Analysis of Monthly Variation and Age-Group Differentials in Cholera Outbreak in Yenagoa, South Southern Nigeria

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Abstract: **The paper considers monthly variation of cholera outbreak and the effect among different age groups in Yenagoa, south southern Nigeria. The data set used spanned from 2016M1 to 2018M12. The method of calculating seasonal variation using monthly index and quarterly index were applied. Chi-Square was adopted to test the homogeneity of cholera across the quarterly indices and different age groups. The results showed that the null hypothesis of no seasonal variation in Cholera cases in Yenagoa is rejected against the alternative and it is significant under 5% level. Hence, the incidence of cholera has seasonal effect in Yenagoa, with peak in the first quarter (January – March) and nadir in the third quarter (July-September). The results also showed that children under the age group (0-14) are the worst hit and represents 87.2 percent of the cases. Therefore, this finding becomes useful for the government and stake holders in terms of disease surveillance and control.**

***Keywords*: Age-group differentials, cholera outbreak, monthly indices, seasonal variation, Test of homogeneity**

I. INTRODUCTION

In the last one to two years, the increasing report on cholera outbreak in Nigerian states has become a concern to the populace. According to LEADERSHIP of August 2nd 2019, Nigeria Centre for Disease Control (NCDC) recorded 83 suspected cases of cholera in three local government areas in Adamawa. According to INDEPENDENT Newspper on the January 31st, 2015, "Bayelsa cholera outbreak death toll now 29, it said that cholera epidemic killed 5 persons in Nembe and a child in Brass areas of Bayelsa. A week before the reporting date, eight persons have been killed in Osiama and Ekede in Sagbama LGA. According to him, the epidemic began between Christmas Eve and early January with 13 persons confirmed death in Igbomotoru area of Southern Ijaw. A resurgence of cholera cases in the northern states primarily in Kano and Kaduna has been reported, but now it is becoming widely spread as it has penetrated states like Rivers, Nasarawa and Ebonyi. Communities like Innoma in Anambra West Local Government Area of Anambra State and Igbomotoru II, Southern Ijaw Local Government Area of Bayelsa State have also been affected. On September 9, 2018, it was reported on the VANGUARD that out of 23,893 Cholera Cases recorded in 18 states 434 persons died as a result of Cholera [20].

Cholera is an acute gastro intestinal infection that characteristically presents with profuse watery diarrhoea and can rapidly result in severe dehydration and death. Its usual mode of transmission is by the oral route [7]. It is a disease of international importance and is immediately noticeable in Nigeria. Cholera caused by Vibrio cholera continues to be a global threat to public health and a key indicator of lack of social development. Once common throughout the world, the infection is now largely confined to developing countries in the tropics and subtropics. It is endemic in Africa, parts of Asia, the Middle East, and South and Central America. In endemic areas, outbreaks usually occur when war or civil unrest disrupts public sanitation services. Natural disasters like earthquake, tsunami, volcanic eruptions, landslides and floods also contribute to outbreak by disrupting the normal balance of nature [19].

According [18] Since the beginning of 2018, a total of 5,607suspected cases have been reported from Nine States (Adamawa, Anambra, Bauchi, Borno, Kano, Nasarawa, Plateau, Yobe and Zamfara). In Nigeria, the infection is endemic and outbreaks are not unusual. In the last quarter of 2009, it was speculated that more than 260 people died of cholera in four Northern states with over 96 people in Maidugari, Biu, Gwoza, Dikwa and Jere council areas of Bauchi state. According to [10], most of the Northern states of Nigeria rely on hand dug wells and contaminated ponds as source of drinking water. Usually, the source of the contamination is other cholera patients when their untreated diarrhoea discharge is allowed to get into water supplies.

On 7 June 2017, the Nigeria Federal Ministry of Health notified WHO of an outbreak of cholera in Kwara State in the western part of the country. The initial cases of acute watery diarrhoea (AWD) started insidiously during the last week of April 2017. Seven stool samples obtained from the initial cases and analysed at the University of Ilorin Teaching Hospital (UITH) laboratory isolated Vibrio cholerae O1 as the causative agent. The number of cases and deaths subsequently increased from the first week of May 2017. As of 14 June 2017, a total of 1,178 suspected cases and nine deaths (case fatality rate 0.8%) have been reported. Four local government areas have been affected, including Ilorin West (508 cases), Ilorin East (303 cases), Ilorin South (96 cases), and Moro (37 cases) [25].

[13] Investigated the outbreak of cholera in Ibadan. In their study, 1384 persons were seen, diagnosed and treated for the disease at the cholera unit, Ibadan from January to December 1996. The outbreak lasted for a whole year. One of their results showed that cholera cases were clustered within the densely populated and poorly planned areas of the city. Though significantly more cases were seen during the rainy season than during the dry season and the deaths were not seasonally related. [17], [9], and [22] each describe a dominant seasonal cycle for classical cholera that is later than then peak of the newer strain, V. cholera El Tor; El Tor is most incident from September to November, just after the monsoon. Several additional studies describe this pattern of two annual El Tor cholera peaks: a smaller spring outbreak in April before the monsoons followed by a larger fall out- break from September to December after the monsoon ([14], [21], [11], [1]). [6] Describe a similar seasonal pattern for another new strain, V. Cholera 0139, when it first appeared in Bangladesh in 1993. These patterns are evident in other areas of the region as well. In Pakistan, classical cholera typically increases from November to January and from April to May ([15], [16]) while in Kolkata, India, seasonal patterns of cholera cases peak in April, May, and June ([8], [12]).

[5] Investigated Seasonality of cholera from 1974 to 2005: a review of global patterns. Using data from 1974 to 2005 as recoded by the World Health Organization Weekly Epidemiological Reports, a database that includes all reported cholera cases in 140 countries. There results suggested that cholera outbreaks demonstrated seasonal patterns in higher absolute latitudes, but closer to the equator, cholera outbreaks do not follow a clear seasonal pattern and concluded that environmental and climatic factors partially control the temporal variability of cholera.

In South America, seasonal peaks are reported in summer months, January to February as well as with the rise in waters following the rainy season in Amazonia, Brazil [2]. Major cholera outbreaks are recorded in eastern African nations including Djibouti, Kenya, Mozambique, Somalia, Uganda and Tanzania where the majority of outbreaks occur following rainfall and/or floods [24]. Recent studies provide possible explanations of how seasonality and endemicity of cholera are maintained ([3] and [5]). The seasonal cycles of cholera appear to be closely associated with changes in flora and fauna populations in the coastal environment [23].

In the south southern Nigeria, no study seems to have focused on the seasonal effect of cholera outbreak and its effect on different age groups in Yenagoa, Bayelsa State. There is no study on the subject matter despite the death toll as a result of the cholera outbreak in the state. It becomes imperative to consider the subject matter for the disease surveillance and control. The remaining part of the paper is arranged as follows; section two presents the materials and methods, section three presents data analysis and results and section four deals with conclusion

II. MATERIALS AND METHODS

This section presents the various methods that were used in the study. It includes seasonal variation framework, chi-square test of homogeneity, Source and method of data collection and test procedures and estimation method and tool used for analysis.

A. Source and Method of Data Collection

The data used in the study is a secondary and collected via transcription from documented records of Federal Medical Centre Yenagoa. And the data set covered the period of 2016M1-2018M12.

B. Seasonal Variation Framework

The method follows a step by step treatment of the data variable under investigation. However, seasonality is a well-known phenomenon in the epidemiology of many diseases, but straightforward analytical method for the examination and evaluation of seasonal patterns are limited. The study employed chi-square test to test the evenness of the quarterly distributions of the reported cases of the disease under investigation.

The procedure is as follows;

- The mean number of Cholera cases adjusted for 30-day month using 31-day months = (Number of reported Cholera for such month × 30)
- Divided by (31 × Number of years).
- The mean number of Cholera cases adjusted for 30-day month using 30-day months = (Number of reported Cholera cases for such month × 30)
- Divided by (30 × Number of years).
- The mean number of Cholera cases adjusted for 30-day month for February is computed to take care of the leap-years = (Number of
- Reported Cholera for February × 30) divided by ((28 × Number of none leap-years) + (29 ×Number of leap-years)).
- Index of Cholera cases (columns (4)) =(Mean Number of Cholera cases in 30-month × 100) divided by (total years annual mean).
- Seasonal variation is computed as the sum of monthly indices in each quarter divided by 3.
- The notes presented below Table1, further clarify any ambiguity in the computational procedures.

C. Chi-Square Test of Homogeneity

Chi-Square test of homogeneity will be adopted to test the null hypothesis that there is no difference in the Cholera cases across the months against the alternative that there is difference in the incidence of Cholera cases across the months (seasonal variation). In other words, the chi-square test is used to test the evenness of the quarterly distribution of the Cholera cases in Yenagoa, and where there is difference in the quarterly distribution, if this is significant, then it adduced that seasonality exist in the incidence of cholera.

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad (1)$$

where, O_{ij} is the observed number of Cholera cases in the i^{th} row and j^{th} column category, E_{ij} is the expected number of Cholera cases and it is obtained using the following formula

$$E_{ij} = \frac{O_{i.} \times O_{.j}}{O_{..}} \qquad (2)$$

where, $O_{i.}$ is the observed column totals, $O_{.j}$ is the observed row totals and $O_{..}$ is the grand total

And the null hypothesis is rejected if $\chi^2 > \chi^2_{0.05,k-1}$ and accepted otherwise.

III. DATA ANALYSIS AND RESULTS

This section presents the estimates of the monthly index of cholera cases, pictorial representation and test of homogeneity in reported cases of cholera across the months (season), across different age-groups and the discussion of results.

A. Index of cholera Analysis

The Table 1 below presents the result analysis of monthly indices of reported Cholera cases in Yenagoa.

Table I. Monthly indices of Reported Cholera Cases in Yenagoa, Bayelsa State

Month of Reported cases of Cholera (1)	*No of reported Cholera (2)*	*Mean no. of Cholera in 30-month (3)*	*Index of Cholera (4)*
January	86	27.7419	380.4169
Februsary	37	13.0588	179.0716
March	34	10.9677	150.3970
April	16	5.3333	73.1340
May	7	2.2581	30.9647
June	13	4.3333	59.4213
July	13	4.1935	57.5043
August	11	3.5484	48.6582
September	5	1.6667	22.8550
October	12	3.8710	53.0819
November	20	6.6667	91.4186
December	12	3.8710	53.0819
Total	256	87.5104	1200.0

Source: Computed by the Author

Notes:

1. Calendar months
2. Reported cases of Cholera by test confirmation
3. Adjustment for 30 - day month
4. (3a) 3 years annual mean for Cholera cases = 87.5104/12 =7.2925
5. Index of Cholera

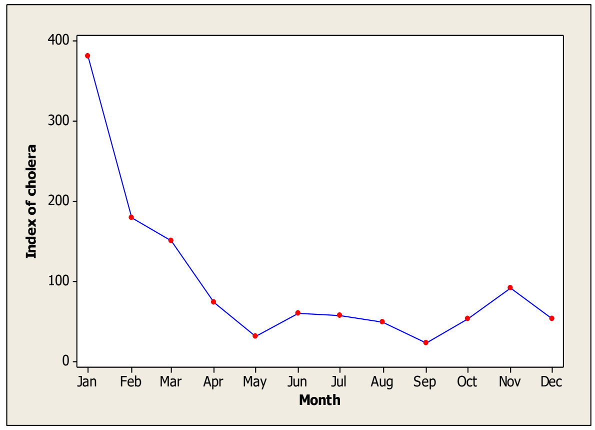

Fig 1. Time plot of monthly Index of Cholera (Adjusted for 30-day Month) in Yenagoa

The distribution of monthly indices of Cholera cases as shown in Figure 1 above indicates that cholera is more prevalence in January, followed by the month of February and then, March. The lowest incidence occurred in September.

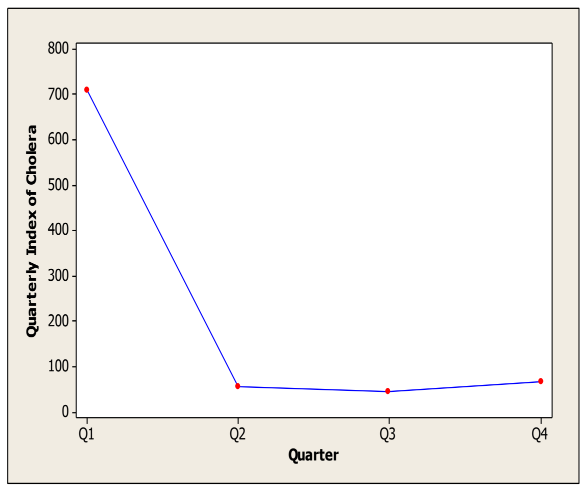

Fig. 2. Plot of quarterly incidence of cholera cases in Yenagoa

Figure 2 presents the graph of seasonal variation in cholera cases in Yenagoa using a pooled data from 2016 to 2018. It is observable that the highest peak occurred in the first quarter (January-March) and the lowest occurred in the third quarter (July-September). This result indicates cholera cases can be more prevalent in the first quarter than any other season.

B. Test of Homogeneity of Cholera Cases across the Season

The season is divided into quarters; each quarter consists of three months. Chi-Square Test of homogeneity is applied to test the hypothesis that there is no difference in the reported cholera cases across the quarters, in other words, there is no seasonal variation in the reported cases of cholera in Yenagoa, and the result is presented in Table 2 below;

Table II. Chi-Square Goodness-of-Fit Test for Observed Counts in Cholera cases

(Quarter)	Observed	Test Proportion	Expected	Contribution to Chi-Sq
1	709.886	0.25	218.315	1106.85
2	54.507	0.25	218.315	122.91
3	43.006	0.25	218.315	140.77
4	65.861	0.25	218.315	106.46
	DF	Chi-Sq	P-Value	
	3	1477.00	0.000	

The observed counts in cholera cases as shown in Table2 above indicates that the null hypothesis of no seasonal variation in Cholera cases in Yenagoa is rejected against the alternative. The Chi-Square value (1477.00) is significant under 5% level as p-value (0.000) is less than 5% level of significance. This result implies that there is difference in the reported cholera cases across the 4 quarters in Yenagoa. Where is hich implies that there is seasonal variation in the incidence of cholera cases in Yenagoa.

C. Test of Homogeneity of Cholera Cases across different Age-Groups

The two-way classification table for test of homogeneity will be used to test the hypothesis that the reported quarterly cases of cholera are the same across four different age-groups in Yenagoa and the result is presented in Table 2 below;

Table III. Observed and Expected Frequencies of Cholera Cases in two-way classification

	0 -14	15 – 29	30 -44	45 and above	$O_{.j}$
Quarter1	143(136.93)	4(6.49)	5(8.26)	5(5.31)	157
Quarter2	27(31..40)	2(1.49)	6(1.89)	1(1.22)	36
Quarter3	20(25.29)	4(1.20)	3(1.53)	2(0.98)	29
Quarter4	42(38.38)	1(1.82)	0(2.32)	1(1.49)	44
$O_{i.}$	232	11	14	9	266

Note that the bold values in the bracket (*) are expected frequencies

Applying Equation(1), the calculated chi-square values becomes;

$$\chi^2 = \frac{(143-136.93)^2}{136.93} + \frac{(27-31.40)^2}{31.40} + \cdots + \frac{(1-1.49)^2}{1.49} = 25.6034$$

The Ch-square table value at $v = (4-1)(4-1) = 9$ under 5% level of significance is presented as $\chi^2_{v,0.05} = \chi^2_{9,0.05} = 16.919$. Since 25.6034 is greater than 16.919, the null hypothesis is rejected in favour of the alternative. Hence, the reported quarterly cases of cholera are not the same across four different age-groups in Yenagoa.

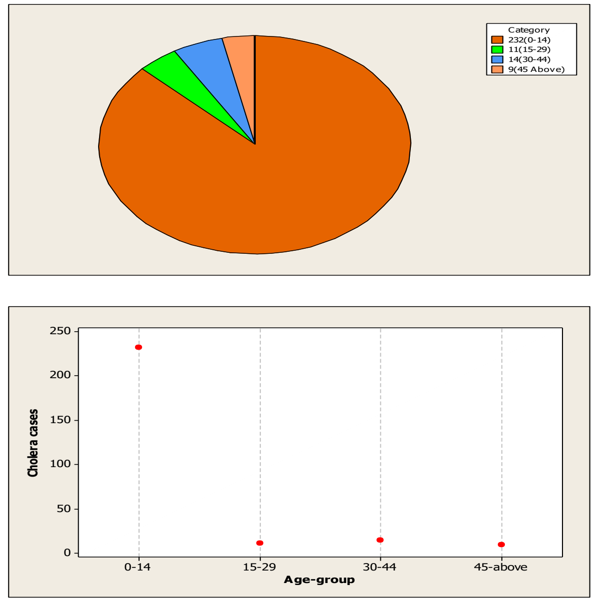

Figure3. Pie chart and line plot of Cholera cases across

Age groups in Yenagoa

The charts in Figure2 above revealed that the incident of cholera cases is more prevalent among age group of (0 – 14) and it represents 87.2% of the cases. Age group (15-29) bear 4.1% of the cases, (30-44) bear 5.3% of the cases and age group (45 and above) represents 3.4% of the cholera cases. This result is clearer looking at the line plot chart in Figure2 above.

D. Discussion of Results

The plot of quarterly incidence of cholera cases in Yenagoa reveals a peak in the first quarter (January – March), this finding is in line with that of [3] who found a seasonal peak of cholera from January to February in Brazil. The result in Table2 reveals the presence of seasonality in cholera cases in Yenagoa. This seasonal pattern has been recognised by many researchers ([5], [18], [10] , [23], [24] and [7]) due to changes in flora and fauna populations in the coastal environment. The seasonal variation of cholera in Yenagoa differs slightly to that of Pakistan, where classical cholera typically increases from November to January and from April to May ([16], [17]) while in Kolkata, India, seasonal patterns of cholera cases showed peak in April, May, and June ([9], [13]).

Again, the incidence of cholera cases across different age group indicates that the age group (0 – 14) represents 87.2% of the cases. This implies that children under the age of 14 are the worst hit and are predominantly affected whenever there is cholera outbreak. The Pie-chart in Figure3 also reveals that the age group 45 and above are the least affected group.

IV. CONCLUSION

The finding of this study showed that there is seasonal effect in the incidence of cholera cases in Yenagoa and the first quarter has the highest number of cases. The result also indicates that children under the age group of (0 – 14) years has the highest incidence rate.

Hence, the findings can be useful to the government and stake holders in the health sector to be proactive in the surveillance and control strategies against cholera outbreak in order to reduce the incidence rate among the age-group of (0 – 14) cholera in the Yenagoa, south southern Nigeria.

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