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SEASONAL EPIDEMIOLOGY OF DIARRHOEA, MALARIA AND PNEUMONIA RELATIVE TO CLIMATIC FACTORS: EVIDENCE FROM ASABA, SOUTH-SOUTHERN, NIGERIA

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ABSTRACT
Understanding the seasonal epidemiology of diarrhoea, malaria and pneumonia relative to climatic factors is the thrust of the study. Empirical monthly data sets used covered the period of 2012M1-2019M12. Graphical exploration, methods of seasonal variability and Chi-square test of homogeneity were employed. The results showed that diarrhoea, malaria and Pneumonia are very high at the peak of rainy season (July-September) especially August, when humidity is relatively high and temperature is low. The result also indicted that the null hypothesis of no seasonal variation in the incidence of malaria and pneumonia is rejected in favour of the alternative as Chi-squared values are significant under 5% level respectively. This implies that the incidence of malaria and pneumonia have seasonal occurrence. However, the findings are imperative for the diseases seasonal determination, surveillance and control in Asaba, south-southern Nigeria.
KEYWORDS: ***Seasonal epidemiology, Diarrhoea, malaria, pneumonia, climatic factors***

1. INTRODUCTION
Climatic factors and their variability play significant role in the incidences of many diseases that affects human health. Weather factors such as temperature, precipitation and humidity are directly related to fluctuations in the incidences and transmission of some diseases through pathogen (viral, bacterial, etc.), bioassay system(rats, etc,), vector (mosquito, flies, etc.), non-bioassay system (water, soil, etc.) and human host. The ability to forecast and identify epidemic events becomes one important component of control efforts that can contribute to the timely implementation of effective prevention and treatment, as recognized by on-going efforts to develop malaria early-warning systems (MEWS) (Cox and Abeku,2001; Thomson and Connor, 2001; WHO-RBM,2001).

Quantifying the role of climate variability, and doing so in the context of epidemiological dynamics, remains an important open problem for these regions and for epidemic malaria in general. Recent developments on parameter estimation for nonlinear dynamical systems now make possible the consideration of epidemiological models that can be confronted to noisy and incomplete data (Ionides *et al, 2006 and* King *et al, 2008).*

However, the observable high incidence rate and severity of some diseases such as diarrhoea, malaria and pneumonia in certain varying weather conditions in many cities in Nigeria, including Asaba has become a concern that spurs the need to research on the above subject matter. Nevertheless, the essence of the study is to empirically examine the seasonality of the aforementioned diseases in relationship to temperature, rainfall and humidity in Asaba, Delta state.

1.1Brief History of Asaba Weather
Asaba is a tropical climate with less rainfall in summer. September accounts for the highest number of rainy days together with the highest relative humidity (85.75 %). And the lowest number of rainy days occurs in December. The month of January has the lowest relative humidity (54.17 %). The temperatures are highest on

average in February, at around 29.0 °C | 84.3 °F. August has the lowest average temperature of the year. It is 25.0 °C | 76.9 °F. The variation in the precipitation between the driest and wettest months is 198 mm | 8 inch. During the year, the average temperatures vary by 4.1 °C | 7.4 °F.

1.2 Diarrhoea and Weather Condition

However, studies have reported different directions in the association between rainfall and diarrhoea disease; some studies have shown positive associations, and others have shown inverse associations. Additionally, both drought and flood have been associated with increased diarrhoea (WHO 2003). Improved understanding of the effects of rainfall extremes and related weather events is necessary to prepare for and address public health in this uncertain future. The World Health Organization (WHO) estimated that between 2030 and 2050, climate change will cause an additional 48,000 deaths per year from diarrhoea alone (**WHO 2018**). Some of this expected increase in risk is related to projected increases in extreme weather events (including flooding and drought).

Chou et al,(2010) examined a climate variation-guided Poisson regression model to predict the dynamics of diarrhoea-associated morbidity. Their results indicated that the maximum temperature and extreme rainfall days were strongly related to diarrhoea-associated morbidity. The impact of maximum temperature on diarrhoea-associated morbidity appeared primarily among children (0-14years) and older adults (40-64years), and had less of an effect on adults (15-39years). Otherwise, relative humidity and extreme rainfall days significantly contributed to the diarrhoea associated morbidity in adult. Wang *et al.,* (2019) studied the lag effect and influencing factors of temperature on other infectious diarrhoea in Zhejiang province and the source of heterogeneity on other infectious diarrhoea (OID) concluded that either high or low temperature could increase the risk of OID, with a lag effect noticed.

Alicia *et al.*, (2020) studied the impact of rainfall on diarrhoea: testing the concentration dilution hypothesis using a systematic review and meta-analysis. Their result showed no linear association between non-extreme rain exposures and diarrhoeal disease, but several studies found a nonlinear association with low and high rain both being associated with diarrhoea and concluded that the effect of rainfall depends on the antecedent conditions. Future studies should use standard, clearly defined exposure variables to strengthen understanding of the relationship between rainfall and diarrhoeal illness.

1.3 Malaria and Weather Condition

The temperature sensitivity to malaria parasites has been established in the past (Boyd,1949, Macdonald , 1957). At lower altitudes where malaria is already a problem, warmer temperatures will alter the growth cycle of the parasite in the mosquito enabling it to develop faster, increasing transmission and thus having implications on the burden of disease (Rogers, 1996 and Sutherst, 1998). Studies in Africa revealed mixed results, with the highest number of malaria cases during the rainy season in Mali (Koram *et al.*,2003 and Dicko *et al.*, 2005). Highest cases of falciparum malaria were found in north-eastern India during the rainy season (Dev and Dash, 2007).

Amaefula. (2010) studied the seasonality of malaria outbreaks in the north-western Nigeria, so as to determine how temperature and rainfall relates to malaria outbreaks. The results showed that at a high temperature (April-May) malaria infection is very low but increases as temperature decreases and fluctuates. And at the peak of the rainy months (July-August), malaria infection is very low but rises through September to its peak in October due to increased number of stagnant pools and sewages which form the breeding habitats for the mosquitoes immediately after the rainy months. Egbendewe-Mondzozo *et al.*,(2011) used a semi-parametric model to show that a marginal increase in temperature and precipitation could cause a significant change in malaria cases in many African countries. Agusto et al.(2015) showed that the optimal temperature for malaria transmission in 67 cities in sub-Saharan Africa lies in the range [16–28]°C.

1.4 Pneumonia and Weather Condition

Pneumonia is a common illness which occurs in all age groups, and is a leading cause of death among the elderly, children under five years and people who are chronically and terminally ill. Pneumonia claims more children less than 5 years of age in Nigeria (Onche, 2009; Falade and Osinusi, 2009).

Oluleye and Akinbobola (2010) investigated the relationship between malaria, pneumonia, rainfall and air temperature over Lagos, Nigeria. Their results showed that coefficient of correlation between rainfall and pneumonia was high in the range of 50 and 90% and positive in February, May, July and August. The months of March, April, June, September, October and December also showed positive correlation but the coefficients are so weak and insufficient. An increased incidence of malaria in north-west of India has been suggested through computational modelling (Laneri *et al.*, 2010).

Rahman *et al.*, (2011) found the highest number of malaria (135), diarrhoea (266) and pneumonia (371) cases occurred during the rainy season. The findings are consistent with other national and international studies.

In the Chittagong hill tract districts of Bangladesh, where malaria is most endemic, the frequency of cases was highest in rainy season. Unfortunately, very few studies on the relationship between various environmental variables and trends of infectious disease incidence have been performed so far in Bangladesh, although there are reports of some infections increasing sporadically in different regions of the country (Rahman, 2008; Huq and Ayer, 2008; Kabir *et al*.2016). Climate change and health related studies are so far mainly reported from developed countries, but studies from vulnerable countries are still meagre (Akompab *et al.*, 2013, Maibach *et al.*, 2008)

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

2. MATERIALS AND METHODS

The section presents the materials and methods used in the study. The Framework for calculating and testing for seasonal variation, chi-square test of homogeneity, source and method of data collection and tool used for analysis are succinctly presented under this section.

2.1. *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 Asaba. And the data set covered the period of years (2012M1-2019M12).

2.2 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 malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases adjusted for 30-day month using 31-day months = (Number of reported malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases for such month × 30) divided by (31 × Number of years).
- The mean number of malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases adjusted for 30-day month using 30-day months = (Number of reported malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases for such month × 30)divided by (30 × Number of years).
- The mean number of malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases adjusted for 30-day month for February is computed to take care of the leap-years = (Number of reported malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases for February × 30) divided by ((28 × Number of none leap-years) + (29 ×Number of leap-years)).
- Index of malaria, pneumonia, diarrhoea, temperature, rainfall and relative humidity cases (columns (4)) =(Mean Number of Malaria /typhoid 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 mathematical representation is as follows;

$$\left.\begin{aligned} Q1 &= (M1 + M2 + M3)/3 \\ Q2 &= (M4 + M5 + M6)/3 \\ Q3 &= (M7 + M8 + M9)/3 \\ Q4 &= (M10 + M11 + M12)/3 \end{aligned}\right\} \quad (1)$$

2.3 *Chi-Square Test of Homogeneity*

Chi-Square test of homogeneity will be adopted to test the null hypothesis that there is no seasonality effect on the occurrence of these diseases (malaria, diarrhoea and pneumonia cases) across the quarters (seasonal variation). In other words, the chi-square test of homogeneity is used to test whether the quarterly indices are the same. If the Chi-square value is significant, the null hypothesis is rejected in favour of the alternative. Then it is adduced that seasonality exist.
The formula is;

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

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

$$E_{ij} = \frac{O_{i.} \times O_{.j}}{O_{..}} \quad (3)$$

where, $O_{i.}$ is the observed column totals, $O_{.j}$ is the observed row totals and $O_{..}$ is the grand total. The null hypothesis is rejected if $\chi^2 > \chi^2_{0.05,k-1}$. Note that the p-value is not significant if the null hypothesis is rejected. The following are the statement of the hypothesis

H_{O1}: There is no seasonal effect in the occurrence of diarrhoea.
H_{A1}: There is seasonal effect in the occurrence of diarrhoea.

H_{O2}: There is no seasonal effect in the occurrence of malaria
H_{A2}: There is seasonal effect in the occurrence of malaria.

H_{O1}: There is no seasonal effect in the occurrence of pneumonia.
H_{A1}: There is seasonal effect in the occurrence of pneumonia.

Decision Rule: If χ^2 value is greater than χ^2 - table value we reject the null hypothesis (H_o) and accept the alternative hypothesis (H_1), and if otherwise, we accept the null hypothesis (H_o) and reject the alternative hypothesis (H_1) at 5% level of significance

3.DATA ANALYSIS AND RESULTS

This section presents the estimates of the monthly indices of temperature, rainfall and humidity and diseases such as diarrhoea, malaria and pneumonia cases. The pictorial representation of the interaction between the climatic factors and these diseases, test for seasonal variation and the discussion of results are also presented under this section.

3.1Analysis of Monthly Indices

The Table 1 below presents the analysis of monthly indices of the climatic factors and the diseases under study in Asaba, Delta State.

Table1. Monthly indices of Temperature and Rainfall in Asaba, Delta State

Month Of Reported Cases (1)	*Mean Temperature (^{0}C) (2)*	*Mean temperature Adjusted for 30-day month (3)*	*Index of Temperature (4)*	*Mean Rainfall (mm) (5)*	*Mean rainfall adjusted for 30-day month (6)*	*Index of rainfall (7)*
Jan	18.625	2.253	83.47	7.24	0.8758	4.307
Feb	21.625	2.833	104.96	15.54	2.0358	10.012
Mar	23.75	2.873	106.44	62.31	7.5375	37.067
Apr	23.25	2.906	107.67	155.11	19.3888	95.349
May	22.65	2.740	101.52	213.24	25.7952	126.854
Jun	23.375	2.922	108.26	246.7	30.8375	151.650
Jul	22.375	2.707	100.29	336..88	40.7516	200.405
Aug	22.0	2.661	98.59	341.61	41.3238	203.219
Sep	21.375	2.672	98.99	307.66	37.2169	183.023
Oct	23.125	2.797	103.63	252.68	30.5661	150.316
Nov	21.21	2.651	98.22	59.11	7.3888	36.336
Dec	19.625	2.374	87.96	2.46	0.2976	1.464
Total		32.389	1200.0	2000.54	244.0154	1200.0

Source: Computed by the Author

(1) Calendar Month
(2) Monthly mean temperature
(3) Mean temperature Adjusted for 30-day month

(3a) Temperature annual mean 32.389/12 = 2.6991
(4) Index of temperature = (3/3a)x100
(5) Monthly average rainfall
(6) Average rainfall adjusted for 30-day month
(6a) Rainfall annual mean = 244.0154/12 =20.3346
(7) Index of Rainfall =(6/6a)x100

The monthly index analysis of temperature in Table1 indicates that February - June are relatively high with a peak in June . This implies that the month of June accounts for the highest ambient temperature(108.26% ^{0}C) in Asaba, followed by April(107.67% ^{0}C) and the lowest occurring in January (83,47% ^{0}C). The monthly index of rainfall indicates high precipitation from June – September with the highest peak in August and December accounting for the driest month.

Table2. Monthly indices of Humidity and Reported diarrhoea Cases in Asaba, Delta State

Month Of Reported Cases (1)	*Mean Humidity (2)*	*Mean Humidity Adjusted for 30-day month (3)*	*Index of Humidity (4)*	*Mean Diarrhoea (25)*	*Mean Diarrhoea adjusted for 30-day month (6)*	*Index of Diarrhoea (7)*
Jan	64.875	7.848	82.490	46.625	5.640	100.734
Feb	65.875	8.630	90.709	50.375	6.599	117.862
Mar	76.125	9.209	96.795	50.375	6.094	108.843
Apr	78.0	9.75	102.482	38.5	4.813	85.963
May	79.375	9.602	100.926	46.625	5.640	100.734
Jun	84.875	10.609	111.511	42.875	5.359	95.715
Jul	87.375	10.570	111.101	54.0	6.532	116.666
Aug	86.0	10.403	109.345	57.125	6.910	123.417
Sep	88.375	11.047	116.114	46.125	5.766	102.985
Oct	75.0	9.073	95.366	41.375	5.005	89.393
Nov	76.625	9.578	100.674	48.375	6.047	108.003
Dec	64.875	7.848	82.490	23.0	2.782	49.688
Total		114.167	1200.0		67.187	1200.0

Source: Computed by the Author

(1) Calendar Month
(2) Monthly mean humidity
(3) Mean humidity Adjusted for 30-day month
(3a) Humidity annual mean 114.167/12 = 9.5139
(4) Index of Humidity = (3/3a)x100
(5) Monthly Diarrhoea rainfall
(6) Average Diarrhoea adjusted for 30-day month
(6a) Diarrhoea annual mean = 67.187/12 =5.5989
(7) Index of Diarrhoea = (6/6a)x100

The monthly index of humidity in Table2 shows that June to September are mostly wet with a peak in September while December and January account for the driest months (lowest humid months). Noticeably, the period of high humidity are also the period of high rainy months in Asaba . the monthly indices of Diarrhoea indicates a highest index in August and a lowest index in December and also observably high in the first quarter of the year.

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Table3. Monthly indices of Reported Malaria and Pneumonia Cases in Asaba, Delta State

Month of Reported Cases (1)	*Mean Malaria (2)*	*Mean Malaria Adjusted for 30-day month (3)*	*Index of Malaria (4)*	*Mean Pneumonia (5)*	*Mean Pneumonia adjusted for 30-day month (6)*	*Index of Pneumonia (7)*
Jan	531.875	64.34	102.935	7.10	0.847	38.451
Feb	350.375	45.901	73.435	9.0	1.179	53.523
Mar	402.75	48.720	77.945	11.125	1.346	61.104
Apr	378.5	47.313	75.694	12.5	1.563	70.955
May	491.625	59.395	95.024	20.625	2.419	109.815
Jun	614.0	76.75	122.789	21.625	2.703	122.707
Jul	708.75	85.736	137.166	32.125	3.871	175.731
Aug	836.875	101.235	161.962	33.875	4.098	186.036
Sep	640.125	80.016	128.015	26.25	3.281	148.947
Oct	490.625	59.35	94.952	15.625	1.890	85.800
Nov	364.5	45.563	72.895	15.25	1.906	86.526
Dec	295.5	35.746	57.189	11.0	1.331	60.423
Total		750.065	1200.0		26.434	1200.0

Source: Computed by the Author

(1) Calendar Month
(2) Monthly mean Malaria
(3) Mean Malaria Adjusted for 30-day month
(3a) Malaria annual mean 750.065/12 = 12.5054
(4) Index of Malaria = (3/3a)x100
(5) Monthly Pneumonia rainfall
(6) Average Pneumonia adjusted for 30-day month
(6a) Pneumonia annual mean = 26.434/12 =2.2028
(7) Index of Pneumonia = (6/6a)x100

The monthly index of malaria in Table 3 above shows high index from June – September with a peak in August. The month of December has the smallest index of occurrence. Pneumonia also shows a high index in the month of May – September with a peak in August and a nadir in January.

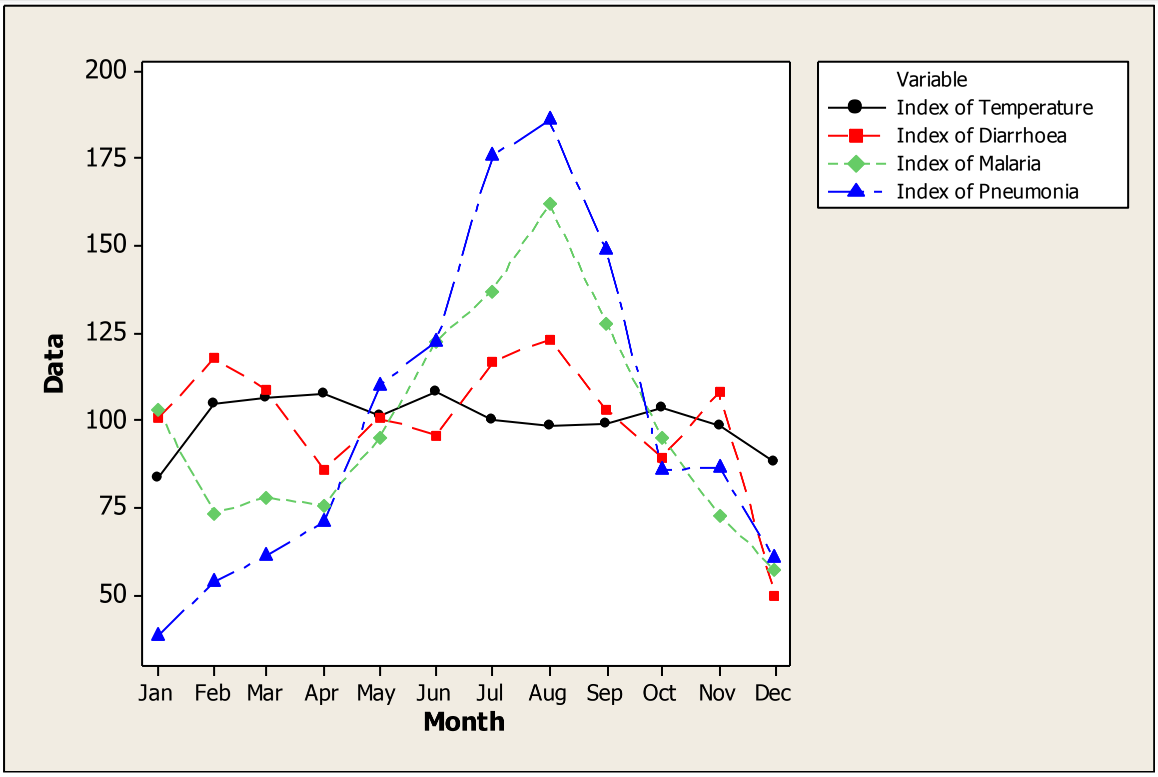

Figure1. Time plot of temperature relative to Diarrhoea, Malaria and Pneumonia in Asaba

The time plot of temperature relative to Diarrhoea, Malaria and Pneumonia in Figure1 reveals that when the temperature index was averagely 98.59, Diarrhoea, Malaria and Pneumonia indices were at their peaks respectively. These three diseases showed very high frequency in the months; June – September with the highest index occurring in August.

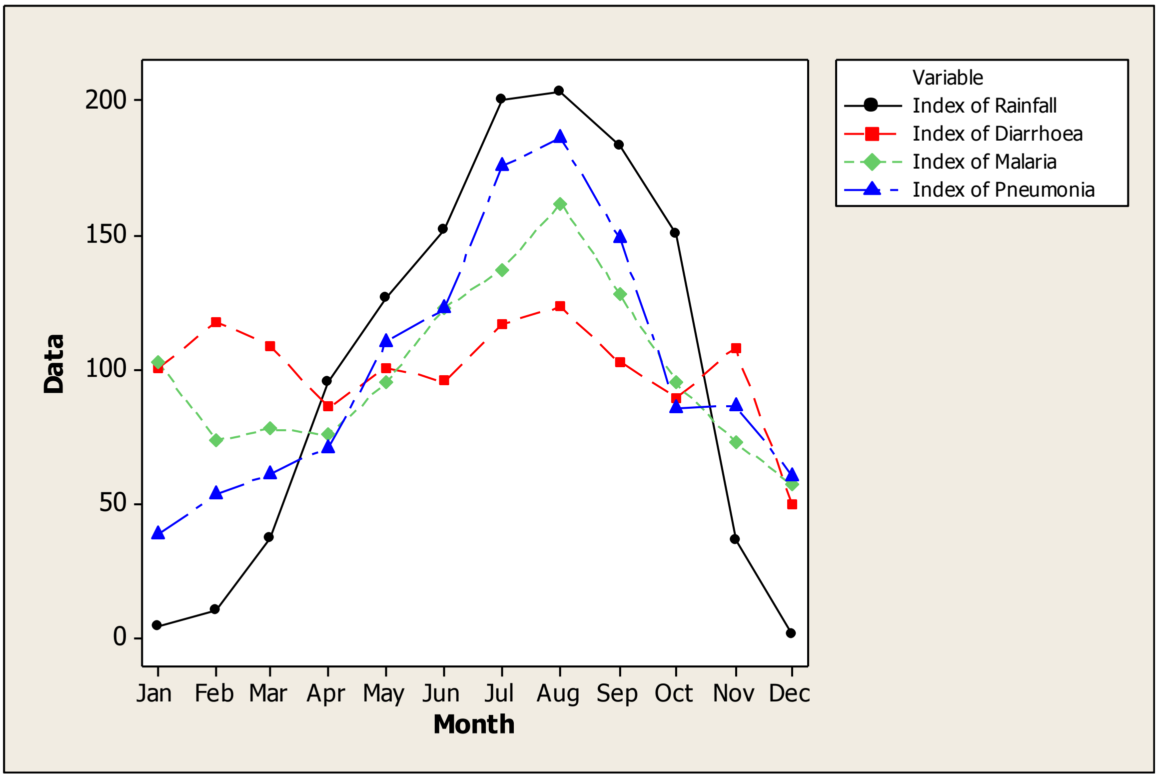

Figure2. Time plot of Rainfall relative to Diarrhoea, Malaria and Pneumonia in Asaba

The time plot of rainfall relative to Diarrhoea, Malaria and Pneumonia in Figure2 reveals that when the rainfall index was at its peak, Diarrhoea, Malaria and Pneumonia indices were at their peaks respectively. It is observable that these three diseases showed a direct relationship with rainfall pattern; as rainfall increases there is a rise in frequencies of the diseases and as rainfall drops there is a drop in the frequency of thesse diseases(or their report index). At the peak of the wet month(August), the index reports of Diarrhoea, Malaria and Pneumonia attend their peak.

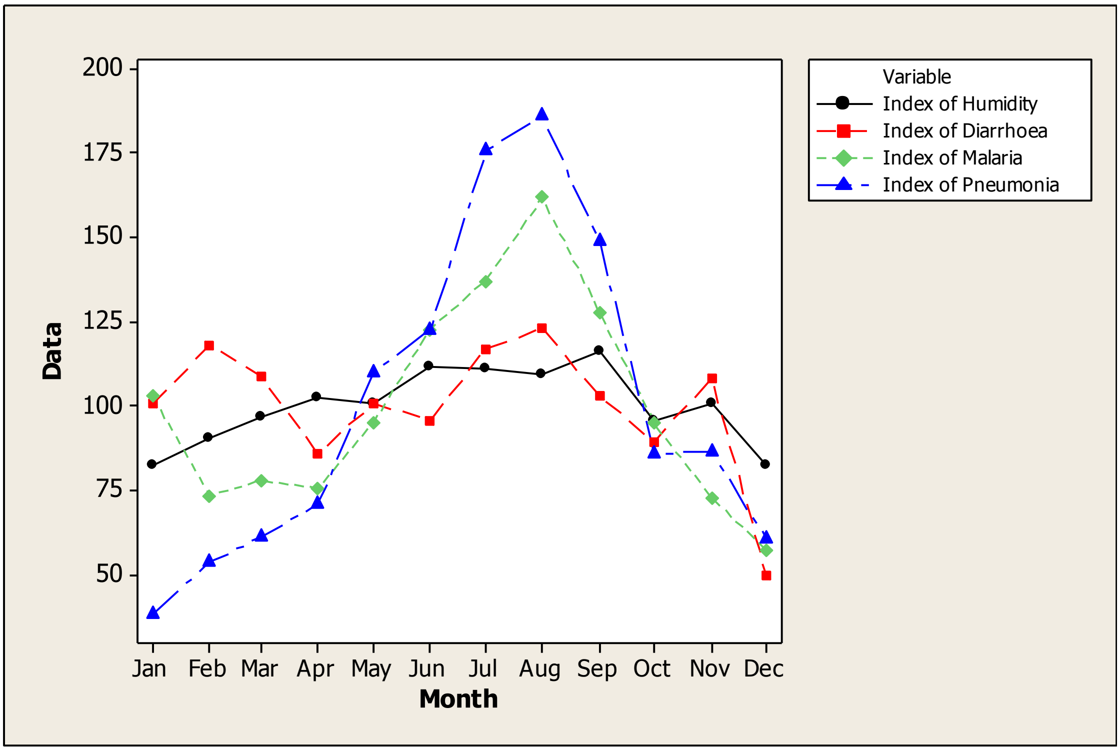

Figure3. Time plot of Humidity relative to Diarrhoea, Malaria and Pneumonia in Asaba

In Figure 3, the index of humidity is highest during the rainy months (June – September) within which the indices of Diarrhoea, Malaria and Pneumonia are also very high. These figures1-3 generally indicates that Diarrhoea, Malaria and Pneumonia are more prevalent in the wet seasons more than the dry or drought months.

3.2Testing for Seasonal Variation

The null hypothesis that there is no seasonal effect (seasonal variation) in the cases of Diarrhoea, Malaria and Pneumonia are carried out using Chi-Square test of homogeneity. In doing so, we divide the monthly indices of Diarrhoea, Malaria and Pneumonia into four quarterly means and test the null hypothesis that the quarterly means are the same.

3.3Analysis of Chi-Square Test of Homogeneity

The Chi-Square Goodness Test of homogeneity for observed quarterly counts in Diarrhoea, Malaria and Pneumonia cases is used to test the hypothesis that there is no difference in the quarterly means (i.e no seasonal variation) are presented in Table 4-6 below;

Table4. Chi-Square Test of Homogeneity for Observed Counts in Diarrhoea

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
1	109.146	0.25	100.000	0.83646
2	94.137	0.25	100.000	0.34373
3	114.356	0.25	100.000	2.06090
4	82.361	0.25	100.000	3.11128
	N	DF	Chi-Sq	P-Value
	400.001	3	6.35236	0.096

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The Chi-Square Test of Homogeneity for observed counts in Diarrhoea cases as shown in Table4 above indicates that the null hypothesis of no seasonal variation in the incidence of Diarrhoea, cannot be rejected. The Chi-Square value is not significant under 5% level as p-value (0.098) is greater than 5% level of significance and the calculated Chi-Square value (6.3524) is less than the table value (7.815). This result implies that there is no difference in the quarterly means. Hence, there is no seasonality in the occurrence of diarrhoea in Asaba.

Table5. Chi-Square Test of Homogeneity for Observed Counts in Malaria

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
1	84.772	0.25	99.9168	2.2956
2	97.836	0.25	99.9168	0.0433
3	142.381	0.25	99.9168	18.0471
4	74.679	0.25	99.9168	6.3749

N	DF	Chi-Sq	P-Value
399.667	3	26.7611	0.000

In Table 5, the Chi-Square Test of Homogeneity for observed counts in Malaria cases indicates that the null hypothesis of no seasonal variation in the incidence of malaria is rejected in favour of the alternative. The Chi-Square value is significant under 5% level as p-value (0.000) is less than 5% level of significance and the calculated Chi-Square value (26.7611) is greater than the table value (7.815). This result implies that there is difference in the quarterly means. Hence, there is seasonal variation in the occurrence of Malaria in Asaba.

Table6. Chi-Square Test of Homogeneity for Observed Counts in Variable: Pneumonia

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
1	51.026	0.25	100.001	23.9856
2	101.159	0.25	100.001	0.0134
3	170.238	0.25	100.001	49.3309
4	77.583	0.25	100.001	5.0258

N	DF	Chi-Sq	P-Value
400.006	3	78.3558	0.000

In Table 6, the Chi-Square Test of Homogeneity for observed counts in Pneumonia cases indicates that the null hypothesis of no seasonal variation in the incidence of Pneumonia in Asaba is rejected in favour of the alternative. The Chi-Square value is significant under 5% level as p-value (0.000) is less than 5% level of significance and the calculated Chi-Square value (78.3558) is greater than the table value (7.815). This result implies that there is difference in the quarterly means. Hence, there is seasonality in the occurrence of Pneumonia in Asaba.

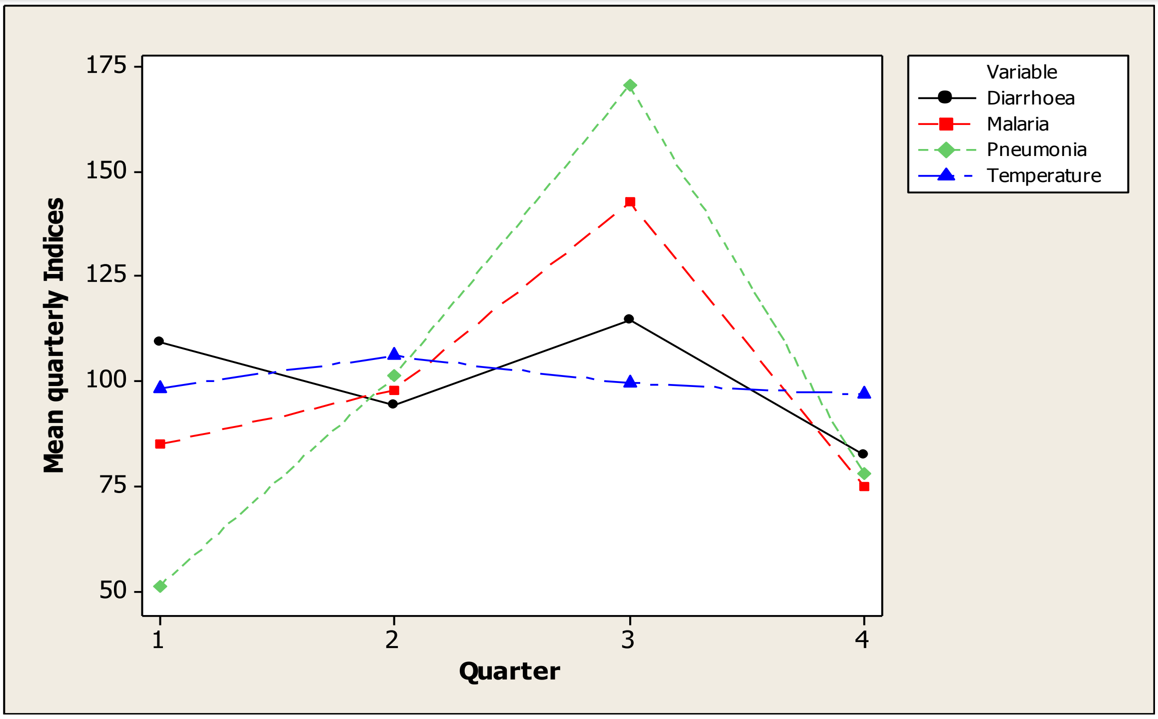

Figure4. Quarterly variation of Diarrhoea, Malaria and Pneumonia relative to Temperature in Asaba

The quarterly variation of diarrhoea, malaria and pneumonia relative to temperature as shown in Figure4 above indicates that Pneumonia and malaria are most prevalence in the third quarter (July-September) when temperature is low.

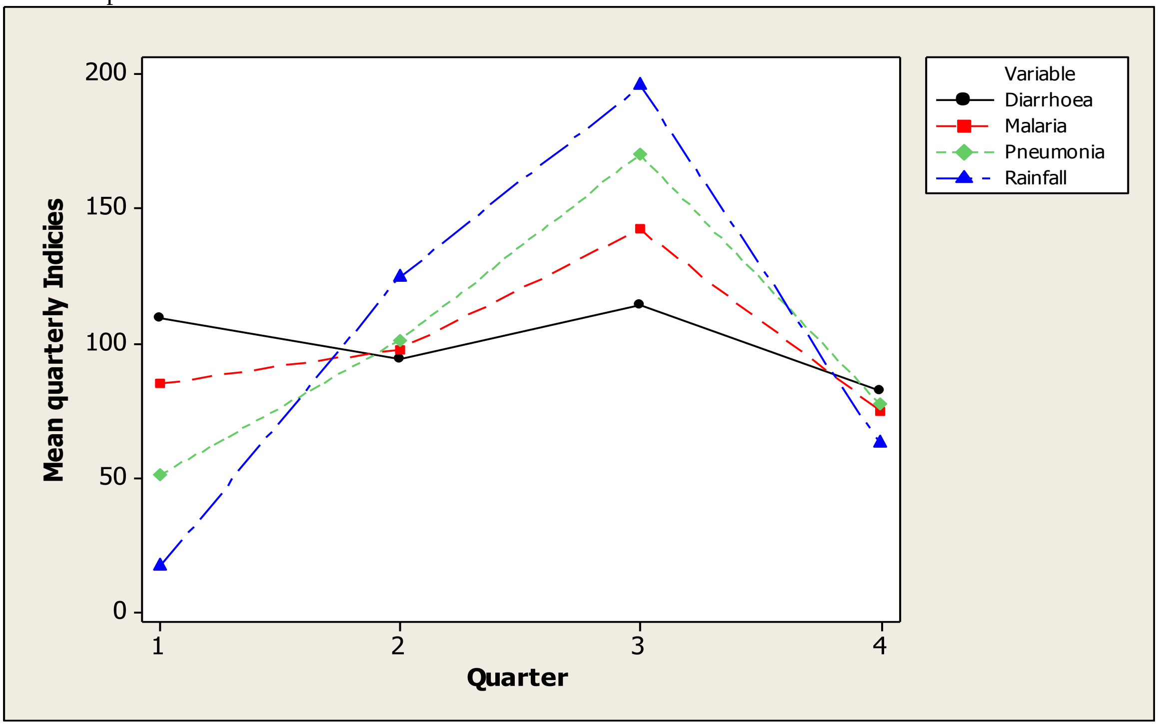

Figure5. Quarterly variation of Diarrhoea, Malaria and Pneumonia relative to Rainfall in Asaba

The quarterly variation of diarrhoea, malaria and pneumonia relative to rainfall as shown in Figure4 indictes that Pneumonia and malaria are most prevalence in the third quarter (July-September) when rainfall is at its peak.

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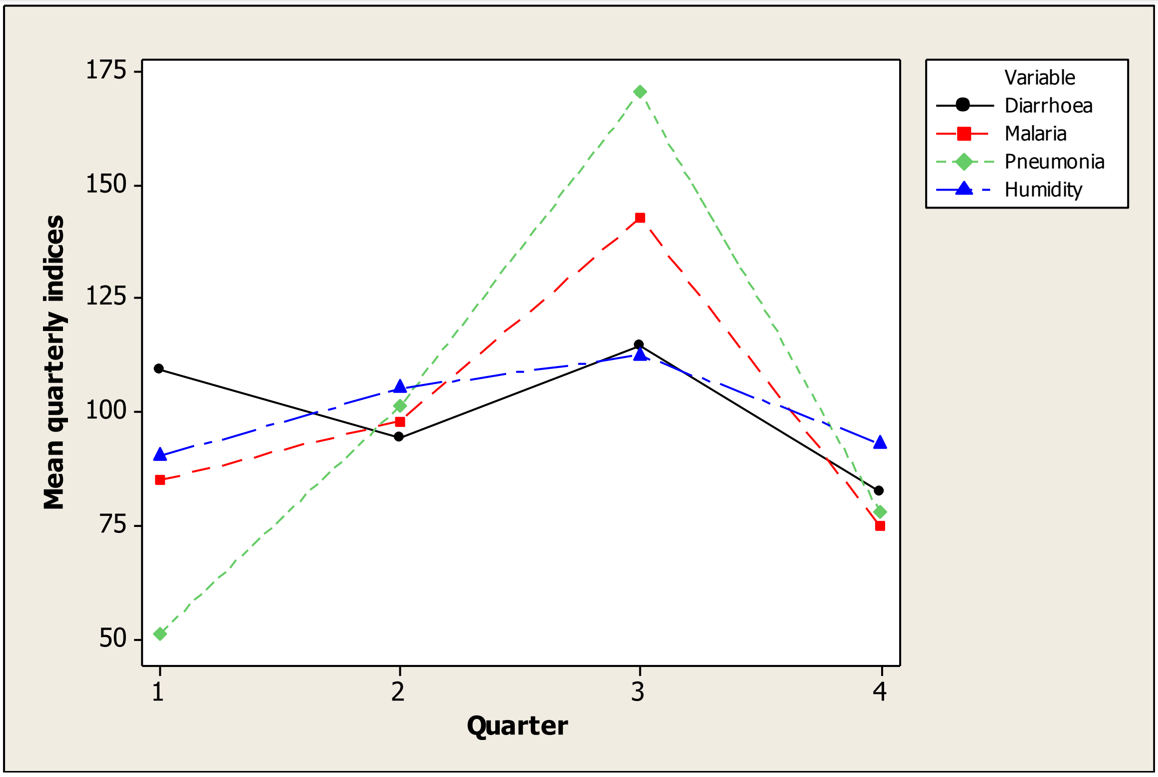

Figure6. Quarterly variation of Diarrhoea, Malaria and Pneumonia relative to Humidity in Asaba

The Figure6 indicted that Pneumonia and malaria are most prevalence when humidity is relatively high in the third quarter (July-September).

3.4 Discussion of Results

The time plot of monthly indices climatic factors relative to Diarrhoea, malaria and Pneumonia in Figure 1-3 generally indicate that the prevalence of the diseases are very high at the peak of rainy season (July-September) especially August , when humidity is relatively high and temperature is low.

Again, a quarterly plot of the diseases as shown in Figure4-6 indicate that the highest incidence of these three diseases occur in the second quarter (Q3), more critical for Pneumonia and Malaria than Diarrhoea. This finding is in line with that of Rahman *et al.*, (2011) for Chittagong hill tract districts of Bangladesh. The finding that malaria is most prevalence within the rainy season and when temperature is low in Asaba is consistent with that of Dicko *et al.*, (2005) for Mali, Koram *et al.*,(2003) for Northern Ghana and Amaefula (2010) for North-Western Nigeria.

The Chi-Square test of homogeneity for observed counts in diarrhoea, malaria and pneumonia cases as shown in Table4-6 above indicate the following; the null hypothesis of no seasonal variation in the incidence of diarrhoea in Asaba, cannot be rejected, implying that observed count in diarrhoea cases does not follow seasonal occurrence. The results in Table 5 and Table6 showed that the null hypothesis of no seasonal variation in the incidences of malaria and Pneumonia were rejected in favour of the alternative, hence the observed counts in malaria and Pneumonia cases follow seasonal occurrence.

4. CONCLUSION

On the basis of the empirical findings, malaria and pneumonia incidences have seasonal occurrences and most prevalence during the rainy season (July-September) or third quarter of the year when temperature is low and humidity is relatively high. Diarrhoea seems not to have seasonal effect but it’s fairly high in the first and third quarters of the year. Hence, the study could be useful to the government and stake holders in the health sector for the diseases study, control and surveillance.

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