CHOLERA INCIDENCE AND ITS ASSOCIATED SOCIAL RISK FACTORS IN NIGERIA

Abstract: Cholera disease is one of the major public health issues in Nigeria, with the disease occurring both in sporadic and epidemic scales. Based on the World Health Organisation's record, Nigeria alone has reported 672,345 (53,827) cases and deaths between 1991 and 2017 – the highest from Africa. This study investigated the geographic pattern of cholera cases and deaths in Nigeria, in order to determine its risk factors and areas that are more at risk. A Global Moran Index spatial autocorrelation was employed to determine the clustering of cholera across the country. Disease rate ratios were computed by categorising the 36 states and Federal Capital Territory of the country into four strata based on geographical location; population density; absolute poverty; and adult literacy. The result indicates a significant positive spatial autocorrelation of cholera in all the twelve years investigated (Moran's I = 0.211, z = 2.11, p = 0.004). Clustering is more pronounced in the northern part of the country, most especially in the northeast, while less clustering is found in the southern part of the country.

Keywords: Cholera, Risk factors, Socioeconomic, Nigeria

1.0 Introduction
Nigeria has a number of infectious diseases; one that still remains a threat to public health is cholera, since the seventh pandemic reached the continent of Africa in the 1970s (Barua and Cvjetanovic, 1970; Cvjetanovic and Barua, 1972; Goodgame and Greenough, 1975). The first reported cases of cholera in Nigeria were in 1971 in a village near the then capital city, Lagos, which resulted in a severe epidemic in which 22,931 cases and 2,945 deaths were recorded (WHO, 2013b). In 1991 nearly 59,478 cases and 7,645 deaths were reported (WHO 2011d). According to United Nations figures in 2010, over 1,555 have died from cholera in Nigeria and nearly 40,000 have
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been infected, in the country's worst outbreak for nearly two decades. World Health Organisation's (WHO) data showed that Nigeria reported 672,345 cases and 53,827 deaths between 1991 and 2017 - the highest figures in Africa.

As in the case of other countries in West Africa, the human pathogen vibrocholerae O1 and O139 (Marin, 2013) are responsible for most of the cholera epidemics and outbreaks in Nigeria. The disease has notable seasonality (e.g., Pascual et al., 2002) and varies both spatially and temporally across the globe, and is well documented to have been influenced by climatic, environmental, and social factors (Harris et al., 2012; Leckebusch and Abdussalam, 2015; Sultan et al., 2005; Rajendran et al., 2011). In Nigeria, the disease tends to occur in sporadic, small outbreaks, and even in large epidemics.

The transmission of cholera in Nigeria might be facilitated by numerous factors such as lack of access to safe drinking water, unhygienic environment, environmental disasters, literacy levels, population congestion, and internal conflicts which usually lead to population being displaced to Internally Displaced Persons (IDPs) camps. Provision of safe drinking water remains a serious issue of concern: this leads people, even in cities, to buy water from street vendors, which have high risk of being contaminated. Typical areas at risk might include populations living in urban and peri-urban slums. These areas are mostly densely populated by people on low incomes, and basic infrastructure is not readily available. Despite the availability of the oral cholera vaccines, anecdotal evidence shows that this effective control method is not yet commonly used in Nigeria. The main control method is treatment through rehydration with oral salts after infection. Investigating long term surveillance epidemiological data is necessary in order to understand pattern and dynamics of infectious diseases; this will help improve the controlling strategies. It will also allow for the determining the areas that are at high risk and the disease driving factors. This would be achieved through exploring existing epidemiological records of the diseases using a GIS based statistical techniques.

2.0 Materials and Methods

The overall analysis would be based on national epidemiological, socioeconomic, and demographic data. Descriptive statistics (e.g., Chevallier et al., 2004; Sasaki et al., 2008), and spatial statistical techniques (e.g., Borroto and Martinez-Peidra 2000; Osei and Duker, 2008) were used in analysing the geographical pattern of cholera in Nigeria.
2.1 Disease Data

Epidemiological data were obtained from two sources and at different spatial and temporal resolutions. Firstly, records of annual suspected cholera cases and deaths at state levels between 2000 and 2017 were obtained from the Epidemiology Division at the National Centre for Disease Control (NCDC) of the Federal Ministry of Health (FMoH). These cases are reported by DSNOs in all the 774 Local Government Areas (LGAs) of Nigeria. Although data exists over a longer time period, due to missing values and uncertainties in the record because of the poor surveillance system structure before 2000, annual data has been collected for only 18 years (2000–2017). Secondly, annual national level records of reported cases of both diseases' cases and deaths from 1991 to 2017 were extracted from the archives of the WHO. Figure 1 presents the 36 states and Federal Capital Territory (FCT) in Nigeria, showing the spatial distribution of states level average annual incidence rate of cholera and case fertility rate of cholera, per 100,000 of population between 2000 and 2017.

In Nigeria, a suspected cholera case is defined: “as when a patient of 5 years or older shows symptoms or dies of acute dehydration, even in areas where the disease is not common” (WHO, 2011).
2.2 Demographic and Socioeconomic Data
State's population census (2006) was obtained from the Nigerian Population Commission (NPC), Nigeria. Annual population estimate for each state was calculated forward and backward using Nigerian population growth rate index provided by World Bank. Population density for each state was computed by dividing each state's population with its aerial cover in square kilometres. The Nigerian National Bureau of Statistics (NBS) provides annual socioeconomic data between 2000 and 2017 for individual states in the country for this study. Data collected includes percentages of population living in absolute poverty and adult literacy.

2.3 Analytical Method
Incidence rate (IR) per 100,000 of population and case fatality rate (CFR) for cholera were computed from the WHO national records between 1991 and 2017. IR and CFR were also calculated for each of the 36 states (Figure 1) in Nigeria and the Federal Capital Territory (FCT) Abuja, using the annual state levels cases and deaths reported between 2000 and 2017 obtained from NCDC.
The IR and CFR of the state's level for the 18 years of data (2000 – 2017) were classified into strata based on their respective values. ArcGIS was used to determine the cut-off point of each interval using the Jenks Natural Break method and subsequently mapped using different colours to represent each of the four intervals. This method basically classifies data by minimising and maximising the variance within and between classes respectively (Jenks, 1967). Global Moran's Index spatial autocorrelation technique is used to investigate the extent to which neighbouring values of IR are correlated and to determine cholera demographic risk factors. The spatial weighing function was determined in respect to the length of the common boundaries by assuming that the states that are sharing longer boundaries are more interconnected than states sharing shorter one or no boundary at all (e.g., Borotto and Matinnez-Piedra, 2000).

The 36 states and FCT were classified into strata based on the following variables: geographic location; population density; poverty status; and adult literacy level according to the computed disease IR. Population-based ratios were then computed for each stratum for the identification of high risk areas, using the stratum with the lowest value of IR in each of the four variables as reference point. To determine the association between these variables and diseases' IR, Mantel-Haenszel Chi Square test was used.

Firstly, Nigeria is divided into six geopolitical regions namely: northwest, northeast, North Central, South West, South South, and South East based on the country's geopolitical zones consisting of 7, 6, 7, 6, 6, and 5 states respectively. For the purpose of identifying regions with the high burden and risk of the selected diseases, this official regional classification is adopted. Secondly, population density for each of the 36 states and FCT per square kilometre was computed based on projected 2006 population census. Three strata namely: high, medium, and low densely populated were identified, with each consisting of 11, 11, and 15 states. Thirdly, four poverty strata were identified based on the mean of the percentage of population living in absolute poverty per state between 2000 and 2017. In Nigeria, absolute poverty is defined as the percentage of population with income less than a fixed proportion of median income. Classification was made based on states with very-high, high, medium, and low poverty, with each of the stratum consisting of 11, 11, 10, and 5 states respectively. And finally, states were stratified into four, based on mean percentage of population with adult literacy per state between 2000 and 2017. In Nigeria, adult literacy is measured on the ability to read and write with understanding, in English or in any of the Nigerian native languages. Classification was made as states with very-high, high, medium, and low literate adults, with each of the stratum consisting of 10, 7, 8, and 10 states respectively. The study further investigate the time coherence in terms of inter annual variability of...
both diseases within states in Nigeria, the state level annual cases between 2000 and 2017 were standardised for each state. An average standardised time series from the most affected states were generated for both diseases and correlated with individual states.

3.0 Results

According to the WHO records between 1991 and 2017, Nigeria alone has reported over 672,345 cases of cholera and 53,827 deaths, with a cumulative IR (272.3) and CFR (6.2%). Within the 26-year period of data 59.3% and 76.8% of the total cases and deaths occurred in only 7 years (1991, 1996, 1999, 2003, 2006, and 2010). The highest number of cases (61,629 IR = 63.4) and deaths (7,711 CFR = 12.5%) occurred in 1991, while the lowest cases (3,171 IR = 3.0) and death (149, CFR = 1.1%) occurred in 1994 and 2004 respectively.

Within the 18 years of data (2000 – 2017) over 57% and 67% of cases and deaths were reported from the northern states of the country (Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, and Sokoto). The most affected states in terms of cumulative IR are; Sokoto (38.9), Adamawa (34.2), Borno (33.4), and Gombe (28.4), while the least affected states are from the southern part of the country (AkwaIbom (2.1), Oyo (2.1), Rivers (2.1), and Ogun (2.3).

The Global Moran's Index spatial autocorrelation reveals a statistically significant results (Moran's I = 0.211, z = 2.11, p = 0.004) which suggest a north to south gradient, with higher spatial clustering of IR occurring in the north eastern region of the country (Figure 2). Furthermore, spatial autocorrelation was computed for all years of available state level data and were all found to be statistically significant (p = 0.000 - 0.023).

The clustering of high rates of cholera was persistent in north east and northwest regions in all the years shown in Figure 2. Table 1a shows that cholera incidence is 3.9 and 3.4 times higher in northeast and northwest regions respectively, if compared with the southeast region. Chi Square test shows cholera IR to have a direct relationship with absolute poverty (p = <0.05), population density (p = <0.01), and a negative but significant relationship with adult literacy (p = <0.05). Table 1a – d shows that the IR of the poorest and densely populated strata are 2.3 and 1.8 times higher than that of their respective lowest stratum, while in the adult literacy stratum, IR is 3.2 times higher in population with less educated literates if compared with that of the highly educated ones.
Figure 2: Spatial distribution of states level annual incidence rate per 100,000 for population (left) and case fatality rate (right) of cholera for 2002, 2006, 2010 and the cumulative incidence rate between 2000 and 2017.
Figure 3 shows the time coherence of cholera interannual variability within states in Nigeria, obviously states from the north-eastern and north-western part of the country shows higher similarities in terms of the interannual variability of the disease with the reference time series (0.37 – 0.98). In the southern part of the country only Delta, Lagos, Enugu and Cross Rivers correlated well, while states such as Oyo, Ogun, Ebonyi, Anambra, Abia, Imo, and Benue shows very low or no correlation at all (0 – 0.2).

Table 1: Cholera incidence rate and population-based rate ratio by strata of states classified based on (a) geopolitical locations, (b) population density, (c) percentage of population living in absolute poverty, and (d) percentage of literate adults between 2000 and 2017.

<table>
<thead>
<tr>
<th>Geopolitical region</th>
<th>Cholera cases</th>
<th>Population</th>
<th>IR (per 100,000)</th>
<th>Rate ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>80357</td>
<td>40497542</td>
<td>198.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Northeast</td>
<td>48494</td>
<td>21469225</td>
<td>225.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Northcentral</td>
<td>29208</td>
<td>22933883</td>
<td>127.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Southsouth</td>
<td>18960</td>
<td>23780792</td>
<td>79.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Southwest</td>
<td>20584</td>
<td>31212581</td>
<td>65.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Southeast</td>
<td>10866</td>
<td>18538039</td>
<td>58.6</td>
<td>Reference</td>
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<table>
<thead>
<tr>
<th>Population density</th>
<th>Cholera cases</th>
<th>Population</th>
<th>IR (per 100,000)</th>
<th>Rate ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>98163</td>
<td>57031901</td>
<td>172.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Medium</td>
<td>57425</td>
<td>45166916</td>
<td>127.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Low</td>
<td>52881</td>
<td>56233246</td>
<td>94.0</td>
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<table>
<thead>
<tr>
<th>Absolute poverty %</th>
<th>Cholera cases</th>
<th>Population</th>
<th>IR (per 100,000)</th>
<th>Rate ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>23740</td>
<td>29360751</td>
<td>80.9</td>
<td>Reference</td>
</tr>
<tr>
<td>Medium</td>
<td>40859</td>
<td>39881488</td>
<td>102.5</td>
<td>1.3</td>
</tr>
<tr>
<td>High</td>
<td>69152</td>
<td>49548594</td>
<td>139.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Very high</td>
<td>74718</td>
<td>39641231</td>
<td>188.5</td>
<td>2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adult Literacy %</th>
<th>Cholera cases</th>
<th>Population</th>
<th>IR (per 100,000)</th>
<th>Rate ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>101749</td>
<td>48912976</td>
<td>208.0</td>
<td>3.2</td>
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<tr>
<td>Medium</td>
<td>49855</td>
<td>29962622</td>
<td>166.4</td>
<td>2.6</td>
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<tr>
<td>High</td>
<td>21590</td>
<td>25446225</td>
<td>84.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Very high</td>
<td>35275</td>
<td>54110240</td>
<td>65.2</td>
<td>Reference</td>
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</table>
Figure 3: Time coherence of the interannual variability of standardised cholera cases within states of Nigeria between 2000 and 2017.

Results from this study confirm that absolute poverty, adult literacy and population density are very important social factors in determining the spatial distribution of cholera in addition to climate. For example, previous studies have linked the incidence of cholera in population with less education (e.g., Hashizume et al., 2008), population density (e.g., Penrose et al., 2010), and poverty (e.g., Traup, 2010). Cholera is known to proliferate in population with insufficient education and careless attitudes towards hygienic conditions, lack or limited access to safe drinking water, inadequate facilities for sewage disposal and treatment (Glass et al., 1992). Higher cholera IR and CFR may not be unconnected with these social factors, because most of the states with low adult literacy and high poverty are located in this region.

The result of the spatial autocorrelation should be treated with caution; this is because in Nigeria, national surveillance data may have been marred with uncertainties because of underreporting of cases, particularly in remote villages where access to health care
facilities is difficult or totally absent. Population living in these areas tend not to report cases by resorting to traditional medication, and when death occurred they hurriedly buried the body without reporting. Another issue is the differences in sizes and shapes among the states which may affect the scales of spatial patterns that could be detected. Also the relatively small number of states (only 36 and FCT) may reduce the robustness of the spatial correlation.

5.0 Conclusion
This study analyses the pattern of cholera in Nigeria, and identified the hot spots of the disease in the country. Also, the study has confirmed the important role of social risk factors on the spatial distribution of this infectious disease. Geographical location, poverty, overcrowding and literacy status all appears to be linked to the spatiotemporal distribution of diseases in addition to climate. These results will help in identifying specific regions where research should be focused; it will also help in knowing where attention should be given in terms of human and resource allocation by relevant authorities.

Reference


