Effects of Temperature and Seasonal Variations on the Prevalence and Trend of Diarrheal Diseases among the Under-five Years Children in Yenagoa: 2016-2020

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Abstract

Background: Diarrheal disease is a principal contributor to the high mortality and morbidity rate among under-5-year-old children, especially in middle and low income countries, and temperature and seasons play a major role. Therefore, this study aimed to determine the effects of temperature and seasons on the prevalence and trends of diarrheal diseases in the Yenagoa Local Government Area of Bayelsa State from 2016 to 2020.

Methods: A facility-based cross-sectional study design was employed, using a uniform stratified sampling method to select six healthcare facilities. A data extraction tool was used to extract information on diarrhea cases from patients' folders in the pediatrics wards while meteorological information was obtained from the NIMET archive. Data was analyzed using SPSS version 25. Descriptive statistics were presented in frequency tables and expressed in percentages. Chi-square for inferential statistics to compare differences in proportions while Poisson regression was run to determine the trend of diarrhea from 2016-2020 based on temperature and seasons at a 95% Confidence interval and a statistical significance of $p \leq 0.05$.

Results: Out of the 916 cases of diarrhea identified, 395(43.1%) were <1 year, with 439(47.9%) between 1 to 2 years and 82(8.9%) were between 3 to <5 years. Dry seasons (aPR 1.14[95% CI:1.11-1.32], $p = 0.001$), maximum temperature (aPR 1.19[95% CI, 1.13- 1.25], $p = 0.001$), and average temperature (aPR 1.03[95% 1.0-1.22], $p = 0.020$) were all significantly associated with diarrhea occurrence.

Conclusion: Although diarrheal disease is preventable and treatable, yet still endemic and highly influenced by seasons and temperature.

Keywords: Effects of temperature, Diarrheal Diseases, under-five children, Seasons, Bayelsa.

Introduction

The World Health Organization (WHO) in 2016 and 2017 stated that diarrheal diseases are the second most common cause of morbidity and mortality among under-five children. It has global cases of about 1.7 billion yearly, causing approximately 760,000 deaths and also the leading cause of malnutrition in the same population. [1,2] In middle- and low-income countries, diarrhea is known to be the third greatest cause of morbidity

and mortality in children less than five years of age.[3] Although lots of interventions have been done to reduce the burden of the disease in developed and developing countries, it remains a huge public health challenge, especially in South Asia and Sub-Saharan Africa.[1,4]

In Nigeria, it is reported as the second topmost cause of mortality resulting in about 16% of children's mortality twelfth monthly.[5,6] In Bayelsa State, it has a prevalence rate of 17.5% according to recent studies.[7] Also, the State Ministry of Health declared diarrhea disease an endemic disease in Bayelsa State based on recorded cases of mortality and morbidity between the year 2016-2020. Diarrheal diseases can easily be prevented and treated, both at the individual and community levels. The prevention and control of diarrheal diseases are achievable by improving sanitary conditions, timely vaccination, breastfeeding and use of medications, yet its health impact is devastating.[2]

Season is termed as a period within a year that is noticeable with distinct climatic settings that occur separately and repeatedly. Each of these seasons has its unique features and characteristics such as weather patterns, temperature and light reoccurring throughout the year. Its trend of occurrence differs significantly in diverse parts of the world depending on the earth and scientific space.[8, 9] Temperature can be measured for minor time intervals such as days, weeks, months and quarters to assess temperature changes. The effects of changing weather on an organism are enormous and crucial since they affect every aspect of human life, including the transmission of diseases like diarrhea among others.

Previous studies done in several countries have demonstrated that there is a relationship between temperature and the occurrence of diarrheal diseases among under-five children,[10,11,12] but in Yenagoa LGA, there is no documented study to affirm this relationship, although, seasons and temperature occur differently in different geographical locations in the world. Therefore, it became very necessary to study the prevalence and trend of diarrheal diseases within these five years and its relationship with temperature in the pattern of occurrence especially among the most vulnerable group, to provide relevant information required for policymakers, program managers in Yenagoa Local Government Area (LGA) to make and take an informed decision.

Methodology

Study Settings

The study was carried out in Yenagoa LGA of Bayelsa State Nigeria. Yenagoa is one of the eight LGAs in the State, and doubles as the capital city of both the LGA as well as the State. Politically, the LGA consists of three constituencies (Epie/Atissa, Gbarain/Ekpetiama, Okordia/Biseni/Zarama), with fifteen wards. The LGA was stratified into the 3 already existing constituencies as strata for this study. A total of 6 health facilities**,** two from each of the 3 constituencies served as the study site.

Federal Medical Center Yenagoa and Diete Koki Memorial Hospital were selected from constituency1 (Epie/Atissa), General Hospital Agudama-Ekpetiama (GHA) and Niger Delta University Teaching Hospital (NDUTH) were selected from constituency 2(Gbarain/Ekpetiama) while Cottage Hospital Tein-Biseni (COT HOSP BI) and Egbebiri Primary Health Centre (PHC EGB) from constituency 3 (kordia/Biseni/Zarama). Except for COT HOSP BI, all other tertiary and secondary health facilities have pediatric wards with a general bed space ranging from 425 (FMCY) to 22 (GHA). The level of care is higher in the tertiary facilities because of the level of infrastructure and specialized manpower.

Study population

The study was a facility-based study with under five years of children as its population. Those eligible for this study were children under five years with suspected cases of diarrheal disease, whose parents resided in Yenagoa LGA of Bayelsa state, and who reported in any of the selected health facilities within the study period. Those who had underlying chronic health, conditions were excluded from the study.

Study Design:

Cross-sectional study design was employed in this study to determine the effects of temperature on the prevalence and trend of diarrheal diseases among the under five years children in the Yenagoa LGA.

Sample size

A sample size of eight hundred and eighteen was estimated using Cochran's formula for a single proportion, $n = [Z^2pq]/d^2$: $q = 1-p$,[13] with a 10% non-response rate.

where n = sample size, Z = standard normal deviate at 95% confidence level (Z= 1.96)

p = proportion (22.5% = 0.225), the prevalence of diarrhea from a previous study[14]

d = margin of error = 0.05

Sampling techniques

A unified stratified sampling method was applied in selecting a total of six health facilities from the already existing 3 constituencies that served as a strata for this study. Two health facilities in each of the constituencies were selected. These health facilities consisted of two tertiary, three secondary, and one primary healthcare facility. The tertiary health facilities were Federal Medical Centre Yenagoa in Constituency 1, and Niger Delta University Teaching Hospital (NDUTH) Okolobiri in Constituency 2. The secondary health facilities were Diete Koki Memorial Hospital (DKMH) Opolo in Constituency 1, General Hospital Agudama-Ekpetiama in Constituency 2, and Cottage Hospital Tein Biseni in Constituency 3. The only primary health facility was Egbebiri Health Centre in Constituency 3.

Data Collection

Data extraction tools were used to extract secondary data from the folders of the patients (under-five children diagnosed with diarrhea), and also from the Nigeria Metrological Agency (NIMET) archive. NIMET is a government agency that is by law saddled with the responsibility to observe, analyze, and report weather and climate information timely and accurately for all aspects of socio-economic development and safety of lives and property including health. The tool for the health facilities sought information about the health facility, the child's social and demographic data, and the information about diagnosis within 2016-2020. The data extraction form was used to extract information about temperature from 2016-2020 from the archive of NIMET.

Data Analysis

Data collected were entered and analyzed in statistical product and service solution (SPSS) version 25. Descriptive statistics were presented in frequencies and percentages, while chi-square was used for the inferential statistics, in comparing differences in proportions of diarrhea cases in the different years. Poisson regression was run to predict the prevalence of diarrhea in the last 5 years based on temperature and seasons at a 95% Confidence Interval and a statistical significance set at $p \leq 0.05$.

Ethical Consideration

Ethical clearance was obtained from the Research and Ethics Committee, University of Port Harcourt, Nigeria. UPH/CEREMAD/REC/MM89/195. Other ethical clearance certificates were obtained from the FMC Yenagoa (FMCY/REC/ECC/2021/MAR/301), Nier Delta University Teaching Hospital (NDUTH/REC/2021/0030/2150), and DKMH (DKMH/ADM/122/187/49). Permission was sought from the administrative heads of the other health facilities. The data was extracted from the individual folders from the Paediatrics Department/ward of the various selected health facilities. The information extracted from the hospital data bank was only used for research purposes and was kept confidential.

Results

A total of 916 folders were retrieved and data extracted from them. From Table 1, children 1 – 2 years old were 439(47.9%) and suffered from diarrheal diseases more than the rest of the under-five years children. The mean age of the children was 1.8 ± 0.98 years. Diarrheal diseases reported in the health facilities indicated that the disease occured slightly more in males, 509(55.6%) than in females. More cases were reported in the FMCY' 373(40.72%) compared to other facilities studied. A higher number of diarrheal cases were observed in 2017 and 2019 compared to the rest of the years, although the trend was not statistically significant (p=0.432) as shown in Table 2.

Similarly, Figure 1 shows the prevalence of diarrheal diseases in the different years with 2016 and 2017 having the highest prevalence of reported diarrheal cases (4.4%) while the least was reported

in 2018 (1.7%). In considering diarrheal distribution in the seasons in Table 3, it appeared to be slightly more in the dry seasons all through the five years with no statistical significance.

Table 4 shows that the average maximum and minimum temperatures for the five years differed significantly (p = 0.001) when summarized. They were more statistically significant in 2020 (24.45 ± 0.77) and 2019 (34.92 ± 2.95) Meanwhile, Figure 2 shows the relationship between temperature and diarrheal diseases throughout the study period. During the dry seasons when the temperature was most likely to increase, diarrhea also increased and became low during the wet season.

In Table 5 Poisson regression model II was run to confirm model I in predicting the occurrence of diarrhea in 5 years (2016-2020) based on temperature and seasons. It was revealed that maximum temperature {1.19 (95% CI, 1.13 to 1.25)}, $p = 0.001$.), dry season {1.14 (95% CI, 1.11-1.32)} $p = 0.001$), and the average temperature {(1.03(95% CI 1.0-1.22)}, $p = 0.020$) were all significantly associated with the occurrence of diarrhea.

Table 1: Patient and facility characteristics (*n=916*)

Variable	Frequency	Percent
Age		
<1	395	43.1
1-2	439	47.9
3-5	82	9.0
Mean	***1.18 ± 0.98 years***	
Gender		
Male	509	55.6
Female	407	44.4
Facility		
COT HOSP BI	58	6.3
DKMH	211	23.0
FMCY	373	40.7
GHA	76	8.3
NDUTH	149	16.3
PHC EGB	49	5.4
Facility type		
Primary	49	5.3
Secondary	345	37.7
Tertiary	522	57.0
Constituency		
1	668	73.0
2	136	14.9
3	111	12.1

COT HOSP BI - Cottage Hospital Biseni. DKMH - Diete Koki Memorial Hospital. PHC - Primary Health Center. NDUTH - Niger Delta University Teaching Hospital. GHA- General Hospital Agudama-Epie. FMCY- Federal Medical Hospital Yenagoa

Table 2: Diarrhea cases seen during 2016-2020 (*n=916*)

Variable	Frequency (%)	95% CI	Cochran-Armitage test for trend
Diarrheal cases			
2016	172 (18.78)	16.33 - 21.49	chi-sq. = 0.618
2017	224 (24.45)	21.73 – 27.40	P = 0.432
2018	112 (12.23)	10.21 – 14.57	
2019	211 (23.03)	20.37 – 25.93	
2020	197 (21.51)	18.92 – 24.34	

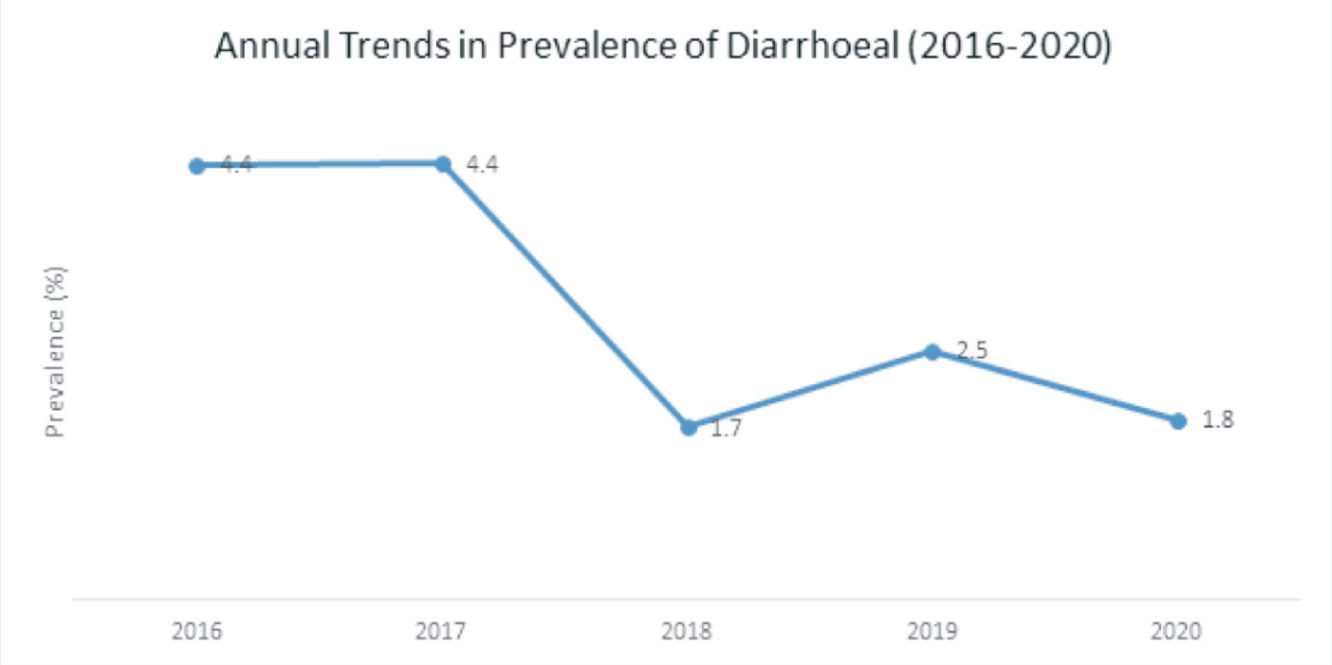

Figure 1: Annual Trends in Prevalence of Diarrheal Diseases (2016-2020)

Table 3. Seasonal distribution of diarrheal cases for the period 2016–2020 (*n=916*)

Variable	Frequency	Percent
Seasons		
Wet season (April-October)	380	41.48
Dry-season (Nov-March)	536	58.52

Table 4: Temperature summarized for the study period 2016–2020.

Variable	Minimum Temperature (°C)	Maximum Temperature (°C)
	Mean ± SD	**Mean ± SD**
Year		
2016	19.76 ± 2.69	29.28 ± 1.43
2017	22.52 ± 2.71	29.15 ± 1.82
2018	24.28 ± 0.64	32.08 ± 1.86
2019	22.57 ± 3.94	34.92 ± 2.95
2020	24.45 ± 0.77	32.82 ± 2.95
Overall	**22.72 ± 2.99**	**31.65 ± 3.04**
ANOVA (p -value)	6.84 *(0.001)**	15.46 *(0.001)**

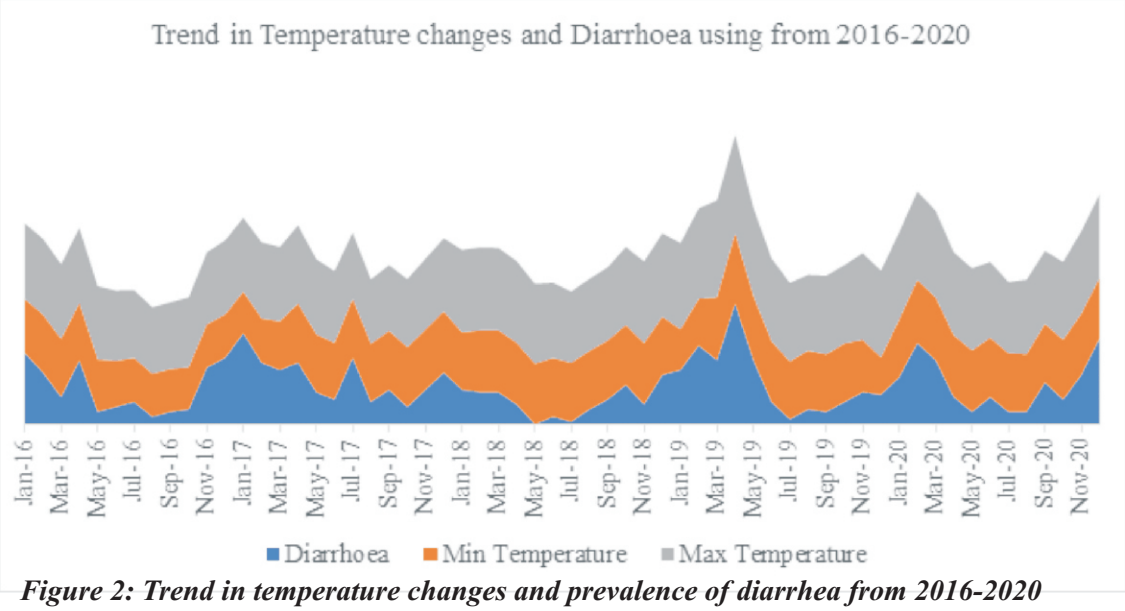

Figure 2: Trend in temperature changes and prevalence of diarrhea from 2016-2020

Table 5: Association between seasonal variation and occurrence of diarrhea using Poisson Regression Analysis (*n=916*)

Variables	Model I		Model II	
	cPR [95% CI]	**P-value**	**aPR [95% CI]**	**P-value**
Minimum Temperature	1.02 [0.99-1.05]	0.108	1.0 [0.98-1.03]	0.783
Maximum Temperature	1.24 [1.20-1.28]	0.001*	1.19 [1.13-1.25]	0.001*
Dry-season (Nov-March)	1.12 [1.09-1.22]	0.001*	1.14 [1.11-1.32]	0.001*
Wet-season (April-October)	0.91 [0.951-0.998]	0.001*	0.90[0.991-0.999]	0.002*
Average Temperature	1.18 [1.13-1.22]	0.001*	1.03[1.0-1.22]	0.020*

***Statistically significant (p<0.05); Notes: R=reference, cPR=crude Poison Regression, aPR=Adjusted Poisson Regression**

Discussion

Analysis was carried out on 916 datasets of diarrheal cases which were extracted from the patients' folders from the six selected health facilities, and out of this number, the study revealed that about two out of every five children were < 1 year old, a little lower than children between the age of 1-2 years. Their mean age was 1.8 ± 0.98 years. This finding is consistent with most studies, that diarrheal diseases among under five years children are more common among 0-2 years old. [15,16,17,18] This revelation may be due to the weak immune status of this age group, their closeness to the floor or ground, and picking up dirt in the mouth especially when left unattended. This current study also discovered that cases of diarrhea occur more in males than females with no significant statistical difference. This is in agreement with other studies both in and out of Nigeria [19,20, 21] but contrary to others.[17]

In this study, diarrheal diseases occurred throughout the five years although a higher prevalence was reported in 2016 and 2017. This finding is an indication that diarrheal disease is endemic and can occur at any time irrespective of the time or year. These yearly figures are seemingly higher than that of the State as revealed by the Nigeria Demographic and Health Survey 2018 two-week survey. [21] Other higher prevalences of diarrhea recorded were that of Kaduna North LGA in Nigeria,[15] Somalia [12] Kenya[22] and Ethiopia.[23] The recorded difference may be due to the most prevailing predisposing factor(s) in the region. Again, the endemicity of diarrheal diseases as shown in this and related previous studies is common among under-5years children especially in Africa and South Asian countries because of a lot of under developmental issues (poor housing facilities, lack of portable water etc.), causing a huge health challenge that is capable giving birth to high morbidity and mortality rate.

From November to March the dry season sets in in Nigeria at large. This study revealed that there is a positive association between dry season and diarrheal diseases. The outcome of Poisson model II predicted a 1.14 times increase in diarrheal cases in the dry seasons. Similarly, temperature and diarrheal also have a positive correlation, because temperature tends to be higher in the dry seasons often times. The exponential value of the maximum temperature was 1.19. This means that the prevalence of diarrheal will be 1.19 times greater for every 1°C increase in temperature. Other previous studies from Bangladesh, China, and Ethiopia, and a systematic review carried out in 26 studies confirmed a positive significant association between temperature and all causes of diarrheal. [24, 11, 20, 25]

This finding may be because the high temperature provides a favorable condition for the breeding and multiplication of causative agents to thrive. The dry weather also gives children freedom especially those 1-2 years to crawl or play around, picking substances into their mouths, and because of their low immune status, they are most likely to come down with diarrhea cases.

Temperature, seasons and other predictors (social, economic, environmental, and behavioral factors) mentioned in other studies [7,15,19] are influential to the occurrence of diarrheal diseases in Yenagoa LGA of Bayelsa State. A study done by Jeff stated that seasons vary in different regions and locations globally.[9] Therefore it influenced the outcome of diseases (diarrheal diseases). The findings in this study show that dry season maximum and average temperature are positive predictors of diarrheal diseases in the Yenagoa LGA this is in line with Nan-nan et al. [20]

The study was retrospective and data collection was restricted to only health facilities, thereby depending on only cases that were reported in the facilities. This implies that the true prevalence and causes of diarrheal cases might not be ascertained. The study also considered the occurrence of diarrheal based on the variations of seasons and temperature but the findings of the study can be generalized to a geographical area that experiences the same seasonal and temperature pattern.

This study revealed that the influence of seasonal variations and temperature on the occurrence of diseases (diarrheal) is relative to the geographical locations considering other predictors. In the Yenagoa Local Government Area of Bayelsa state where we have low land and more wet seasons the occurrence of diarrheal tends to decrease and increase during the dry seasons. Therefore, when other places like the northern part of Nigeria are

experiencing outbreaks of diarrheal diseases in the rainy seasons Yenagoa local government should expect theirs in the dry seasons and prepare proactively to prevent zero deaths.

Conclusion

In conclusion, this study has revealed that diarrheal diseases in Yenagoa LGA is endemic with epidemic outbreaks during the dry seasons and when temperatures increase. Seasons and temperature are non-modifiable factors, therefore, stakeholders and policymakers should pay more attention to the period and implement all sustainable public health strategies, programs and policies for control of diarrheal diseases. This is imperative as it will aid in reducing or eliminating the disease, and by extension reduce morbidity and mortality among under five years children. The government, NGOs and the individuals must all play their respective roles to achieve zero deaths at the advent of the outbreak of diarrheal diseases in Yenagoa LGA of Bayelsa State especially during the dry seasons.

Based on the findings of this study the following recommendations are made: The government of Bayelsa State Ministry of Health and all health policymakers should intensify surveillance and management of diarrheal diseases in the dry season, from Nov-March. Since almost half of the cases are among the < 1-year old routine childhood immunization will play a vital role in the reduction and elimination of diarrheal diseases. The program of water, sanitation, and hygiene (WASH) by UNICEF should be intensified by a rigorous health education carried out in the LGA. The campaign should be carried on the four rules of home treatment of diarrheal which include: giving more fluid, treating with zinc supplements, continuing feeding, and then to go to the health facility. Stick to the Integrated Action Plan for Pneumonia and Diarrheal by 2025 and 2030

For Individuals and Communities

At the individual and community level, environmental sanitation, personal and food hygiene, especially during the dry season should be ensured. In addition, health-seeking behaviour, use of basic sanitary facilities and elimination of open defecation should be pursued.

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