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TIME SERIES ANALYSIS OF MALARIA DISEASE

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ABSTRACT

We present the time series analysis of monthly number of mortality of children less than five years of age as a result of malaria in specialist hospital Damaturu, the interest of this paper was to fit the best forecasting model to the time series data and observe the forecast over time. An ARIMA models (1, 0,), (0, 0, 1) and (1, 0, 1) were fitted and model (1, 0, 1) happen to be the best for the data. The paper also shows an increasing trend over time. There are increases of monthly number of mortality over time and hence Government should provide better infrastructural facilities, equipment and drugs to our hospital for effective diagnosis and treatment.

Keywords: Mortality, Malaria, Mosquito and Children

INTRODUCTION

This write up is on time series analysis of Mortality of Children less than five years as a Result of Malaria Disease in Specialist Hospital Damaturu, Yobe State, for the period of ten years (2008-2017). Malaria is a disease caused by microscopic protozoan called plasmodium. It lives in the blood and liver of an infected person when a female anophase mosquito suck blood from an infected person it absorbs plasmodium into its stomach along with blood cells, the plasmodium multiply and then pass to the mosquito salivary gland. When the mosquito bites another person it squirts saliva and plasmodium into their blood stream and they become infected with malaria.

Malaria can be simply defined as the disease caused by the bite of a certain kind of mosquito paroxysm of chills, rigor and fever. The parasite is transmitted by female mosquito. There are four species of plasmodium;

- Plasmodium malaria
- Plasmodium falcifanum
- Plasmodium virax
- Plasmodium ovale

A time series is a set of observation sequentially taken over a specified period usually at equal interval, example: the total annual production of good over a number of years. Time series is of paramount importance in the various fields of human endeavor. Governments sometimes may be interested in studying her revenue and expenditure pattern, in which case the use of time series may come in. Time series analysis may be used for example in studying the productivity, payments of salary, unemployment trend and other economic indicators for short and long terms development by the government. Government can also use time series to monitor the pattern and activities of migration so that provision can be made well in advance.The importance of time series is not restricted to government along, it is also applicable in various field of life, such as business organization in studying or forecasting the demand of goods and services. Medical scientist may be studying the effect of their new drugs over time; the engineer may be working on machine tools.

STATEMENT OF PROBLEM

Mosquito bites an infected person to sock blood with galetocytes (male and female parasite). Sexual –R takes place in the mosquito to produce ookinnates which develop in oocysts containing thousands of sprozoites. Sprozoites are enucleated into man during feeding by female anothelene.

Sprozoites hide in the liver where they multiply and develop into pre-enythrocytic schizonts. Schizonts burst to release merazoites which enter the blood stream.

OBJECTIVE

- To establish a model that will predict the trend values
- To fit a trend line
- To fit an ARIMA model to the data
- To forecast the future trend
- To suggest possible ways of reducing the trend
- To make recommendation based on the findings.

SIGNIFICANCE OF THE STUDY

The research findings will provide a sound basis and a vital tool in the forecasting of the children death by the malaria. For instance if the trend is found to be increasing, the government should be advise to plan and make adequate funding to the health sector for the provision of hospital material and staffing to meet the demand of the disease. Also the research finding may enable and assist non government organization (i.e WHO, UNICEF, ACF, RED CROSS etc.) in getting information about the number of children death as a result of malaria disease, in particular hospital. And it will provide relevance materials as a guide for students and other researcher's undertaking a similar work.

LITERATURE REVIEW

A lot of people have done research on malaria. Here we review some literature works on malaria disease and its effect on human live.

According to National Institute of Allergy and Infectious Diseases, Malaria is a disease caused by a parasite that lives part of its life in humans and part in mosquitoes. Malaria remains one of the major killers of humans worldwide, threatening the lives of more than one-third of the world's population. It thrives in the tropical areas of Asia, Africa, and Central and South America, where it strikes millions of people. Sadly, more than 1 million of its victims, mostly young children, die yearly, Philips (2001).

Although malaria has been virtually eradicated in the United States and other regions with temperate climates, it continues to affect hundreds of people in this country every year. The Centers for Disease Control and Prevention (CDC) estimates 1,200 cases of malaria are diagnosed each year in the United States. People who live in the United States typically get malaria during trips to malaria-endemic areas of the world.

Malaria has been around since ancient times. The early Egyptians wrote about it on papyrus, and the famous Greek physician Hippocrates described it in detail. It devastated invaders of the Roman Empire. In ancient Rome, as in other temperate climates, malaria lurked in marshes. Hence, the name is derived from the Italian, "*mal aria,*" or bad air. In 1880, the French scientist, Shepard (1991) discovered the real cause of malaria, the single-celled Plasmodium parasite. Almost 20 years later, scientists working in India and Italy discovered that Anopheles mosquitoes are responsible for transmitting malaria. Historically, the United States is no stranger to the tragedy of malaria. This disease, then commonly known as "fever and ague," took a toll on early settlers.

Malaria has been a significant factor in virtually all of the military campaigns involving the United States. In World War II and the Vietnam War, more personnel time was lost due to malaria than to bullets according to National Institute of Allergy and Infectious Diseases, Schonfeld (2007).

However don't get an extreme ailment when in doubt. In stable transmission areas infants are secured by the antibodies of their mom and through breastfeeding. After three months infants have a higher vulnerability for a contamination with the parasite. In high transmission zones this period lasts until the age of 3-5 years.

In zones with an occasional transmission, the period can most last 10 years. Without re-contamination the obtained safety can disappear in a matter of years (Victora et al. 2003).Furthermore kids under five years old experience the greatest malaria issues since they are regularly super-contaminated with different parasites and/or that they frequently experience the ill effects of healthful insufficiencies. These lead to a weaker resistant framework, which prompts a higher weakness for malaria. In addition, a malaria contamination and lack of healthy sustenance are explanations behind an expanding paleness trouble in kids.

Malaria is viewed as the most important parasitic disease in people. There are upwards of 350-500 million clinical scenes for each year around the world keeping in mind most gauges of mortality brought about by Malaria lie at around 1 million deaths for each year , a few estimations go as high as 3 million . All of these deaths happen in kid, living in malarious nations in sub-Saharan Africa (SSA) where 25% of all youth mortality beneath the age of five (around 800,000 youthful kids) is owing to intestinal sickness. Of those youngsters who survive cerebral intestinal sickness (malaria), more than 15% endure neurological deficiencies which incorporate shortcoming, spasticity, visual impairment, discourse issues and epilepsy. Where such kids are inadequately overseen and don't have entry to particular instructive offices, these deficiencies may meddle with future learning and improvement. Children less than five years old are at most noteworthy danger for malaria since they have not yet gained defensive invulnerability. Individuals with semi-safety are contaminated (Appawu, 2004).

Plasmodium falciparum is responsible for most malaria deaths, especially in Africa. The infection can develop suddenly and produce several life-threatening complications. With prompt, effective treatment, however, it is almost always curable. Plasmodium vivax, the most geographically widespread of the species, produces less severe symptoms. Relapses, however, can occur for up to 3 years, and chronic disease is debilitating. Once common in temperate climates, P. vivax is now found mostly in the tropics, especially throughout Asia. Plasmodium malariae infections not only produce typical malaria symptoms but also can persist in the blood for very long periods, possibly decades, without ever producing symptoms, Taiar(2007).

Appawu and colleagues studied malaria transmission dynamics in the Kassena Nankana District, a site in northern Ghana proposed for testing malaria vaccines. Intensive mosquitoes sampling was done for one year using human landing catches in three micro-ecological sites that is irrigated, lowland and rocky highlands. Transmission was highly seasonal and the heaviest transmission occurred from June to October. The intensity of transmission was higher for people in the irrigated communities than the non-irrigated ones. Approximately 60% of malaria transmission in KND occurred indoors during the second half of the night, peaking at daybreak between 04.00 to 06.00 hours.

Malaria is also a major problem in Papua New Guinea as it accounts for a high proportion of sickness and death. This is because in addition to human suffering, it also put severe stress on the health facilities and directly hinders economic growth. It has been suggested that a malaria vaccine would be best, most cost effective and safe public health measure to reduce the burden of malaria (Minja, 2001).

Holtz et al (2002) contend that the serious threat posed by the spread of drug-resistant malaria in Africa has been widely acknowledged. Chloroquine resistant malaria is now almost universal and resistant to successor drug, sulfadoxine-pyrimethamine (SP) is growing rapidly. If the question of cost of treatment is not successfully addressed this could lead to adverse result from the deployment of combination therapy as a first-line treatment. Adverse effect of costly treatment ranges from increase in delays in infected individuals presenting themselves to the health care facilities for treatment to exclusion of the poorest malaria sufferers from receiving treatment altogether (Holtz, 2002).

The World Health Organization launched the global eradication of malaria in 1955. Unfortunately, this coincided with the struggle for independence in sub-Sahara Africa. Countries with temperate climates succeeded in eradicating the disease. Countries like India and Sri Lanka had sharp reduction in morbidity

The Roll Back Malaria (RBM) initiative launched in 1998 has the ambitious target of decreasing malaria mortality by 50% by the year 2010. Although several control and preventive measures will contribute to the achievement of this target, an essential contribution needs to come from a substantial reduction of the case-fatality rate for the disease (WHO, 2002). African leaders met in Abuja in 2000 to reaffirm their commitment to the RBM. The goals of the Abuja Declaration include ensuring that 60% of those with malaria have access to treatment within 24 hours of the onset of the symptoms; at least 60% of the at-risk pregnant women receive preventive drugs and at least 60% of the at-risk sleep under bed nets (The African Summit on Roll Back Malaria, 2005). After nine years of implementing the Abuja Declaration, it appears Ghana is making a negligible success since the morbidity rate is still high and in Effiduase malaria is still the most common disease recorded daily at the health centres. The ability to prevent and treat the disease is a function of one"s income so the issue of affordability in terms of treatment and the acquisition of the nets should not be downplayed if modest gain is to be achieved different from the others(Nuwaha, F., 2001).

METHODOLOGY

An ARIMA model is a class of statistical models for analyzing and forecasting time series data. It explicitly caters to a suite of standard structures in time series data, and as such provides a simple yet powerful method for making skillful time series forecasts.

ARIMA is an acronym that stands for Autoregressive Integrated Moving Average. It is a generalization of the simpler Autoregressive Moving Average and adds the notion of integration.

This acronym is descriptive, capturing the key aspects of the model itself. Briefly, they are:

AR: Auto regression. A model that uses the dependent relationship between an observation and some number of lagged observations.

I : Integrated . The use of differencing of raw observations (e.g. subtracting an observation from an observation at the previous time step) in order to make the time series stationary.

MA : Moving Average . A model that uses the dependency between an observation and a residual error from a moving average model applied to lagged observations.

Each of these components are explicitly specified in the model as a parameter. A standard notation is used of ARIMA (p,d,q) where the parameters are substituted with integer values to quickly indicate the specific ARIMA model being used.

The parameters of the ARIMA model are defined as follows:

p : The number of lag observations included in the model, also called the lag order.

d : The number of times that the raw observations are differenced, also called the degree of differencing.

q : The size of the moving average window, also called the order of moving average.

RESULTS

Trend Analysis

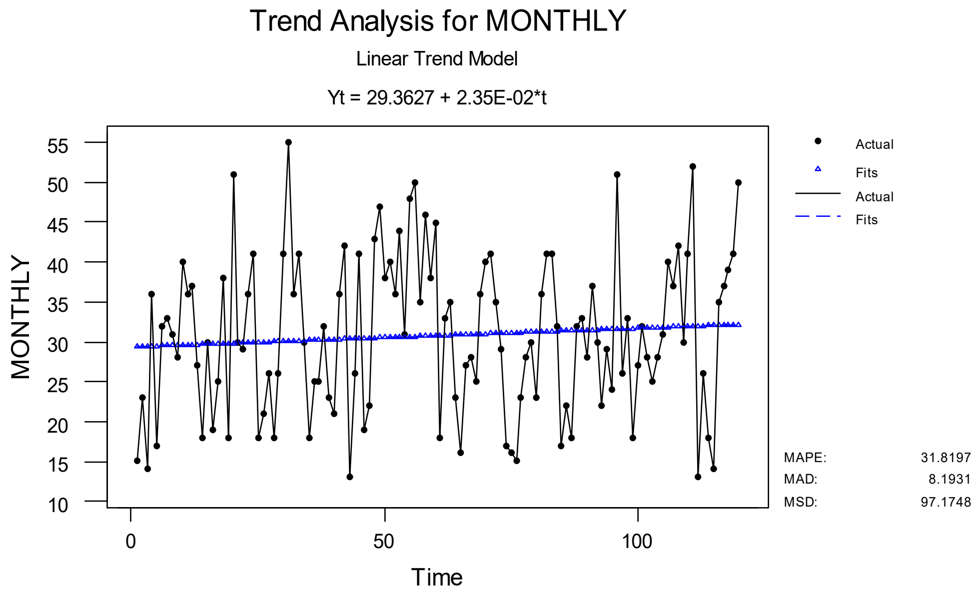
Data MONTHLY
Length 120.000
N Missing 0

Fitted Trend Equation
$Y_t = 29.3627 + 2.35E\text{-}02*t$

Accuracy Measures
MAPE: 31.8197
MAD: 8.19312

MSD: 97.1748

FIG I



Regression Analysis

The regression equation is

MONTHLY MORTALITY = 29.4 + 0.0235 MONTH

Predictor	Coef	StDev	T	P
Constant	29.363	1.826	16.08	0.000
MONTH	0.02348	0.02620	0.90	0.372

S = 9.941 R-Sq = 0.7% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	79.39	79.39	0.80	0.372
Error	118	11660.98	98.82		
Total	119	11740.37			

Unusual Observations

Obs	MONTH	MONTHLY	Fit	StDev Fit	Residual	St Resid
20	20	51.000	29.832	1.396	21.168	2.15R
31	31	55.000	30.091	1.192	24.909	2.52R
111	111	52.000	31.969	1.604	20.031	2.04R

R denotes an observation with a large standardized residual

FIG II

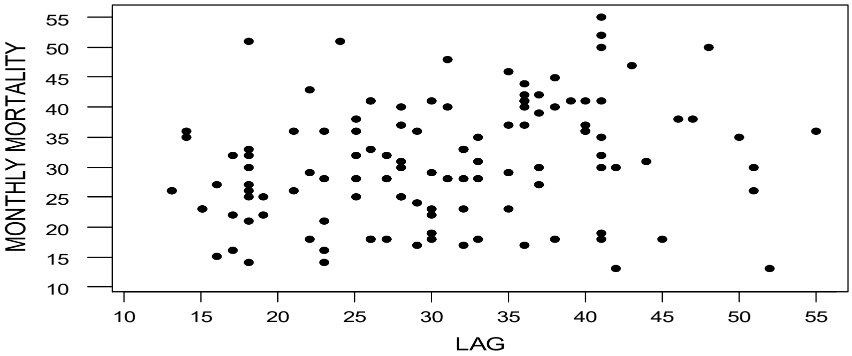
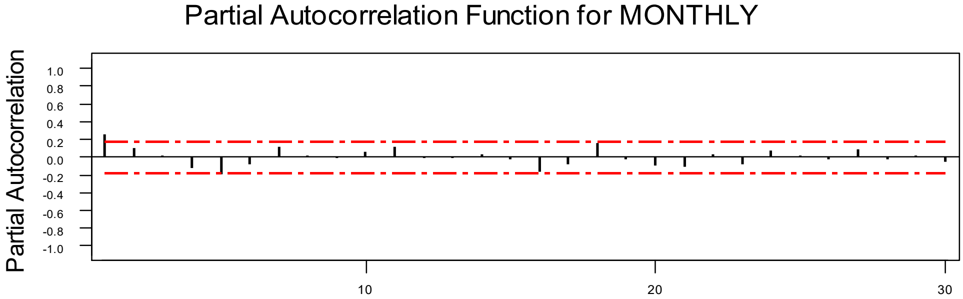


FIG III



Lag	PAC	T	Lag	PAC	T	Lag	PAC	T	Lag	PAC	T
1	0.25	2.77	10	0.06	0.67	19	-0.03	-0.34	28	-0.03	-0.38
2	0.09	1.02	11	0.12	1.30	20	-0.10	-1.13	29	0.02	0.22
3	0.01	0.13	12	-0.01	-0.10	21	-0.11	-1.23	30	-0.06	-0.65
4	-0.13	-1.46	13	-0.01	-0.11	22	0.03	0.34			
5	-0.20	-2.22	14	0.03	0.32	23	-0.08	-0.85			
6	-0.08	-0.85	15	-0.03	-0.32	24	0.08	0.84			
7	0.11	1.18	16	-0.17	-1.84	25	0.02	0.21			
8	0.01	0.08	17	-0.08	-0.85	26	-0.02	-0.25			
9	-0.01	-0.16	18	0.16	1.70	27	0.08	0.91			

ARIMA (1,0,0) Model

ARIMA model for MONTHLY MORTALITY

Estimates at each iteration

Iteration	SSE	Parameters	
0	11258.0	0.100	27.795
1	10949.3	0.250	23.129
2	10945.9	0.266	22.619
3	10945.8	0.267	22.569
4	10945.8	0.267	22.564

Relative change in each estimate less than 0.0010

Final Estimates of Parameters

Type Coef StDev T

AR 1	0.2673	0.0902	2.96
Constant	22.5637	0.8787	25.68
Mean	30.794	1.199	

Number of observations: 120
Residuals: SS = 10929.3 (backforecasts excluded)
MS = 92.6 DF = 118

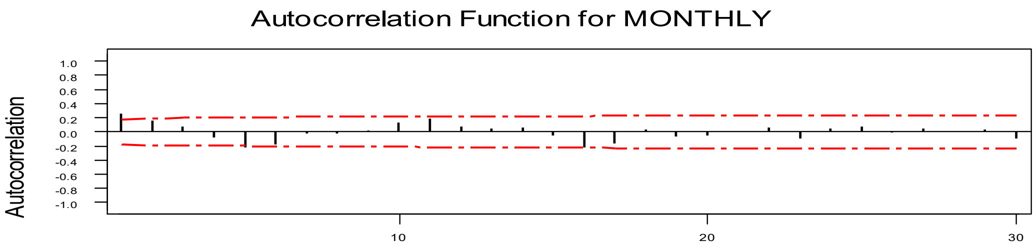
Modified Box-Pierce (Ljung-Box) Chi-Square statistic

Lag	12	24	36	48
Chi-Square	13.7(DF=11)	28.6(DF=23)	36.7(DF=35)	60.9(DF=47)

Forecasts from period 120

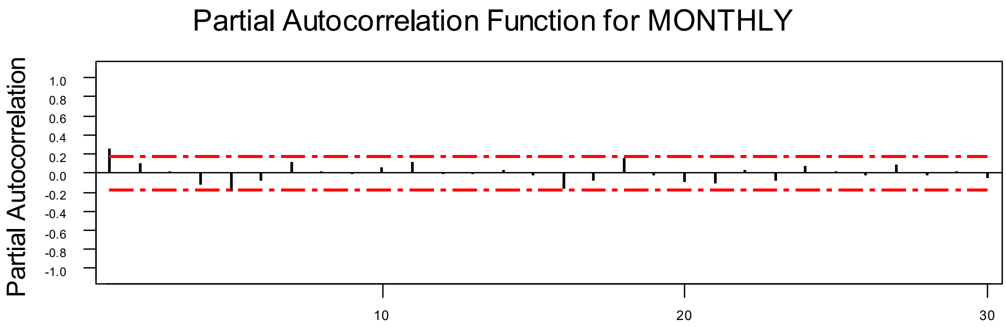
		95 Percent Limits		
Period	Forecast	Lower	Upper	Actual
121	35.9269	17.0601	54.7937	
122	32.1657	12.6367	51.6947	
123	31.1604	11.5850	50.7359	
124	30.8918	11.3130	50.4706	
125	30.8200	11.2410	50.3990	
126	30.8008	11.2217	50.3798	
127	30.7956	11.2166	50.3747	
128	30.7943	11.2152	50.3733	
129	30.7939	11.2149	50.3729	
130	30.7938	11.2148	50.3728	
131	30.7938	11.2148	50.3728	
132	30.7938	11.2147	50.3728	

FIG IV



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ	Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.25	2.77	7.89	10	0.12	1.16	25.44	19	-0.08	-0.65	43.94	28	-0.00	-0.03	47.35
2	0.15	1.56	10.71	11	0.18	1.71	30.02	20	-0.06	-0.48	44.41	29	0.03	0.25	47.49
3	0.07	0.70	11.32	12	0.07	0.65	30.72	21	-0.00	-0.00	44.41	30	-0.10	-0.86	49.20
4	-0.09	-0.92	12.37	13	0.05	0.42	31.02	22	0.05	0.46	44.85				
5	-0.23	-2.25	18.83	14	0.05	0.48	31.42	23	-0.09	-0.78	46.12				
6	-0.18	-1.76	23.17	15	-0.06	-0.51	31.86	24	0.04	0.34	46.38				
7	-0.02	-0.22	23.24	16	-0.22	-1.99	38.81	25	0.07	0.58	47.11				
8	-0.03	-0.30	23.38	17	-0.17	-1.50	43.04	26	-0.01	-0.12	47.14				
9	0.01	0.11	23.40	18	0.02	0.19	43.11	27	0.04	0.31	47.35				

FIG V



Lag	PAC	T	Lag	PAC	T	Lag	PAC	T	Lag	PAC	T
1	0.25	2.77	10	0.06	0.67	19	-0.03	-0.34	28	-0.03	-0.38
2	0.09	1.02	11	0.12	1.30	20	-0.10	-1.13	29	0.02	0.22
3	0.01	0.13	12	-0.01	-0.10	21	-0.11	-1.23	30	-0.06	-0.65
4	-0.13	-1.46	13	-0.01	-0.11	22	0.03	0.34			
5	-0.20	-2.22	14	0.03	0.32	23	-0.08	-0.85			
6	-0.08	-0.85	15	-0.03	-0.32	24	0.08	0.84			
7	0.11	1.18	16	-0.17	-1.84	25	0.02	0.21			
8	0.01	0.08	17	-0.08	-0.85	26	-0.02	-0.25			
9	-0.01	-0.16	18	0.16	1.70	27	0.08	0.91			

ARIMA (0,0,1)Model

ARIMA model for MONTHLY MORTALITY

Estimates at each iteration

Iteration	SSE	Parameters	
0	12491.2	0.100	30.883
1	11480.0	-0.050	30.882
2	11101.2	-0.200	30.846
3	11095.5	-0.222	30.795
4	11095.4	-0.220	30.788
5	11095.4	-0.220	30.788
6	11095.4	-0.220	30.788

Relative change in each estimate less than 0.0010

Final Estimates of Parameters

Type	Coef	StDev	T
MA 1	-0.2201	0.0908	-2.42
Constant	30.788	1.080	28.52
Mean	30.788	1.080	

Number of observations: 120
Residuals: SS = 11084.6 (backforecasts excluded)
MS = 93.9 DF = 118

Modified Box-Pierce (Ljung-Box) Chi-Square statistic

Lag	12	24	36	48
Chi-Square	15.8(DF=11)	29.9(DF=23)	38.7(DF=35)	66.1(DF=47)

Forecasts from period 120

Period	Forecast	95 Percent Limits Lower	Upper	Actual
121	34.5986	15.5982	53.5990	

122	30.7876	11.3324	50.2429
123	30.7876	11.3324	50.2429
124	30.7876	11.3324	50.2429
125	30.7876	11.3324	50.2429
126	30.7876	11.3324	50.2429
127	30.7876	11.3324	50.2429
128	30.7876	11.3324	50.2429
129	30.7876	11.3324	50.2429
130	30.7876	11.3324	50.2429
131	30.7876	11.3324	50.2429
132	30.7876	11.3324	50.2429

FIG VI

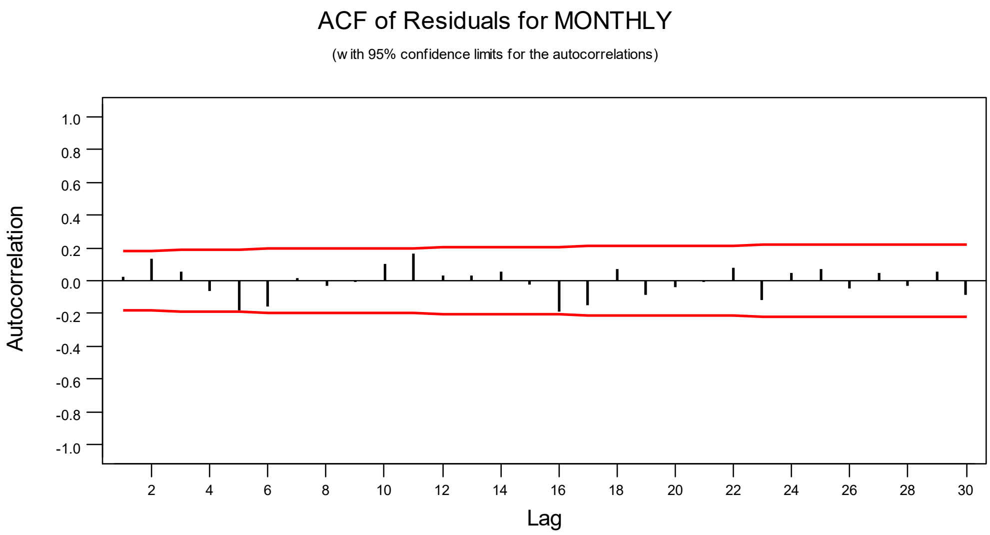
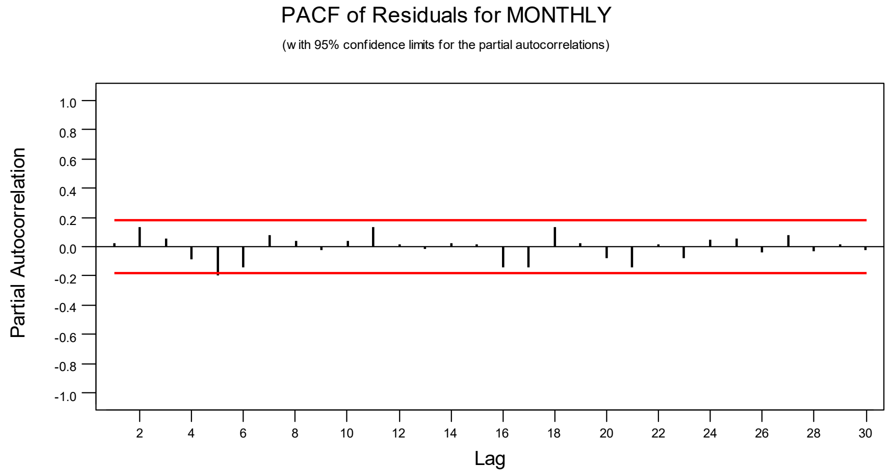


FIG VII



ARIMA (1,0,1) Model

ARIMA model for MONTHLY MORTALITY

Estimates at each iteration
Iteration SSE Parameters

0	11741.6	0.100	0.100	27.795
1	10964.8	0.221	-0.021	24.031
2	10891.8	0.371	0.129	19.407
3	10864.9	0.521	0.279	14.773
4	10863.6	0.473	0.213	16.231
5	10863.1	0.526	0.274	14.608
6	10862.7	0.481	0.221	15.966
7	10862.4	0.520	0.267	14.779
8	10862.2	0.487	0.227	15.808
9	10862.1	0.516	0.262	14.910
10	10862.0	0.490	0.232	15.691
11	10861.9	0.513	0.258	15.009
12	10861.8	0.493	0.235	15.603
13	10861.7	0.510	0.256	15.083
14	10861.7	0.495	0.238	15.537
15	10861.7	0.508	0.253	15.140
16	10861.6	0.497	0.240	15.487
17	10861.6	0.507	0.252	15.183
18	10861.6	0.498	0.241	15.449
19	10861.6	0.506	0.250	15.216
20	10861.6	0.499	0.243	15.419
21	10861.6	0.505	0.249	15.242
22	10861.6	0.500	0.243	15.397
23	10861.6	0.505	0.249	15.261
24	10861.6	0.501	0.244	15.380
25	10861.6	0.504	0.248	15.276

** Convergence criterion not met after 25 iterations

Final Estimates of Parameters

Type	Coef	StDev	T
AR 1	0.5040	0.2820	1.79
MA 1	0.2482	0.3138	0.79
Constant	15.2760	0.6615	23.09
Mean	30.799	1.334	

Number of observations: 120
Residuals: SS = 10839.2 (backforecasts excluded)
MS = 92.6 DF = 117

Modified Box-Pierce (Ljung-Box) Chi-Square statistic

Lag	12	24	36	48
Chi-Square	14.1(DF=10)	29.9(DF=22)	37.6(DF=34)	61.9(DF=46)

Forecasts from period 120

		95 Percent Limits		
Period	Forecast	Lower	Upper	Actual
121	36.5120	17.6430	55.3810	
122	33.6786	14.2019	53.1554	
123	32.2505	12.6224	51.8787	
124	31.5308	11.8644	51.1972	
125	31.1680	11.4919	50.8441	

126	30.9851	11.3066	50.6637
127	30.8930	11.2138	50.5722
128	30.8465	11.1672	50.5259
2 129	30.8231	11.1437	50.5025
130	30.8113	11.1319	50.4908
131	30.8054	11.1260	50.4848
132	30.8024	11.1230	50.4818

FIG VIII

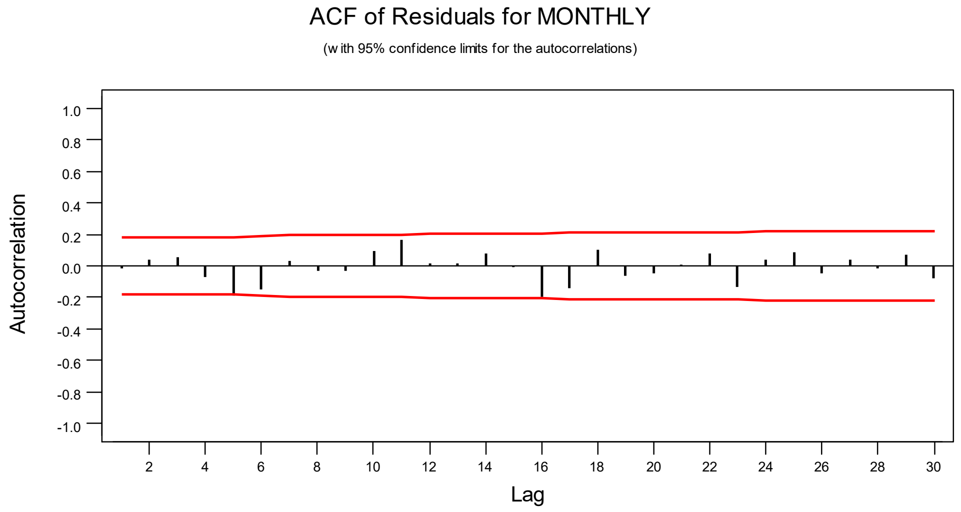
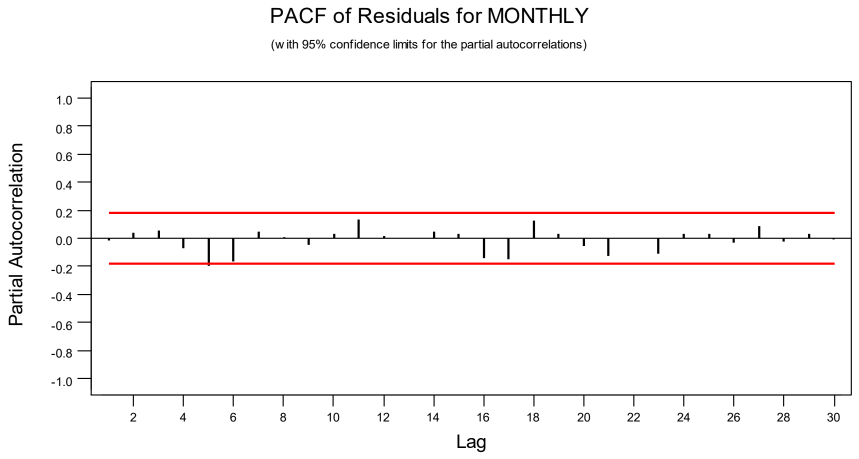


FIG IX



DISCUSSION OF THE RESULT FINDINGS

The result of the analysis of this work is discussed below;

THE TREND ANALYSIS FOR ARIMA(1,0,0), ARIMA (0,0,1) AND ARIMA (1,0,1) MODELS;

Preliminary studies of the monthly number of mortality of children less than five years as a result of malaria in specialist hospital Damaturu, Yobe State between 2008 to 2017 indicate that the trend is upward which shows in fig I.

LAG PLOT RESULT

The fig II shows that the lag of the monthly number of mortality of childen less than five years as a result of malaria in specialist hospital Damaturu, Yobe State the lag plot does not exhibit any identifiable structure because the point does not show any trend, it is randomly scatted.

SUMMARY AND CONCLUSION

The general pattern of the monthly number of mortality of children less than five years as a result of malaria was studied through the Box-Jenkins models and forecast of future of monthly number of mortality was computed. The most adequate model identified is ARIMA (1, 0, 1) while satisfying all the assumption of ARIMA, and has lowest mean square error when compared to other two models. The trend values indicated an increasing trend that increase in number of monthly mortality which implies lack of improvement in the health sector.

RECOMMENDATIONS

Based on the finding, We recommended that the Specialist Hospital Damaturu may adopt ARIMA (1,0,1) in their future forecast of monthly number of mortality of children less than five years as a result of malaria. We also made the following recommendation:

a) Government should provide better infrastructural facilities, equipment and drugs to our hospitals for effective diagnosis and treatment.
b) Government should provide/employ medical personnel and nurse for proper management of work.
c) Adequate funds should be provided for effective supervision by community health and environment protection agencies, so that the environment can be clean and all water way can be cleared and sprayed with insecticide especially in the period of the year June - October when the cases of malaria are very high.
d) Societies should be enlightening on health care measures so as to have a clean and malaria free environment.

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