COMPARING THE PREDICTIVE ABILITY OF SOME SELECTED TIME SERIES MODELS ON REPORTED CASES OF IMMUNIZATION IN ABUTH, ZARIA

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Abstract
The study was conducted on data showing the number of children being immunized against measles in Institute of Child Health Care Delivery, Ahmadu Bello University Teaching Hospital (ABUTH), Zaria. Two methodologies of times series analysis Moving Average and Least Square Methods were selected for the research. Based on the findings from the study, the result from the 3-yearly Moving average shows that the predicting values remain constants, indicating that, we would continue having a constant value while forecasting for the future years to come if we use a 3-yearly moving average method on the data set. The time series (method of least square) carried out, gives equation (Y_t = -15 + 23.0X_t) which is the trend equation of Y_ti.e, measles cases at a time t, for any given value of Xt with varying and non-constant forecasted values. The results obtained from the two concepts have clearly shown that the Least Square method gives a more reliable forecast than the 3-yearly Moving average Method of time series analysis. The result shows that a unit increase in time will lead to an increase of 23.0 units of measles.Therefore,the development of a sustainable framework for achieving high vaccination coverage among children younger than 5 years of age in the country is hence recommended.

Keywords: *Time Series, Least-Squares, Moving Average, Forecast, Measles, Analysis*

INTRODUCTION

Measles is a highly infectious and contagious disease of the respiratory system caused by Morbilivirus which belongs to the family Paramyxoviridae, Hashiguchi *et al*. (2011). The disease is a common cause of childhood morbidity and mortality across the globe, particularly in developing countries and has been characterized by high fever, cough, conjunctivitis, coryza, malaise and maculopapular rash along with erythematous patches throughout the body, Ellison (1931), Yanagi *et al*., (2006) and Fazlalipour *et al*., (2008). Measles infection has been controlled by the introduction of live attenuated measles vaccine in the United States and Europe Gindler *et al*., (2004). However, measles is still affecting developing countries due to insufficient coverage and improper handling of vaccines (Polland and Jacobson, (1994) and Muscat *et al*., (2009).Historically, immunization against vaccine-preventable diseases (VPDs) in children has been started by World Health Organization (WHO) in 1974, and it was initiated in Pakistan in the year 1978, Ali (2000) and Bugvi *et al*., (2014). In general, the vaccine coverage against VPDs in Pakistan ranged between 56% to 88 % which significantly varied among various Provinces, Sheikh *et al*., (2011). Recently, an increased number of measles outbreaks with high morbidity and mortality has been observed in various regions of Pakistan during recent years, Khan and Khan, (2012) and Khan and Qazi, (2014). These particular episodes of higher incidence of measles were started in Thatta, Mirpurkhas and Jacobabad Districts of Sindh Province by the end of 2012, which later on spread towards Punjab Province. The spread of measles was reported to be higher in both rural as well as developed cities of Pakistan along with a high incidence of mortality and morbidity. The important factors

considered for these outbreaks were associated with vaccination failure due to several reasons i.e., low vaccination coverage, malnutrition and vitamin-A deficiencies, poor vaccination facilities in remote and rural areas, Mis-handling of vaccines and lack of immunization awareness among parents due to lower levels of education in various areas of the country. To combat the situation extensive supplementary immunization activities have been initiated which targets children less than 10 years of age particularly in Punjab, Pakistan under the Expanded Program on Immunization (EPI). Therefore, in the current investigation, the impact of supplementary vaccination has been estimated in children from Faisalabad and Kaduna using enzyme-linked Immunosorbent assay (ELISA) as outlined in the supplemental material. A total of 871/1053 (82.71 %) children from Faisalabad and 647/813 (79.58 %) children from Kaduna were found vaccinated either with a single or dual dose of measles vaccination (Table 1). Out of these 264 blood samples from vaccinated and 100 samples from non-vaccinated children were collected randomly and analysed for the presence of anti-measles IgG antibodies. Only 73.48 % of vaccinated children developed humoral immune responses as detected through ELISA. This indicates that the protection against measles was not optimum according to WHO standards, Rabenau *et al*., (2007) and Fazlalipour (2008) and Lauridan and Van Damme, (2007). Sero conversion following vaccination against measles in developing countries has been reported to be lower (75 %) due to certain factors as described previously, Fowotade *et al*., (2013) and Shah *et al*., (2012). The highest values (95 %) for measles vaccination have been reported in European countries, Tischer and Gerike, (2000).

STATEMENT OF THE PROBLEM

In order to attain health for all, it is important that an attempt has to be made to address diseases burdens and other health problems that significantly contribute to the poor health status of Nigeria. Despite all efforts by the governments and especially NGOs to eradicate Measles still the disease is rampant in our society. Based on this, there is a need to mount urgent and appropriate health interventions capable of achieving this prime goal of alleviation and eradication of all vector-borne diseases killing the children of our society. The main goal of the policy is to develop and promote an immunization programme geared toward the reduction of childhood morbidity and mortality through adequate immunization coverage of all at-risk populations. Because of this, we have to provide the guideline and framework for the proper implementation of an immunization schedule for the target and at-risk population. To establish comprehensive guidelines to assure compliance with the plans to detect, control or eliminate the occurrence of vaccine-preventable diseases (VPDS).

AIM AND OBJECTIVES OF THE STUDY

The study aims to assess the effects of Moving Average and Least Squares methods on the datashowing the number of children being immunized against measles in (ABUTH), institute of child health care delivery. This aim shall be achieved through the following objectives;

i) To compare between Moving Average and Least Squares methods of time series analysis.
ii) To determine the trend on the level of immunization against measles at the Institute of Child Healthcare ABUTH Zaria.

SIGNIFICANCE OF STUDY

This research will aid in assessing the best methods between Moving Average and Least Square Method on the immunization process of the institute of health care, ABU, Zaria. And also, in policy-making and knowledge on routine immunization in

Zaria. It will also be useful in evaluating the performance of existing population policies and programmes aimed at promoting immunization programmes.

METHODOLOGY

Component of a Time Series

The movement of a time structure data is governed by some peculiar inheritance that can be characterized by their regularity and their effect in the entire series. The forces could also be due to chance in the social, economic, physiological, or environmental characteristicsof the system. The pattern generated in these forces is the components of time series which possess; Secular, Seasonal, Cyclical and irregular movements.

Mathematical Model for a Time Series

Decomposition of time series can be achieved by using the following;

(a) Additional model: the model assumes that the observed valves is the sum for component of time series i.e. $Y_t = T_t + S_t + C_t + I_t$ or $X_t = T_t + S_t + C_t + I_t$ *where*

Y_t = original data; T_t = trend value; S_t = Seasonal movement; C_t = cyclical component; I_t = Irregular component

(b) Multiplicative model: the model assumes that the observed value is obtained by multiplying the trend (T_t) by the ratio of three-component as below.

$Y_t = T_t \times S_t \times C_t \times I_t$ or $X_t = T_t \times S_t \times C_t \times I_t$

The multiplicative model assumes that the components due to different causes aren't necessarily independent and they can affect one another. Most of the time series relating to economic and business phenomena conform to the multiplicative model.

(c) Mixed model: this assumes that first, these components or the three are multiplied together with the 1st or last sum together with the multiplied component as shown below

$Y_t = T_t S_t C_t + I_t$

or $Y_t = T_t + St\ C_t\ I_t$

The two Methods of Secular Trend (Tt) selected and used in the Research.

The following are used to measure the trend of the given data and distribution.

1. Method moving average
2. Method of least square.

Moving Average: It is the simplest device for reducing fluctuation and obtaining trend values.This method consists of taking the arithmetic mean of the values for a certain timespan and replacing it at a certain timespan.

In this method, an average value of year number, months, week, or days is taken at the trend valves in the middle point of the period of moving averages.

Linear Trend by the Method of Least Squares

This is the best method for obtaining trend values.It provides a basic convenient basin for obtaining the line of best fit in a series. A line of best is a sum of a line from which the sum of deviation of various points on either side is zero since the sum of the square from the arithmetic mean is zero. Therefore, the sum of deviation from the line of the best fit is zero, for this reason, the sum of the square for the deviation of various points from the line of the best fit is the least, that is why this method is not as the method of least square.

This method satisfies the following conditions

i. $\varepsilon(y_i - \hat{y}) = 0$i.e the sum of the derivatives of the actual values of y is zero

ii. $\varepsilon\ (y_i - \hat{y})^2$is the least, i.e the sum of the square of derivative from the actual values and the computed values of y is least.

The straight line has an equation of the type

$$y_i = \alpha + \beta_{xi}$$

Where Y represents the estimated valves of trend x represents the estimated valves

$$\varepsilon y = N\alpha + \beta\varepsilon x \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where N representsthe number of years for which data is given.

$$\varepsilon xy = N\alpha + \beta(0) = \frac{\varepsilon y}{N} = \frac{N\alpha}{N} => \alpha = \frac{\varepsilon\alpha}{N} =$$

$$\varepsilon xy = \alpha(0) + \beta(\varepsilon x)^2 = \frac{\varepsilon xy}{\varepsilon x^2} = \frac{\beta x^2}{\varepsilon x^2} => \beta =$$

This provides that the constant 'α' is simply equal to the mean of Y values and the constant 'β' gives the rate of change. The Constants 'α' refers to the Y-intercepts, i.e., the difference between the point of origin and the point where the trend line touches the Y-axis. The constant 'β' refers to the slope of the line which of trend x represent the derivable in the timeperiod.

$\alpha$and β are constants by solving the following two normal equations

$$\varepsilon xy = \alpha\varepsilon x + \beta\varepsilon x^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

When $\varepsilon x = 0$, the two normal equations for finding the constraints α and β will be indicates the change in Y for each unit change in X.

DATA PRESENTATION AND ANALYSIS

Presentation of Data

The table shows the number of children being immunized against measles in (ABUTH) institute of child health care Banzazzau between the period of 2012 - 2020.

Table 4.1 Cases of Measles

Year	Measles Case
2001	88
2002	68
2003	97
2004	45
2005	101
2006	150
2007	202
2008	87
2009	69
2010	190
2011	55
2012	187
2013	667
2014	188
2015	86
2016	120
2017	375
2018	1282
2019	13

Data Analysis

Model Summary

The 3-yearly Moving Averages for Measles Cases of ABUTH, Zaria.

Year	Measles Case	Moving Average	Predict	Error
2001	88	*	*	*
2002	68	*	*	*
2003	97	84.333	*	*
2004	45	70.000	84.333	-39.33
2005	101	81.000	70.000	31.00
2006	150	98.667	81.000	69.00
2007	202	151.000	98.667	103.33
2008	87	146.333	151.000	-64.00
2009	69	119.333	146.333	-77.33
2010	190	115.333	119.333	70.67
2011	55	104.677	115.333	-60.33
2012	187	144.000	104.33	82.33
2013	667	303.000	144.000	523.33
2014	188	347.333	303.000	115.00
2015	86	313.667	347.333	-261.33
2016	120	131.333	313.667	-193.67
2017	375	193.667	131.333	243.67
2018	1282	592.333	193.667	1088.33
2019	13	556.667	592.333	-579.33

WORKSHEET 1

Forecast for five consecutive years

Period	**Forecast**	**Lower**	**upper**
20	556.667	-138.959	1252.29
21	556.667	-138.959	1252.29
22	556.667	-138.959	1252.29
23	556.667	-138.959	1252.29
24	556.667	-138.959	1252.29

Moving Average for Measles Case

Data Measles Case
Length 19
NMissing 0
Moving Average

Length 3
Accuracy Measures

MAPE 363
MAD 225
MSD 125966

INTERPRETATION

The above model shows 3 yearly moving averages as well as predicting values and Errors. Comparing the MA and Predict values, they are the same and hence we have a constant value as a forecast for the future years to come. It shows graphically in the plot below.

WORKSHEET 1

Figure 4.1 Moving Average for MEASLES CASE

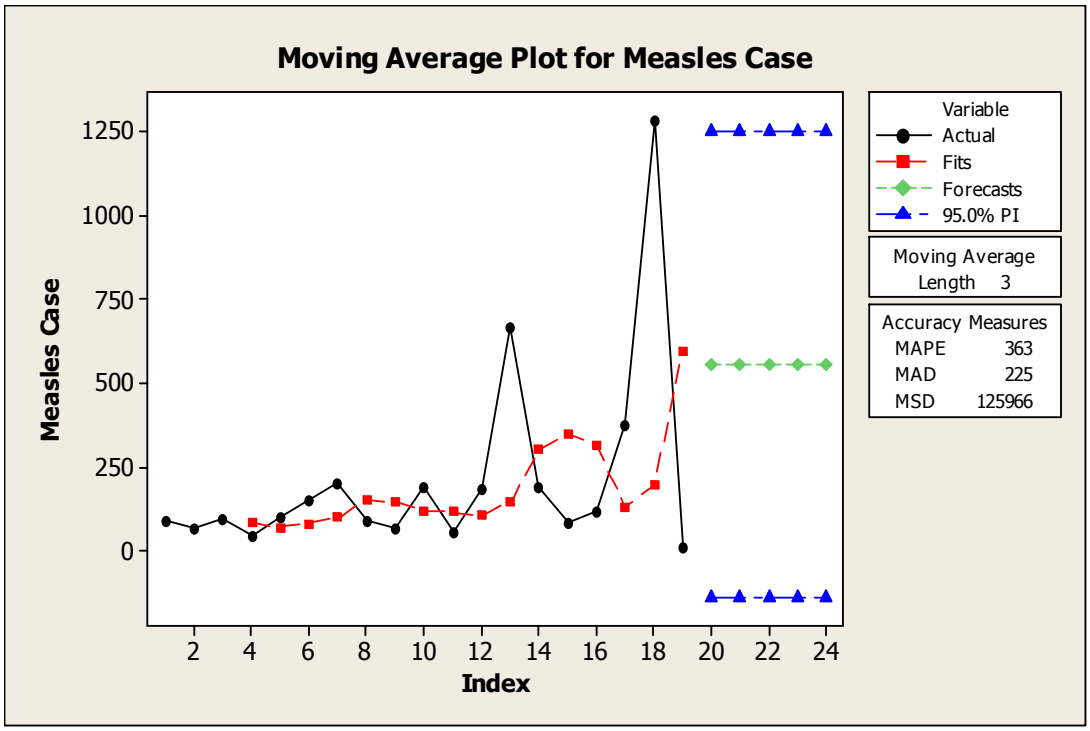


Table 4.3: Trend Analysis for MEASLES CASE

Data Measles Case
Length 19
NMissing 0

Fitted Trend Equation

Yt = -15 + 23.0*t

Accuracy Measures

MAPE 250.9
MAD 159.5
MSD 68293.9

Forecasts

Period	Forecast
20	443.877
21	466.844
22	489.811
23	512.777
24	535.744

Trend Analysis Plot for MeaslesCase

Interpretation

From the analysis carried out on Measles, the equation (Y_t = -15 + 23.0X_t) is the trend equation of Y(Measles) for any shows a relationship between Measles and time. That is to say, a unit increase in time will lead to an increase of 23.0 units of Measles. This is also showing an increase in the forecasts below.

Figure 4.2: Trend Analysis Plot for Measles Case

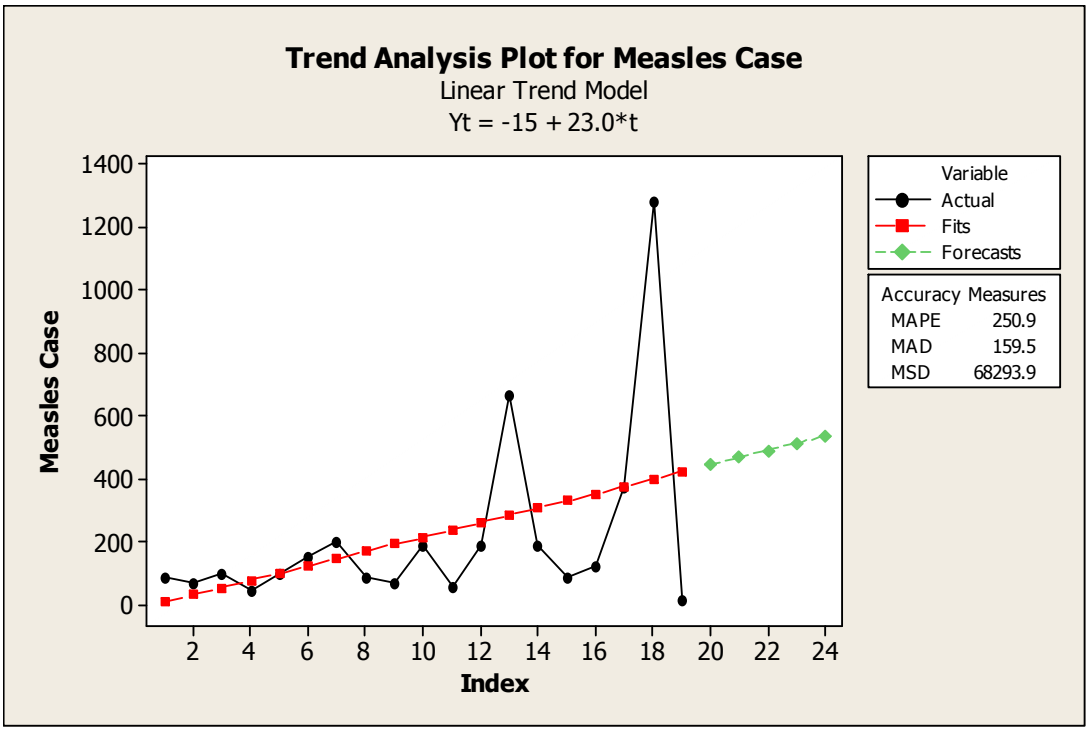
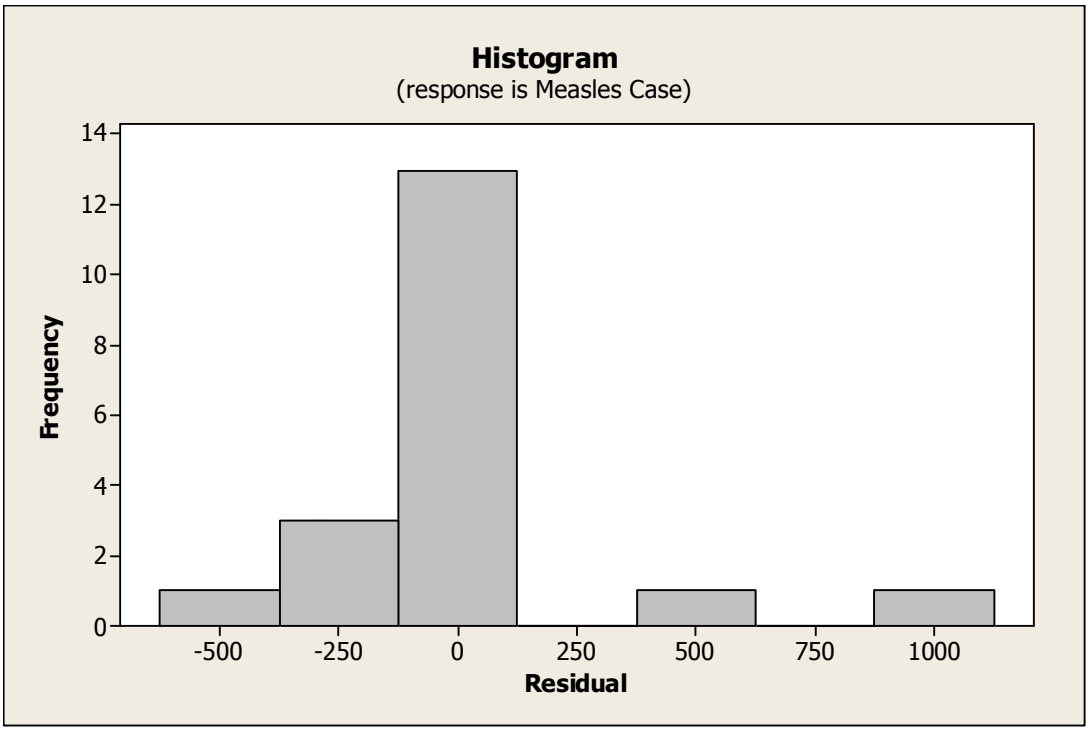


Figure 4.3: Chart of measles case



Above is a Histogram showing the proportion of Measles

CONCLUSION

Based on the findings of the study, the result of the moving average shows that the3- yearly moving average and the predicting values and errors comparing the MA are the same, hence we have constant values as a forecast for the future years to come.

The time series method (least square) carried out on the measles data set gives the trend equation (Y_t = -15 + 23.0X_t), indicating a relationship between measles and time and the best forecasting statistical paraphernalia for the cases of measles in the country.

RECOMMENDATIONS

The use of the Least Square method of time series is recommended for a better forecast of the prevalence of cases of measles in Nigeria. The development of a sustainable framework for achieving high vaccination coverage among children younger than 5 years of age in the country is therefore recommended. Supplemental immunization among target groups during outbreaks as well as a second routine vaccination schedule is also recommended. We also suggest that government should create awareness, and acknowledge that communication isan essential tool for eradicating disease so that some parents should have more information on when, where, how and why their child should be vaccinated.

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