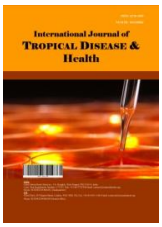

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Spatiotemporal Trend of Waterborne Disease in Enugu Urban, Nigeria: A Retrospective Study

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Authors' contributions

This work was carried out in collaboration among all authors. Authors FCO and OJO designed the study and wrote the protocol. Authors OJO and IA performed the statistical analysis and wrote the first draft of the manuscript. Authors CI and JA managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Many water sources in Nigeria are contaminated with pathogens. Several towns have witnessed outbreaks of enteric diseases due to poor hygienic standards of available drinking water. This research was undertaken to determine the spatiotemporal trends of waterborne diseases (WBDs) in Enugu, Nigeria using retrospective records from January 2013 to December 2016. A total of 18,495 individual reported cases of WBDs were analysed. The analysis showed an increasing temporal trend from 2013 to 2015, with a slight decrease in 2016. Typhoid fever had the highest frequency (48.9%) followed by diarrhoea (40%) and then dysentery (11.1%). The highest (88.9%) incidence of waterborne diseases per 10,000 peoples was from Enugu North followed by Enugu South (62.6%) and least was Enugu East (44.4%). Highest occurrence of typhoid fever and dysentery per 10,000 peoples was also found in Enugu North while Enugu East had the highest occurrence of diarrhoea in the four-year trends. WBDs were highest between January and March and least in July. The

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months with peak occurrence of WBDs falls within the dry season. The importance of having drinking water in both quality and quantity cannot be overestimated as portrayed in this study. Drinking water quality in Enugu urban is very poor especially during the dry season. This suggests a need for setting up a modality to tackle challenges of limited water supply during the dry seasons of the year and to educate the populace on household water treatment and storage method.

Keywords: Drinking water; dysentery; typhoid fever; waterborne; diarrhoea.

1. INTRODUCTION

The quality of drinking water is an issue of public health importance in developing and developed countries worldwide. According to World Health Organization (WHO), each year 3.4 million people, mostly children, die from water-related diseases [1]. Many water sources in Nigeria are contaminated with pathogens; this has resulted to several towns in Nigeria witnessing outbreaks of enteric diseases due to poor hygienic standards of the available water [2]. Waterborne diseases (WBDs) are those diseases directly transmitted by drinking water contaminated by human or animal faeces and urine borne pathogenic viruses, bacteria, protozoa or helminths. The diseases include; cholera, dysentery, typhoid fever, hepatitis A and E, giardiasis, cryptosporidiosis and amoebiasis [3,4,5]. The effects of WBDs cannot be underestimated; outbreaks are usually characterized by severe acute morbidity and high incidence fatality, as was recently reported for cholera outbreak in Nigeria, where many deaths occurred especially among children of less than five years [6,7]. WBDs can cause great economic loss from incapacitation that may ensue, and indirectly disrupts trade and travel [8].

Studies on spatial and temporal variations in diseases distribution have played crucial role in the evaluation of health care performances and interventions [9]. According to Davis et al. [10], spatiotemporal analyses can be used to confirm disease clusters statistically over time and space, as it will increase confidence in assuming the relatedness of cases, provide better information on where interventions could be targeted most effectively, when or where to anticipate outbreaks and examine the manner in which health variables vary over time. Despite its importance in determining disease distribution and measuring effective public health interventions towards the analysed disease case, spatiotemporal epidemiology studies have been minimally reported in Nigeria. Oluwatoyin [11], the only published study on spatiotemporal WBDs in Nigeria, reported an increasing temporal trend of the WBDs in Kwara State, Western, Nigeria. This paucity of information portrays the necessity for this epidemiology report on spatiotemporal studies of WBDs, especially in the Eastern part of the country. The research intends to report the trends of reported cases of WBDs using secondary hospital-based data and to determine the population at risk which will necessitate intervention towards improving drinking water and sanitation level among the populace.

2. MATERIALS AND METHODS

2.1 Study Area

Enugu Urban which is the study area is made up of Enugu East, Enugu North, and Enugu South Local Government Areas (LGAs). These LGAs consist of the urban, semi-urban, peri-urban areas and urban slums [12]. Enugu Urban is located within latitude 6.24° N and 6.3° N and longitude 7.27° E and 7.32° E. The State Water Corporation uses what it terms the administrative method approach in the allocation of water supply to consumers in Enugu Urban area. This involves the estimation of water demand based on past consumption data [13]. What this means is that established records of water consumption for each area or sector is used for future water provision. Despite this approach, many areas in the study area are faced with an inconsistent to no water supply; thereby compelling the inhabitants to explore other sources of water such as wells, streams, rivers and some unhygienic water storage methods.

2.2 Data Collection

Data collection followed a retrospective approach. Quantitative secondary data on medical records covering a period of four year for Enugu urban inhabitants, from January 2013 to December 2016 was obtained from Enugu State Ministry of Health. These quantitative medical records were reviewed to determine the spatial and temporal trends in the distribution of WBDs the area.

2.3 Statistical Analysis

Data collected from this research was collated and entered into Microsoft Excel 2010 and exported to SPSS version 21 (IBM Corporation, Armonk, NY, USA) for statistical analysis. The retrospective records were analysed using one-way ANOVA to establish the frequency and percentage of WBDs reported from January 2013 to December 2016 in the three LGA and by age groups.

3. RESULTS

A total of 18,495 cases of WBDs were reported in Enugu urban during the four-year period. Only records of three WBDs, namely diarrhoea, dysentery and typhoid fever were available. Typhoid fever was the most reported case accounting for 48.9% of total reported incidence (Table 1). Diarrhoea cases were similar in frequency to typhoid (40%); but dysentery was relatively low. The mean distribution of reported cases of the three WBDs in Enugu urban was significantly different ($F = 7.227$; $p = 0.002$).

3.1 Temporal Distribution of Reported Cases of WBDs in Enugu Urban, Enugu State, Nigeria

Fig. 1 shows the temporal variation in reported cases of WBDs for the four-year duration, January 2013 to December 2016. The annual cumulative reported cases for each of the three WBDs are presented. There was a progressive increase in the number of reported cases of WBDs from 2013 to 2015 with a slight decrease in 2016. Annual reported cases of WBD from 2013 to 2016 was similar; the slight progressive increase between 2013 and 2015 was not significant statistically ($p > 0.05$).

The four years trend of diarrhoea, dysentery and typhoid fever on a monthly scale is presented in Figs. 2, 3 and 4 respectively. Diarrhoea cases were reported in all months from January 2013 to December 2016. There was a distinct pattern of diarrhoea incidence; incidence peaked in the months of January to March annually. This was associated with significantly different monthly reported incidence ($F = 23.579$, $p < 0.0001$). Dysentery similarly followed the same trend as diarrhoea, except in 2015. Peak incidence of dysentery occurred between the months of January to March; though in 2015 incidence was higher between October and November. There was similarly significant difference in monthly incidence of dysentery ($F = 3.860$, $p = 0.001$). Reported monthly incidence of typhoid fever indicated minimal changes for the duration under consideration. There was no obvious month of peak incidence annually; monthly incidence was similar from statistical analysis ($F = 1.083$, $p = 0.401$).

Cumulatively, reported incidence of diarrhoea peaked in January and February; dysentery and typhoid peaked in March (Fig. 5A). Overall, incidence of WBDs was relatively higher in January, February and March compared to other months (Fig. 5B).

3.2 Analysis of Spatial Distribution of WBDs Cases in Enugu Urban, Enugu State, Nigeria

Enugu North had the highest overall reported cases of WBDs (46.6%) for the duration under consideration. This was followed by Enugu South (26.8%) and Enugu East (26.6%). For specific WBDs, Enugu East had the highest cases of diarrhoea per annum for the four years duration. This was followed by Enugu North (Fig. 6A). Dysentery and typhoid fever cases were highest in Enugu North per annum except in 2015 when typhoid fever case was reported more in Enugu East (Fig. 6B, C). Reported cases of diarrhoea were not significantly different between the three locations ($P = 0.739$) while reported cases of typhoid fever and dysentery in the three LGAs were significantly different ($P < 0.0001$ and $P = 0.007$ respectively).

Annual incidences of WBDs based on the reported cases and 2006 population census figure for Enugu East, Enugu North and Enugu South are summarized in Table 2. Enugu North had the highest incidence of WBDs for each of the four years followed by Enugu South. On average, incidence of WBDs in Enugu North was 88.9 per 10, 000. The least incidence was at Enugu East, 44.4 per 10,000. The incidence of each of the three reported WBDs are also presented in Table 2.

3.3 Distribution of Reported Cases of WBDs across Age Groups in Enugu Urban

The distribution of WBDs as a function of age group is shown in Table 3. Children between the

ages of 12-59 months were most vulnerable to diarrhoea. Age group 20-40 yrs had the highest reported cases of typhoid fever, while dysentery was mostly reported by age group greater than 40. The least occurrence of typhoid fever and dysentery was seen among age group 0-28 days However, there were no incidence of diarrhoea cases in age groups greater than 5 years.

Table 1. Four-year frequency of reported cases of three WBDs for Enugu Urban, Enugu State, Nigeria (January 2013 - December 2016)

WBDs	Frequency	Proportion (%)
Diarrhoea	7395	40
Dysentery	2062	11.1
Typhoid fever	9038	48.9
Total	**18495**	**100**
F = 7.227; p = 0.002		

Table 2. Spatiotemporal annual incidence reported cases of WBDs in Enugu Urban, Enugu State, Nigeria. (Incidence per 10,000 peoples based on 2006 population Census)

Year	Enugu East	Enugu North	Enugu South
2013	40.5	75.1	62.4
2014	46.1	84.0	64.5
2015	42.9	113.5	62.3
2016	47.7	83.5	61.0
Cumulative Average	**44.4**	**88.9**	**62.6**
WBDs			
Diarrhoea	25.2	26.1	28.2
Dysentery	2.5	14.3	5.1
Typhoid	17.1	49.5	29.6

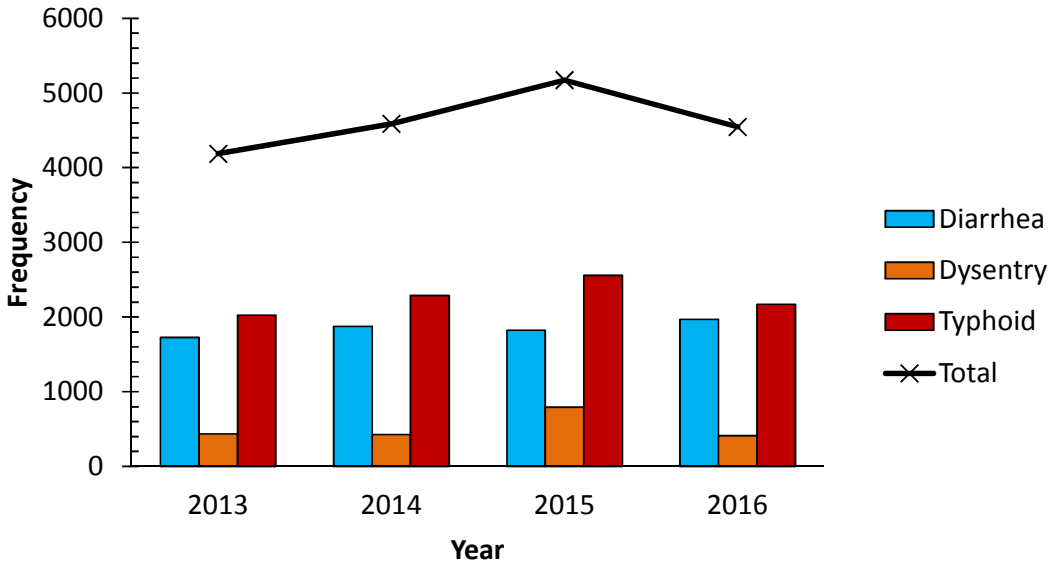

Fig. 1. Annual reported incidence of WBDs in Enugu Urban, Enugu State

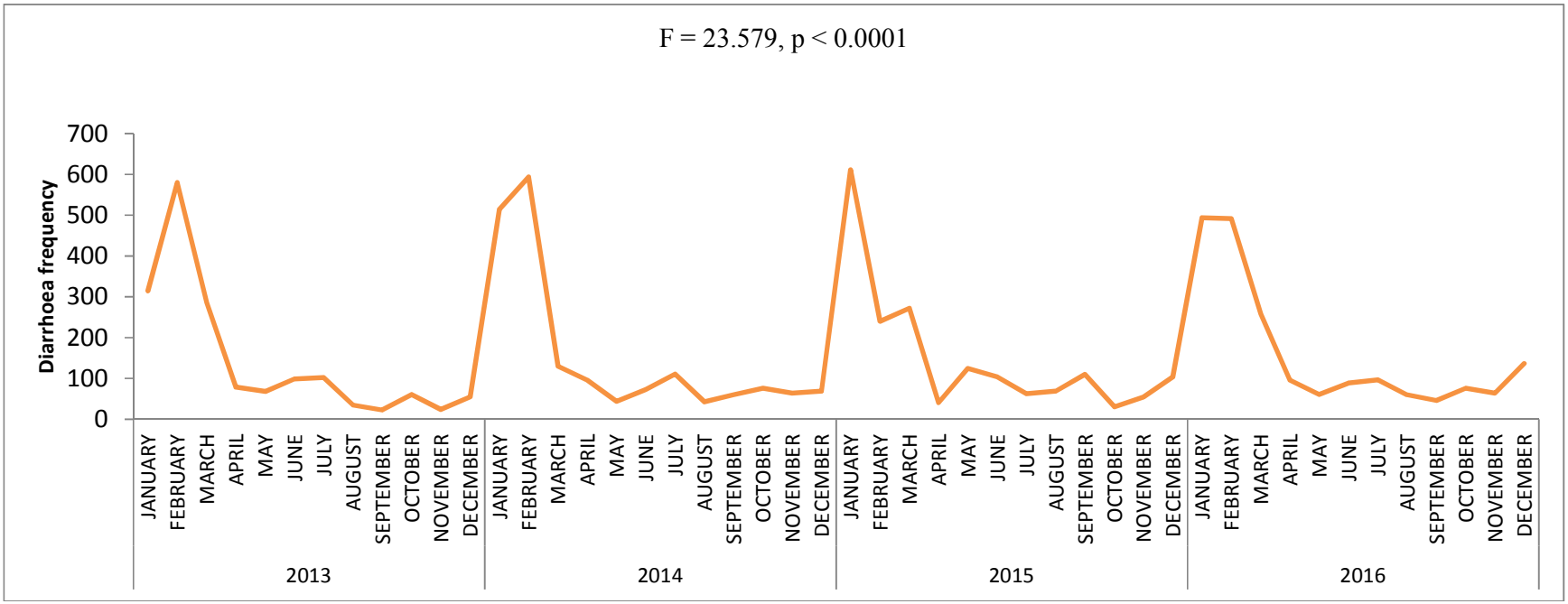

Fig. 2. Monthly variation of reported cases of diarrhoea in Enugu Urban, Enugu State Nigeria, from January, 2013 – December, 2016

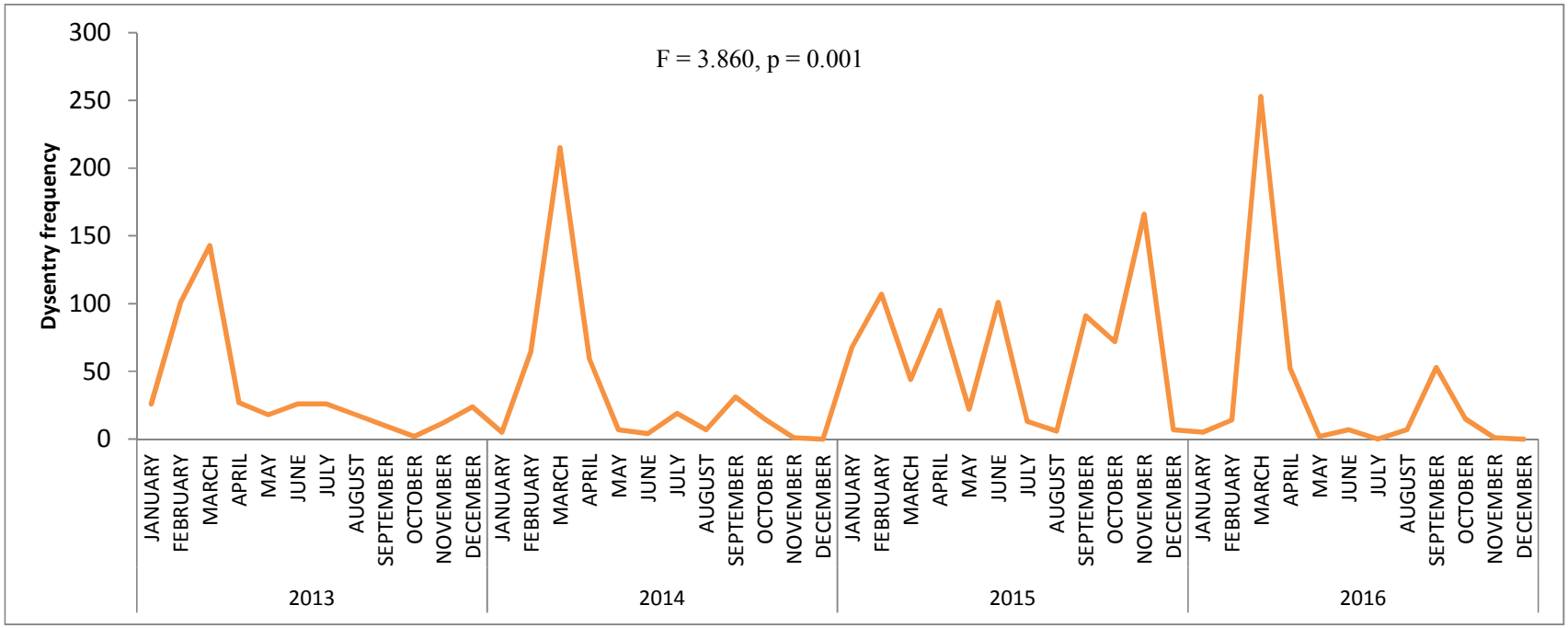

Fig 3. Monthly variation of reported cases of dysentery in Enugu Urban, Enugu State Nigeria, from January, 2013 – December, 2016

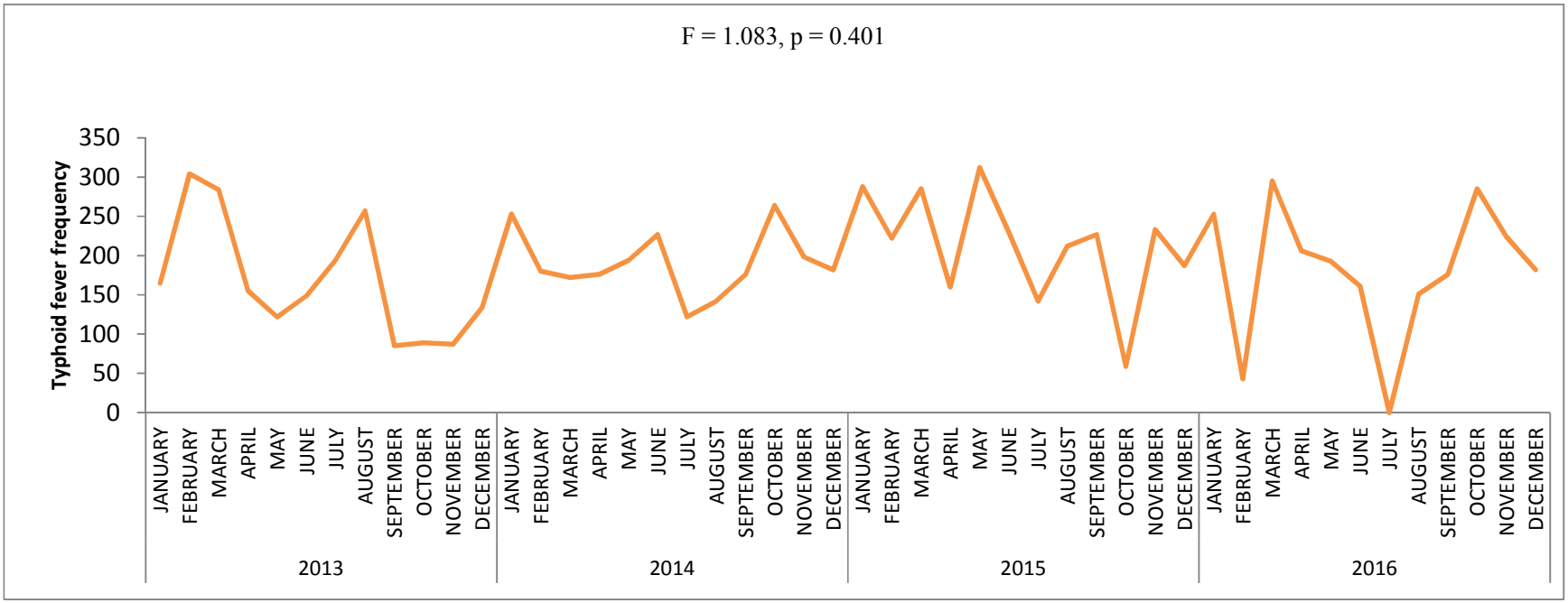

Fig. 4. Monthly variation of reported cases of typhoid fever in Enugu Urban, Enugu State, Nigeria, from January, 2013 – December, 2016

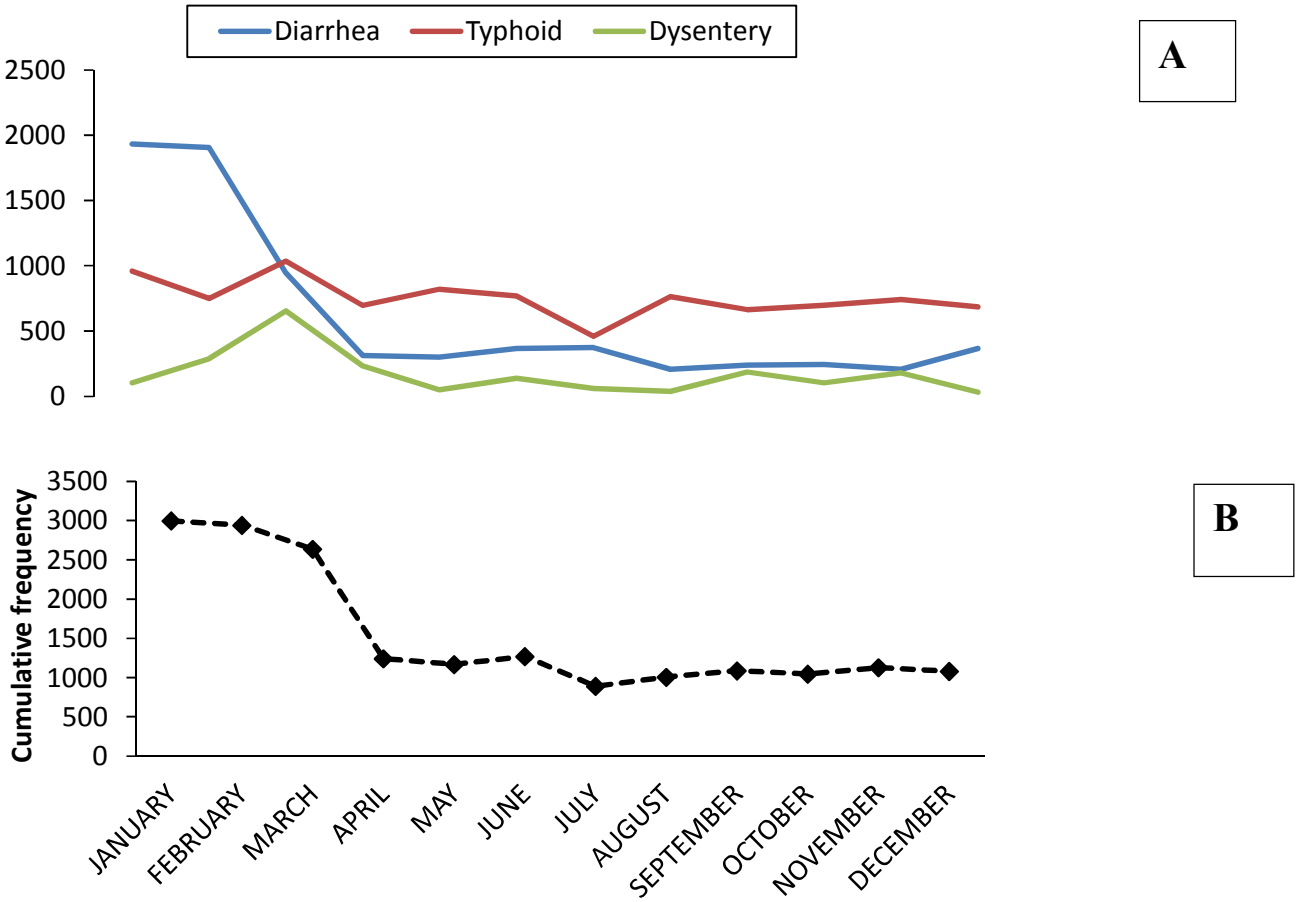

Fig. 5. Cumulative monthly reported cases of WBDs in Enugu Urban, Enugu State, Nigeria. (A) Three WBDs; diarrhoea, dysentery and typhoid, (B) Overall WBDs burden

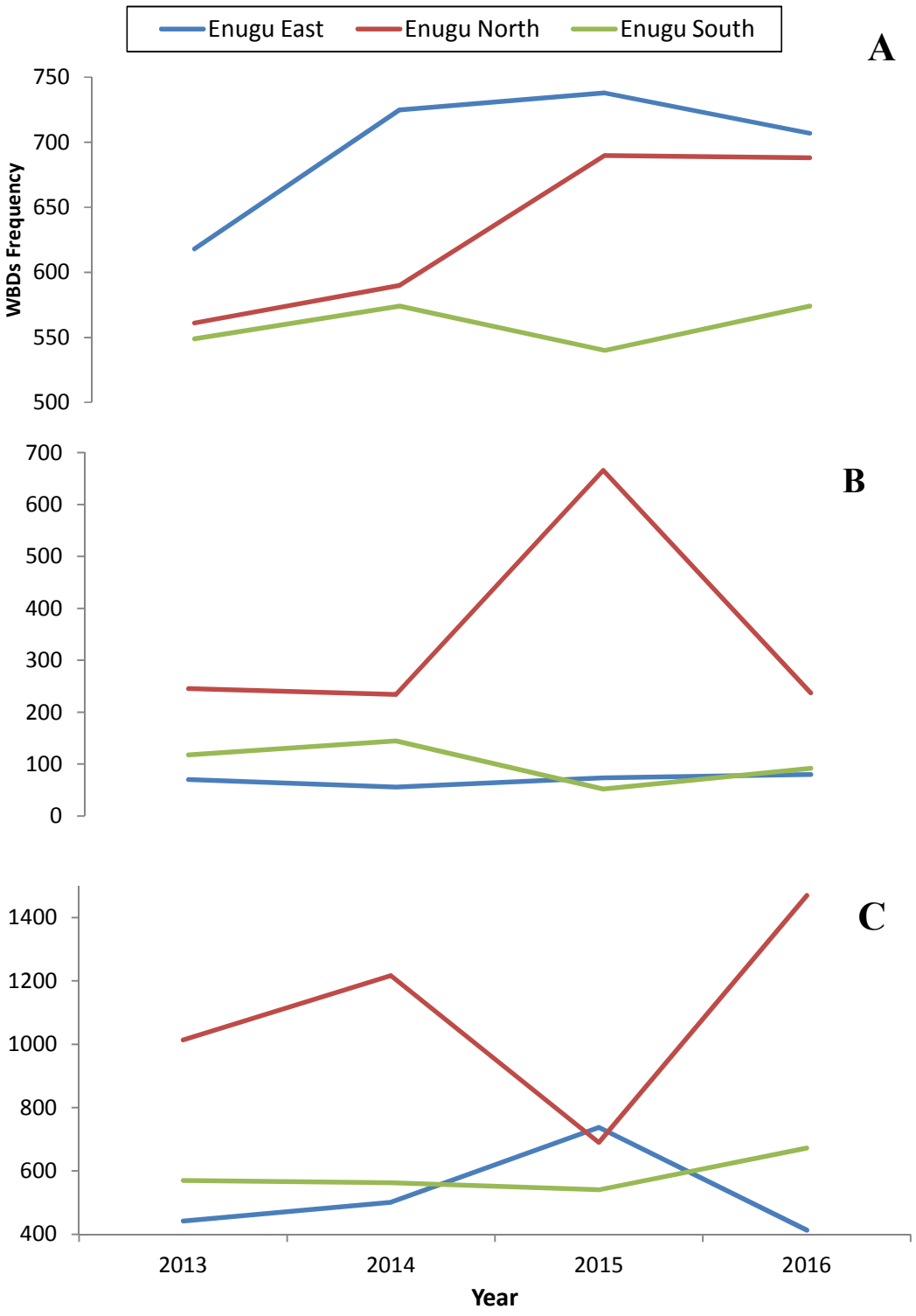

Fig. 6. Spatiotemporal distribution of reported cases of WBDs in Enugu Urban, Enugu State, Nigeria. (A) Diarrhoea, (B) dysentery, (C) typhoid fever

Table 3. Reported cases of WBDs among age groups in Enugu Urban, Enugu State, Nigeria

Age groups	WBDs		
	Diarrhoea	**Typhoid fever**	**Dysentery**
0 – 28 days	303	6	20
1 – 11 months	3468	20	300
12 – 59 months	3768	176	335
5 – 9 years	-	621	128
10 – 19 years	-	1711	199
20 – 40 years	-	3622	529
> 40 years	-	2882	540
P - values	**< 0.0001**	**< 0.0001**	**0.004**

4. DISCUSSION

The analysis of 18,495 reported cases of WBDs from Public Health and Epidemiological Unit, Enugu State Ministry of Health, South Eastern, Nigeria from January 2013 to December 2016 was used to ascertain the spatiotemporal trend of WBDs in Enugu Urban. The high rate of diarrheal infection (40%) among children below 5 years highlights its implication as one of the leading causes of child morbidity and mortality in developing countries. This finding also corresponds to the high rate of diarrheal infection identified in this susceptible age group from two Asia and five sub-Saharan African countries as reported by Global Enteric Multicenter Study (GEMS) [14]. The high case of typhoid fever (48.9%) in Enugu Urban from the present study corroborates findings by Adeyinka et al. [15] where typhoid fever was the most frequently reported WBD in Western Nigeria from 2002 – 2008 in all age groups when compared with other WBDs. The present survey also indicated that reported cases of diarrhoea were limited to children of less than 5 years (< 59 months). It is uncertain whether this is due to diarrhoea surveillance protocol for the State or to other factors. Records of diarrhoea cases may have been intentionally limited to children of less than 5 years as they are the most at risk group. However, this may also be attributed to their unguided playing habit, low immunity, lack of proper sanitation and poor hygiene by caregivers. Inasmuch as the household probably may have relied on the same drinking water source, there are several possibilities for children to get their water contaminated as it journeys from source to mouth. Reported cases of typhoid and dysentery in Enugu Urban were higher in older age groups as also reported by Mweetwa [16] in Zambia, depicting higher case fatality rates of typhoid and dysentery among older patients than children which is in agreement with the present study. However, this finding does not correspond to that carried out by Qureshi *et al.* [17] in Pakistan and Uganda sub-county by Bashiru and Asokan [18] which both reported that all WBDs were more prevalent in children of < 5 yrs.

The progressive temporal increase in the reported cases of WBDs from 2013 to 2015 may be attributed to increase in population density, lack of sanitation, socio-economic, environmental and climatic factors which greatly contribute to an increase in disease burden of a population [4,19]. A survey by Bashiru and Asokan [18] in Uganda showed that there was progressive increase in the burden of WBDs from 2010 – 2014 in the sub-county of Uganda. In the present study, the occurrence of WBDs peaked between January and March corresponding to drier periods of the year. In Enugu State, the dry season starts in October and ends in April, during the period of January to March which is the mid-dry season, water reserves would have been depleted between October and December. This scarcity of water may have compelled the peaking of WBDs between January and March. Reported cases of WBDs from April to December were low; this period (especially April to October is rainy season) is marked by greater water availability. Similar finding was made by Qureshi et al. [17] where incidence of WBDs in Pakistan decreased during the months of July and September which were during the rainy season. The high significant difference in the reported cases of diarrhoea in January and February when compared with other months of the years imply that diarrhoea disease is more common during the drier season of the year, that is often accompanied by dry and dusty winds of harmattan, drying up of water bodies, thus concentrating diarrhoea causing pathogens in the available drinking water bodies. Traditionally, most of the inhabitants in this location source their drinking water entirely from borehole and well. However, these water bodies are often

dried and scarce during this dry period, thus exposing them to other water sources with increased risk for waterborne pathogens.

Several studies have shown that climatic factors significantly affect seasonal childhood diarrhoea, with more cases observed during the periods of high temperature and drier months of the year these could be attributed to increased ambient temperature which favours the growth of bacterial and parasitic diarrheal pathogens [20,21,22]. Variable rainfall patterns, floods and extreme temperature are increasing in frequency and intensity, affecting drinking water sources and increasing the risk of WBD [23]. The rising trend of WBDs in Enugu Urban deserves further analysis with focus on probably relationship with climate change. Typhoid and dysentery cases had their peak frequency in March for the four years. The seasonal variation of typhoid fever was not significant while that of dysentery was significant, implying that dysentery occur mostly in March in Enugu Urban. This can be attributed to some environmental conditions such as surface runoff and flooding, increasing the rate of drinking water sources contamination at the beginning of the rainy season; this month often records the first rainfall events after the long dry season, therefore washing contaminants from the surface into the water sources [24].

Enugu North had the highest frequency of reported cases of WBDs followed by Enugu South and the least was Enugu East. Following the community structure of Enugu urban, Enugu North which had the highest frequency of WBDs had less population and better physical structures when compared with other LGA. From the hospital epidemiological records, the inhabitants of Enugu North had a significantly high incidence of WBD per 10,000 persons based on 2006 population census. It can be assumed that most inhabitants of this area, with their keen understanding of the importance of proper diagnostics and treatment visit hospitals at any episode of disease cases, or that their major central water sources may have been contaminated without proper treatment measures. This assumption requires further verification to determine why despite their level of knowledge, low population, and the presence of better physical infrastructures still recorded high frequency of WBD especially dysentery and typhoid. The less reported cases of WBDs in Enugu East irrespective of their high population and characteristics may also be due to the fact that they may have developed putative immunity against waterborne pathogens as a result of frequent exposures to the different strains of WBD pathogens. Also, it can be attributed that they may have relied on several traditional medications or may have depended on self-medications because of the abundance of kiosk medicine stores in the location especially Enugu East, inadvertently preventing the incidence from being documented as also reported by Qureshi et al. [17].

5. CONCLUSION AND RECOMMENDATION

The retrospective epidemiology study highlights the preponderance of waterborne diseases in the study area, proposing a need for substantial public health intervention measures in developing countries. The results obtained from this study may be used to extrapolate the current scenario of waterborne diseases in urban communities with similar environmental conditions. This study strongly recommends the provision of safe, consistent and easily accessible potable drinking water sources to improve the general welfare of Nigerians. Also, government should give closer attention to urban water supply, sanitation and hygiene policy, ensuring that appropriate measures are taken to improve access to safe drinking water, sanitation and hygiene. Since the availability of both potable water and adequate sanitation has potential to prevent at least 9.1% of the global disease burden and 6.3% of all deaths [25].

CONSENT

It is not applicable.

ETHICAL APPROVAL

Ethical approval for the study was obtained from the University of Nigeria Teaching Hospital, Enugu State. Approval was also obtained from Public Health and Epidemiology Unit, Enugu State Ministry of Health, Enugu State, Nigeria. The ethical approval number is NHREC/05/01/2008B-FWA00002458-1RB00002323.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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