorrelation function shows that this data has stationary trend. This is because the time series plot does not indicate graphic trend and the plot autocorrelation is not decrease gradually.

Techniques for stationary pattern

In this research, four forecasting techniques for stationary pattern were used: (i) Additive Decomposition Method, (ii) Multiplicative Decomposition Method, (iii) Simple Exponential Smoothing (SES) and (iv) Adaptive Response Rate Exponential Smoothing (ARRES). The performance of these techniques was evaluated based on four error measurements; (i) Mean Absolute Deviation (MAD), (ii) Mean Squares Error (MSE), (iii) Mean Percentage Error (MPE) and (iv) Mean Absolute Percentage Error (MAPE). The best technique was selected based on the least evaluation of error measurement, that is, minimum values of MAD, MSE, MPE or MAPE. Table 1 represented the error measurement for evaluation.

Table 1: Error measurements for evaluation

Method	MAD	MSE	MPE	MAPE
Additive Decomposition	48700.267	3420679606	-0.6315	0.6743
Multiplicative Decomposition	46727.737	3162048804	-0.6375	0.6662
Simple Exponential Smoothing	48896.531	3844670413	-0.9230	0.9243
ARRES	49359.154	3899023145	-0.9294	0.9302

As shown in Table 1, Multiplicative Decomposition has the lowest error measurements for MAD, MSE and MAPE which recorded 46727.737, 3162048804 and 0.6662, respectively. While on the other hand, the lowest error measurement for MPE was obtained by Additive Decomposition which the value is 0.6315. However, after comparing the overall performance of anticipated techniques which was based on the measurements error, Multiplicative Decomposition method displays the lowest values of error measurements which indicates the greatest accuracy and implies the suitability for this research.

Forecasting Paracetamol Demand

Based on the results, after evaluating and comparing the four forecasting techniques, Multiplicative Decomposition has been chosen as the best method to forecast the demand of paracetamol in the next five years. Table 2 shows the results of forecast demand of paracetamol for 2021 to 2025. Overall, the demand fluctuate from month to month, even though the number of paracetamol demand is decreasing from 2021 to 2025. The lowest demand of paracetamol is in June for the next five years.

Table 2: Forecast demand of paracetamol for 2021 to 2025

Year	Month	Forecast Value	Year	Month	Forecast Value	Year	Month	Forecast Value
2021	1	165221	**2022**	1	153662	**2023**	1	122637
	2	120257		2	111794		2	103332
	3	179031		3	166358		3	153685
	4	145834		4	135450		4	125066
	5	165987		5	154098		5	142208
	6	93490		6	86753		6	80016
	7	102953		7	95489		7	88026
	8	161758		8	149960		8	138162
	9	232112		9	215079		9	198046
	10	128336		10	118860		10	109385
	11	141974		11	131426		11	120879
	12	174951		12	161872		12	148794

2024	1	130544	**2025**	1	118985
	2	94869		2	86407
	3	141013		3	128340
	4	114681		4	104297
	5	130318		5	118428
	6	73279		6	66542
	7	80562		7	73098
	8	126364		8	114566
	9	181013		9	163980
	10	99909		10	90434
	11	110331		11	99784
	12	135716		12	122637

Based on Table 2, the results presented that the forecasted value for September shows the highest demand for paracetamol in five years prediction from 2021 to 2025. This decision is influenced by a dramatic increase in paracetamol demand showed in past years specifically in September 2018. The paracetamol demand of 442000 tablets were recorded in that particular year. The reason of this higher demand in

September still under investigation. However, though September has been forecasted to has the highest demand, the data shows that the demand for paracetamol will likely to continue moving downwards over the next five years which is based on the prediction done in this study. This flow of demand is illustrated in Figure 3.

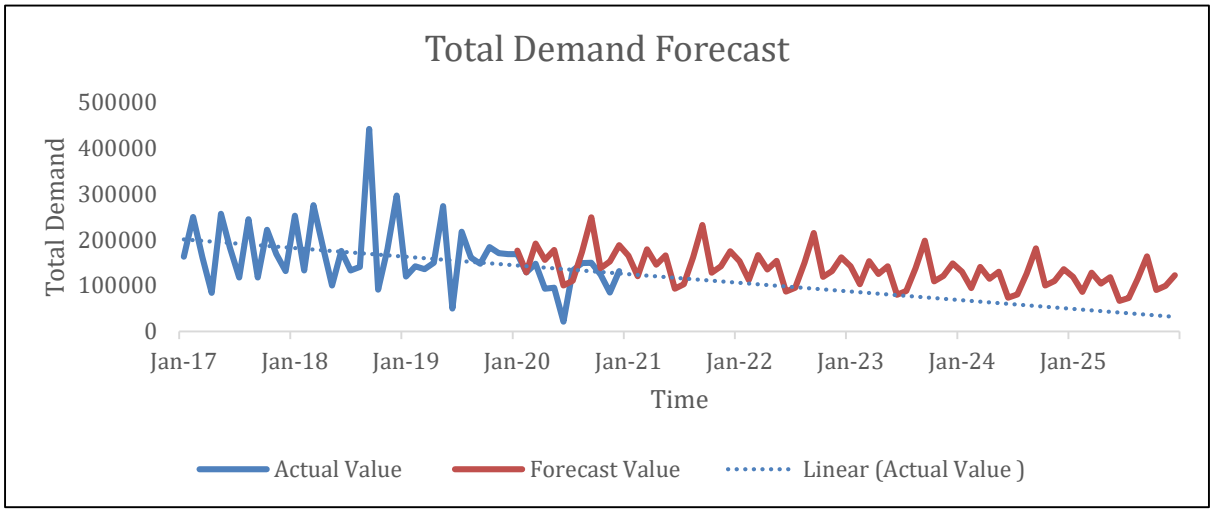

Figure 3: Actual and forecast paracetamol demand from 2017 - 2025

CONCLUSION

This research is to study the demand pattern for paracetamol for the next five years. This study analyzes seasonal and trend pattern in monthly demand of paracetamol at UMMC Pharmacy. Multiplicative decomposition was identified as the best model to forecast the paracetamol demand for the next five years which is from 2021 to 2025. The forecast values were based on the analyses of 36 months' data (2017-2020). The result presented that the forecast value for September has the highest demand of paracetamol in five years prediction. The data also shows that the demand for paracetamol is likely will continue to move downwards over this five year ahead prediction. This model is therefore could be a limelight for deep investigation on the paracetamol demand and appropriate to forecast demand values in the catchment which can help UMMC Pharmacy to plan their medicine inventory in the future.

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