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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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%.

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:

\[ y = a + bx \]  

Where:
- \( y \) = the dependent variable
- \( a \) = y intercept
- \( b \) = slope
- \( x \) = independent variable

The y intercept can be obtained using

\[ a = \bar{y} - b \bar{x} \]  

From the data collected in table 1,

\[ \bar{x} = 3 \text{ and } \bar{y} = 162 \]  

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

\[ a = 162 - b(3) = 77.8 \]  

\[ y = 77.8 + 28.2x \]  

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.

\[ f_t = f_{t-1} + \alpha(A_{t-1} - f_{t-1}) \]  

Where:
- \( f_t \) = forecast for a particular period
- \( f_{t-1} \) = previous forecast
- \( A_{t-1} \) = 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:

\[ Y_t = b_0 + b_1(t) + b_2(t^2) \]  

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>
<thead>
<tr>
<th>S/NO</th>
<th>Predicted Values</th>
<th>Observed</th>
<th>MPE</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>106.00</td>
<td>165</td>
<td>-55.16</td>
<td>55.16</td>
</tr>
<tr>
<td>2.</td>
<td>134.20</td>
<td>110</td>
<td>18.03</td>
<td>18.03</td>
</tr>
<tr>
<td>3.</td>
<td>162.40</td>
<td>157</td>
<td>3.33</td>
<td>3.33</td>
</tr>
<tr>
<td>4.</td>
<td>190.60</td>
<td>175</td>
<td>8.18</td>
<td>8.18</td>
</tr>
<tr>
<td>5.</td>
<td>218.80</td>
<td>203</td>
<td>7.22</td>
<td>7.22</td>
</tr>
</tbody>
</table>

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

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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

<table>
<thead>
<tr>
<th>Model</th>
<th>MPE</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>-18.84</td>
<td>92.42</td>
</tr>
<tr>
<td>Exponential</td>
<td>-37.79</td>
<td>83.52</td>
</tr>
<tr>
<td>Quadratic</td>
<td>-1.08</td>
<td>43.62</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>S/No</th>
<th>Predicted Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>6</td>
<td>272.98</td>
</tr>
<tr>
<td>2017</td>
<td>7</td>
<td>355.81</td>
</tr>
<tr>
<td>2018</td>
<td>8</td>
<td>457.88</td>
</tr>
<tr>
<td>2019</td>
<td>9</td>
<td>579.70</td>
</tr>
<tr>
<td>2020</td>
<td>10</td>
<td>721.10</td>
</tr>
</tbody>
</table>

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.

REFERENCES


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