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Forecast of Number of Malaria Cases in Ligula Referral Hospital in Mtwara, Tanzania

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ABSTRACT

Based on SMA model, the forecast of number of Malaria cases in Ligula Referral Hospital in Mtwara have been analyzed. The study employed data of LRRH Statistics office from 2013 to 2021. The findings revealed that 3 – years SMA model (with error of 10%) was better than 5 – years SMA model (with error of 14%) in forecasting the number of malaria cases at LRRH. Furthermore, the result showed a slight decrease in number of malaria cases at LRRH for the next two years, that is 2022 and 2023. The number of malaria cases may decrease by 12% and 5% in 2022 and 2023 respectively. This being the case, the government and other stakeholders should put much effort in ensuring there is significant decrease in number of malaria cases.

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Malaria is a mosquito-borne disease caused by Plasmodium parasites and transmitted by Anopheles species mosquitoes [1]. Globally, the latest report indicates that the number of malaria cases is increasing. There were an estimated 241 million malaria cases in 2020 compared to 227 million cases in 2019 – an increase of about 14 million cases. About 95% of all malaria cases were in the African Region. The total number of malaria cases in 2020 is essentially the same as that reported in the year 2000. However, over this 20-year period, the population at risk of malaria in sub-Saharan Africa nearly doubled [2].

According to [10], Tanzania is undergoing an epidemiological transition for malaria transmission with some areas of the country having less than 10% (hypoendemic) and other areas greater than or equal to 10% malaria prevalence (mesoendemic) [3]. report asserts that major decline in malaria prevalence has been witnessed in Tanzania [4]. Malaria prevalence among children under the age of five has declined more than 50%, from 18.1% in 2007 to 7.3% in 2017. Importantly, some regions such as Arusha and Manyara have reached a prevalence of less than 1%, while in other regions prevalence has remained high at greater than or equal to 10%. According to the global malaria strategy requires stratification of such areas to target effective malaria interventions [5]. However, the majority (96%) of the population in Tanzania mainland is still at risk for malaria infection [6].

Eradicating or reducing the number of patients with malaria cases is connected to decision making. One of the crucial issue in decision making related to malaria cases is identifying in advance the number of malaria cases or deaths caused by malaria. Prediction of malaria cases or deaths due to malaria have been done using various techniques. For instance [7], used monthly incidence data collected from five states in Sudan with unstable malaria transmission to develop applicable and understood time series models and to find out what method can provide better performance to predict future incidences level. They tested four methods of the forecast namely, autoregressive integrated moving average (ARIMA); exponential smoothing; transformation model; and moving average. The result showed that transformation method performed significantly better than the other methods for Gadaref, Gazira, North Kordofan, and Northern, while the moving average model performed significantly better for Khartoum [3], used Genelized linear models, Poisson and negative binomial regression models to model the Data malaria incidence in Apac district in Uganda. These models were used to fit monthly malaria incidences as a function of monthly rainfall and average temperature. Negative binomial model provided a better fit as compared to the Poisson regression model. The Pearson correlation test indicated a strong positive association between rainfall and malaria incidences [9]. ARIMA model to forecast malaria surveillance in India. They found that the model was highly effective and significant in prediction of future epidemiological surveillance of malaria in India.

Ligula Regional Referral Hospital (LRRH) is largest hospital in Mtwara which receives people with malaria cases both from Outpatient Department (OPD) and Inpatient Department (IPD). The data of malaria cases at LRRH from 2013 to 2021 do not show either increasing or decreasing pattern (LRRH Statistics Office, 2022). This means that in order to be able to make decision on effort to be put in place to reduce or eradicate the number of malaria cases using data from LRRH, it is important to forecast the trend in future using the same data. This may be done by modeling the same data using statistical techniques. This study intends to predict the number of malaria cases for both OPD and IPD at LRRH using moving average methods. The reason for selecting

moving averages method is to filters out the noise from random data fluctuations, which provide a better prediction of the trend. To the best level of my understanding no studies which have been conducted in Mtwara region using moving average methods to predict the number of malaria cases in Ligula Hospital.

Materials and Methods

Collection of Data

The secondary data used in this study were collected from Statistics office of Ligula Hospital in Mtwara region. The data included malaria cases for both Outpatient and Inpatients Departments of Ligula Hospital from 2013 to 2021. The data collected from Statistics office of Ligula Hospital is shown in Table 1.

Table 1: The Number of Malaria Cases at LRRH from 2013 to 2021

Year	Malaria cases (IPD)	Malaria cases (OPD)	Total
2013	729	226	955
2014	1218	1371	2589
2015	1231	37	1268
2016	1302	456	1758
2017	1020	177	1197
2018	758	611	1369
2019	630	761	1391
2020	537	779	1316
2021	443	1086	1529

Source: LRRH Statistics Office (2022).

Study Area

LRRH was officially opened on 14/10/1964 by the First President of the United Republic of Tanzania, the late, Mwalimu Julius Kambarage Nyerere and is found in Mtwara region. The hospital serves as a referral hospital for all hospitals in the Mtwara region with a total population of about 1,451,078 million. However, the majority of these patients come from Mtwara and Mtwara Rural Municipal Councils where these Councils do not have district hospitals. At present the hospital has a capacity of 241 beds (bed capacity), the bed occupancy rate is 36% and the average hospital stay (Average length of stay) is 4 days [10].

Moving Average Methods

A moving Average (MA) is a time series constructed by taking averages of several sequential values of another time series. It is a type of mathematical convolution [11]. Though, there are numerous MA methods, in this study Simple Moving Average (SMA) methods were employed.

Simple Moving Average

The SMA is a forecasting method where all the weights of recent actual value used for the forecasting are equal. Generally, SMA is given by the formula:

$$SMA = \frac{\text{Total demand for a certain number of recent data}}{\text{Number of data}}$$

The simple moving average is represented in the following form:

$$F_{t+1} = \frac{X_t + X_{t-1} + X_{t-2} + \cdots + X_{t-n+1}}{n}$$

Where, F_{t+1} is a forecast for the next period t+1
n are a number of periods to be averaged

$X_t+X_{t-1}+X_{t-2}+\cdots+X_{t-n+1}$ are the actual values for the past period, two periods ago, three periods ago and so on, respectively.

The Model

The appropriate model to capture the malaria cases data at LRRH was developed by using Microsoft Excel and SPSS. The formula for 3 –years MA and 5-years MA used are as shown in equation (1) and (2) respectively;

$$F_{t+1} = \frac{X_t + X_{t-1} + X_{t-2}}{3} \quad (1)$$

$$F_{t+1} = \frac{X_t + X_{t-1} + X_{t-2} + X_{t-3} + X_{t-4}}{5} \quad (2)$$

The Simple Moving Average (SMA) for 3-years was developed first, followed by the Simple Moving Average (SMA) for 5-years. The error computation for each model which included Mean Absolute Deviation (MAD), Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) between SMA for 3-years and SMA for 5-years was done. The results that indicate the forecast of number of malaria cases for both 3 – years SMA and 5 –years SMA and their corresponding errors are shown in Table 2.

Table 2: Forecast of Malaria Cases Using 3-Years SMA and 5-Years SMA and their Corresponding Errors

				Errors due to 3- years SMA			Errors due to 5-years SMA		
				138	28046	10	178	46944	14
					167			217	
Years	Total	3-years SMA	5- years SMA	MAD	MSE	MAPE	MAD	MSE	MAPE
2013	955								
2014	2589								
2015	1268	1604		336	112896	26			
2016	1758	1872		114	12996	6			
2017	1197	1408	1553	211	44521	18	356	126736	30
2018	1369	1441	1636	72	5184	5	267	71289	20
2019	1391	1319	1397	72	5184	5	6	36	0.4
2020	1316	1359	1406	43	1849	3	90	8100	7
2021	1529	1412	1360	117	13689	8	169	28561	11

Trend Analysis

Table 3 and figure 1 indicate the actual and forecasted number of malaria cases at LRRH. Generally the result shows a decreasing trend as revealed by the forecast equation, that is y = -60.393+ 1850.2. This being the case, based on the 3- years SMA model, the number of malaria cases is expected to be decreasing year after year.

Table 3: Forecast of Malaria Cases at LRRH using 3-years SMA model

Period	Total	3-SMA	Number of Malaria cases decrease in 2022 and 2023 (in %)
2013	955		
2014	2589		
2015	1268	1604	
2016	1758	1872	
2017	1197	1408	
2018	1369	1441	
2019	1391	1319	
2020	1316	1359	
2021	1529	1412	
2022		1,246	12 %
2023		1,186	5%

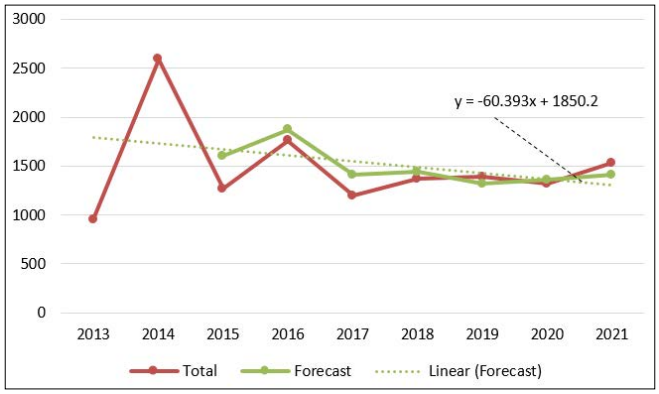

Figure 1: Shows Actual and predicted number of Malaria cases at LRRH

Results and Discussion

Forecasting Accuracy Measures

Based on the result obtained in Table 2, 3 – years SMA and 5- years SMA models are compared to get the model which forecasts the number of malaria cases at LRRH accurately. The result indicated that 3 – years SMA model is better than 5 – years SMA model. 3 – years SMA model has smaller errors than the 5 –years SMA model as shown in Table 4 and Figure 2.

Table 4. Forecasting accuracy measures

Error type	3-Year SMA Model	5-Years SMA Model
MAD	138	178
MAPE	10	14
MSE	167	217

Figure 2: Forecasting accuracy measures

Generally, MAPE is the most preferred forecasting accuracy measures since MAPE states the percentage error in the forecasting of the actual result during a certain period. MAPE usually provides information on whether the percentage error is too high or too low. According to Nathania (2021), the MAPE value range of less than 10%, between 10% - 20%, between 20% - 50% and greater than 50% indicate very good, good, decent and bad forecasting model ability respectively. In view of the MAPE value range specified in table 4 and figure 2, both models are in the range of 10-20% which can be taken as having good forecasting model ability. According to, the smaller the error rate generated, the better the forecast [12]. With an error rate of less than 5%, it means that the forecasting already has an accuracy rate of more than 95% and the results can be said to be accurate. Referring to the errors in table 4 and figure 2, 3 – years SMA model is better than 5- years SMA model because it has low MAPE value of 10%, which means that model has ability of forecasting accurately the number of malaria cases at LRRH by 90%. Furthermore, by comparing the value of MAD and MSD of both models, it is clear that 3 – years SMA model has a lower value of both measurements. Therefore, we can conclude that the forecast done by using the 3 – years SMA model is slightly more accurate than the forecast done by using the 5 – years SMA model.

Forecast of Number of Malaria Cases as LRRH

In view of table 3 and figure 1, the result reveal that the number of malaria cases is expected to be decreasing year after year. The result reveals that in 2022 and 2023 the number of malaria cases is forecasted to be 1,246 and 1,186 respectively. However, the number of malaria cases decrease is not significant. The number of malaria cases may decrease by 12% and 5% in 2022 and 2023 respectively. This finding is in line with the result obtained by which asserts that major decline in malaria prevalence has been witnessed in Tanzania [4].

Conclusion

The model forecast shows a slight decrease in number of malaria cases at LRRH for the next two years, that is 2022 and 2023. The number of malaria cases may decrease by 12% and 5% in 2022 and 2023 respectively. This being the case, the government and other stakeholders should put much effort in ensuring there is significant decrease of number of malaria cases [13-15].

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