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Comparison of various models on cancer rate and forecasting

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ABSTRACT: In this research work, three models were identified; linear regression model, exponential growth model and the quadratic trend model and the results of the work compared. Data collected from Niger State Hospital Management Board was used for the forecast and the result revealed that the quadratic trend model gave the best fit with mean percentage error of -1.08 and mean absolute percentage error of 43.62. Hence, the quadratic trend model was used for the forecast and the result indicated 27.5 percent annual increase in the future trend and the number of patients with cancer that will visit the hospitals within the study area. This figure is well above the national risk of getting cancer before age 75 years fixed at 10.4 percent.©JASEM

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Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. If the spread is not controlled, it can result in death. Cancer is caused by external factors, such as tobacco, infectious organisms, and an unhealthy diet and internal factors, such as inherited genetic mutations, hormones and immune conditions. These factors may act together or in sequence to cause cancer. Ten or more years often pass between exposure to external factors and detectable cancer. Treatments include surgery, radiation, chemotherapy, hormone therapy, immune therapy, and targeted therapy. Cancer can start almost anywhere in the human body, which is made up of trillions of cells. Normally, human cells grow and divide to form new cells as the body needs them. When cells grow old or become damaged, they die, and new cells take their place. When cancer develops, this orderly process breaks down. As cells become more and more abnormal, old or damaged cells survive when they should die, and new cells form when they are not needed. These extra cells can divide without stopping and may form growths called tumors (Bawa, 2017). Many cancers form solid tumors, which are masses of tissue. Cancers of the blood, such as leukemia, generally do not form solid tumors. Cancerous tumors are malignant, which means they can spread into, or invade, nearby tissues. In addition, as these tumors grow, some cancer cells can break off and travel to distant places in the body through the blood or the lymph system and form new tumors far from the original tumor. Most cancers are linked to environmental and lifestyle changes; ironically, they are mostly preventable. While smoking is the main cause of the burden of global cancer mortality, other risk factors such as sedentary lifestyle and alcohol consumption plays a major role.

In native Africans, 6,500,000 people of a projected 965 million are diagnosed to have cancer yearly, with lifetime risk of female being twice that in the developed world. Common occurrence in Nigeria includes cervical, breast prostate, skin and gastric cancers. Breast cancer is the most prevalent cancer in the world and the second most common cause of cancer related mortality in women worldwide (Parkin et al., 2005). It also accounts for 23% (1.38 million) of the total new cancer cases and 14% (458,400) of the total cancer deaths in 2008 and ranks fifth as cause of death (Ferlay et al., 2010). Breast cancer is common in women both in the developed and the developing countries, comprising 16% of all female cancers. Although it is thought to be common cancer in the developed countries, majority (69%) of all breast cancer deaths occurs in developing world. Indeed, increase life expectancy, increase urbanization and adoption of western lifestyles have increased the incidence of breast cancer in the developing countries [see Kanavos, 2006; Berry et al, 2006; Lin et al, 2011; Parkin and Fernandoz, 2006; Stewart and Kleigues, 2003]. According to the Nigerian Cancer Organisation and Resources (2017), the risk of getting cancer in Nigeria before age 75 years was put at 10.4%.

The accurate incidence of malignant disease even in the most advanced communities presents many problems. In developing countries where vital statistics are not available the problem becomes even more complex and difficult. This research work records an attempt to assess the incidence of cancer disease in Niger State. The State appeared to be well suited for such investigation, it has been providing Secondary Health Care facilities and services as well as operating its Primary Health Care system. The State has a Federal Medical Centre at Bida, a State

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Specialist Hospital at Minna and a Referral Hospital also at Minna. Other General Hospitals are located in Bida, Minna, Kontagora, Suleja and Lapai. Also, there are eight Rural Hospitals located at Agaie, Mokwa, Lemu, Paiko, Kuta, Wushishi, Agwara and New Bussa. In addition to these, there are 256 Primary Healthcare Centers with at least one located in each Local Government Area in the State. There are over 160 private health care establishments (clinics, maternity homes, etc.) in the State. There are four major health institutions in the State. Located in Minna, the State capital, are the School of Midwifery and School of Health Technology; while there is one each of School of Nursing and School of Health Technology at Bida and TuganMagajiya, respectively. These provide the middle manpower needs of the State in the health sector.

The objective of this work is to compare the identified models and use the appropriate model to bring to knowledge the possible trends of cancer in Niger State, project the number of patients that will visit the hospitals with cancer cases and measure progress in the management of patients with cancer.

MATERIALS AND METHODS

The data collected is for five years period, 2011 to 2015. Methods of linear regression, exponential smoothing and quadratic model were used for the forecast.

Linear Regression **:** In linear regression analysis, the relationship between the variables is assumed to be on a straight line and the dependent variable is to be forecasted. It is of the form:

$$y = a + bx \quad (1)$$

Where:
y = the dependent variable
a = y intercept
b = slope
x = independent variable
The y intercept can be obtained using

$$a = \bar{y} - b\bar{x} \quad (2)$$

Table 1: Annual Data on Cancer Rate 2011-2015 in Niger State

YEAR	OBSERVED
2011	165
2012	110
2013	157
2014	175
2015	203

Source: Niger State Hospital Management Board, Minna, Niger State

And

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} \quad (3)$$

From the data collected in table 1,

$$\bar{x} = 3 \text{ and } \bar{y} = 162 \quad (4)$$

$$b = \frac{2571 - 5(3)(162)}{55 - 5(3)^2} = 28.2 \quad (5)$$

$$a = 162 - b(3) = 77.8 \quad (6)$$

$$y = 77.8 + 28.2x \quad (7)$$

*Exponential Smoothing***:** An exponential smoothing equation is considered to be approximate model for the secular trend component of a time series when the data appears not to fall in a straight line. An exponential trend line is used for the estimation.

$$f_t = f_{(t-1)} + \alpha(A_{(t-1)} - f_{(t-1)}) \quad (8)$$

Where:
f_t = forecast for a particular period
$f_{(t-1)}$ = previous forecast
α = smoothing constant
$A_{(t-1)}$= actual of previous period.

*Quadratic Model***:** A quadratic trend equation is considered to be approximate model for the secular trend component or nonlinear trend of a time series when the data appear not to fall in a linear or straight line, the coefficient of the variable can be estimated by a simple mathematical method.
The quadratic trend model is given by:

$$Y_t = b_0 - b_1(t) + b_2(t^2) \quad (9)$$

Where:
Y_t = Forecast in period t
t = Time period
$b_0, b_1 \text{ and } b_2$ are the quadratic trends

*Measure of Accuracy***:** The mean percentage error (MPE) and the mean absolute percentage error (MAPE) are next used to estimate the accuracy measure.

Table 2: Compilation for Linear Regression

S/NO	Predicted Values	Observed	MPE	MAPE
1.	106.00	165	-55.16	55.16
2.	134.20	110	18.03	18.03
3.	162.40	157	3.33	3.33
4.	190.60	175	8.18	8.18
5.	218.80	203	7.22	7.22
			-18.84	92.42

Table 3: Compilation for Exponential Smoothing

S/NO	Predicted Values	Observed	MPE	MAPE
1.	160.00	165	-3.03	3.03
2.	161.00	110	31.68	31.68
3.	150.80	157	-4.11	4.11
4.	152.04	175	-15.10	15.10
5.	156.63	203	-29.60	29.60
			-37.79	83.52

Table 4: Compilation for Quadratic Model

S/NO	Predicted Values	Observed	MPE	MAPE
1.	153.38	165	-7.58	7.58
2.	138.14	110	18.19	18.19
3.	143.20	157	-9.65	9.65
4.	166.40	175	-5.17	5.17
5.	209.51	203	3.11	3.11
			-1.08	43.62

RESULTS AND DISCUSSION

The accuracy measure among the linear regression, exponential smoothing and quadratic model is further compared to determine which model will give the best forecast. From table 2, 3 and 4, the MPE and MAPE are obtained and represented below.

Table 5: Analysis of accuracy measure

Model	MPE	MAPE
Linear	-18.84	92.42
Exponential	-37.79	83.52
Quadratic	-1.08	43.62

The computed values of accuracy measure shows that the linear regression and exponential smoothing have MAPE of 92.42 and 83.52 respectively and MPE of -18.84 and -37.79 respectively. This is larger than the quadratic model with MAPE of 43.62 and MPE of -1.08. Therefore, the quadratic model is preferred to be used in forecasting of the cancer rate.

Consequently, from the data generated, the following table is obtained.

Table 6: Forecast Using the Quadratic Model

Year	S/No	Predicted Values
2016	6	272.98
2017	7	355.81
2018	8	457.88
2019	9	579.70
2020	10	721.10

The table shows results for the future forecast of the next five years after 2015 that is 2016, 2017, 2018, 2019, 2020 with the forecast values of 272.98, 355.81, 457.88, 579.70, 721.10 respectively which indicated increase in cancer rate. On the average, the rate of cancer increase by approximately 27.5% cases annually. This further affirms the alarm on rising global incidence of cancer as pointed out by the World Health Organisation (WHO, 2017).

Conclusion: Based on the data used in the research and the trend analysis, result revealed the cancer rate forecast in Niger State over five years (2016 to 2020) as 273, 356, 458, 580 and 721 respectively which signified 27.5% annual increase well above the national risk of getting cancer before the age of 75 years fixed at 10.4% . This calls on governments, health practitioners and the general public to take urgent action now to prevent cancer cases. Government should set up a comprehensive cancer control programme.

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