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Spatial Pattern of Acute Gastroenteritis and Isolation of Enterobacteria from Domestic Water in Ile-Ife, Osun State, Nigeria

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Abstract: Acute gastroenteritis (AGE) contributes significantly to the burden of illness from infectious diseases worldwide especially in developing countries. This study aims to determine the spatial pattern of AGE and isolate Enterobacteria from domestic water in Ile-Ife, a peri-urban community. The medical records of AGE cases between 2008-2012 with due ethical approval from a tertiary hospital in Ile-Ife were reviewed. Using a global positioning system (GPS), the coordinates of the residential addresses retrieved from the records were determined. One hundred residential houses were randomly selected, data on sources of water supply and sewage disposal systems were obtained. The microbial count and identification of the bacterial isolates cultured from the water samples collected were done. A total of 373 AGE cases were recorded in 21 administrative units (wards) within the study period. The occurrence of AGE was observed to increase as the year progresses and 6 (28.6%) of the AGE burden hotspots were identified. All the water samples analysed contained bacterial coliforms above the permissible level. Two hundred and one bacterial isolates were identified with the frequency of the isolates as follows: *Shigella* spp (19.9%), *Serratia* spp (13.4%), *Aeromonas* spp (10.5%), *E. coli*, *Salmonella* spp, *Klebsiella* spp (10%), and other Enterobacteria (26.2%). The spatial pattern and AGE burden hotspots identified could assist in the early detection of AGE outbreaks and intervention. This study shows the wide distribution of enteric bacteria in the water sources and suggests water treatment at the point of use to forestall AGE outbreaks in the community.

Keywords: Acute gastroenteritis, Enterobacteria, Hotspots, Spatial pattern, Water

INTRODUCTION

Water is unarguably a very important resource for life sustaining processes. However, it is acceptably one of the major vehicles of transmission of diseases in humans (Sánchez *et al.,* 2018). Pathogenic microorganisms were reported to be the greatest risk associated with the ingestion of water (WHO, 2011). Waterborne pathogens affecting humans include bacteria, enteric viruses, protozoa and helminths (Ashbolt, 2004). Contaminated drinking water and food are the most important source of transmission of Acute Gastroenteritis (AGE). Its effect is more severe in immune-compromised individuals, infants and the elderly (Ezeonwu *et al.,* 2013; Chen *et al.,* 2015). It has been shown that through the environment, a cycle of transmission from man to man is maintained (Chin, 2000; Fletcher *et al*., 2011).

Acute gastroenteritis contributes significantly to the burden of illness from infectious diseases worldwide (King *et al.,* 2003). It has been reported that approximately four billion global cases of diarrhoea and about two million deaths are attributable to unsafe water, sanitation and hygiene (WHO, 2011). Ashbolt (2004) observed that nine out of ten of such deaths occurred in children, with a significant majority of deaths recorded in developing countries. Several enteric microorganisms have been found responsible for gastroenteritis illnesses. The link between poor microbial water quality and infectious diseases has been well documented (Oswald *et al.,* 2007; Cronin *et al.,* 2008; Sanchez *et al.,* 2018). Lai *et al.* (2016) observed that acute bacterial gastroenteritis is highly associated with season, frequency of diarrhoea and emesis.

Mapping of disease is an activity closely related to disease surveillance and cluster detection. It has widely been used for descriptive purposes to identify patterns of geographical variation in diseases and to develop new ideas about the cause of diseases (Pollack *et al.,* 2005). Probability mapping has been used to identify area units within regions having significantly high or low disease rates (Gesler, 1986).

Geographical information systems (GIS) and mapping of spatial aspects of diseases have been observed to increase the understanding of disease outbreak, forecast disease risk and public health problems thereby providing a holistic approach to disease control (Pollack *et al.,* 2005; Sarkar *et al.,* 2007; Joseph and Balasubramaniam, 2014). Moonan *et al.* (2004) was able to identify geographical areas where on-going tuberculosis transmission was occurring by linking GIS technology with molecular surveillance in a study conducted in India. Consequently, significant hotspots of tuberculosis were identified in a study conducted by Tiwari *et al.* (2006) using GIS and spatial scan statistics in a district in India.

Studies in Nigeria have shown that acute gastroenteritis is one of the three most common causes of morbidity and mortality among children admitted in hospitals (Ezeonwu *et al.,* 2013; Iyoha and Abiodun, 2015). Despite reported outbreaks of AGE in communities in Nigeria, there is little information available in the use of GIS assisted method to ascertain the spatial patterns and the identification of hotspots of the disease. Hence, this study aimed to determine the spatial pattern of AGE in order to identify the hotspots that could serve as reservoir for AGE outbreak in Ile-Ife as well as identify the enterobacteria in the domestic water.

MATERIALS AND METHODS

Study Area and Design

The study area is Ile-Ife –a peri-urban area in Osun State, Nigeria. It has a geographic grid 7°28'N4°34'E coordinates and is about 218km (135 miles) North-east of Lagos State, Nigeria. The area is stratified into twenty-one administrative units (wards). After due ethical approval, the medical records of AGE patients presented at the Obafemi Awolowo University Teaching Hospitals for five years' period (2008-2012) were accessed and the house addresses of affected households were retrieved. A global positioning device was used for recording the geographical coordinates of AGE-affected households as described (Joseph and Balasubramaniam, 2014). The data was imported into ArcGIS 10.3 and the digitized map of Ile-Ife was used for the study.

Collection of the water samples

One hundred houses as captured in the medical records of the respondents were selected using purposive random sampling technique. Information of the sources of water supply and types of sewage disposal system were obtained from the household selected. Thereafter, water samples at the source of water supply from different points for each residence were collected in sterile glass wares and transported immediately in ice packs to the microbiology laboratory for processing.

Bacteriological analysis of the water samples

The microbiological quality of the drinking water samples was subjected to total coliform count (TCC) using the multiple fermentation tube technique (most probable number), and further subjected to faecal and total coliform confirmatory test as described by APHA (1998). Heterotrophic plate count was done as described by Eaton *et al.* (2005). The culturing of the samples was performed by spreading 0.1 mL of a water sample on appropriate media and incubated at 37 ^{o}C for 18-24 hrs. These procedures were conducted in duplicates and repeated for other water samples. The isolates associated with AGE were characterised by various biochemical means (Cheesbrough, 2006) and identified as described (Holt *et al.,* 1994).

RESULTS

A total of 373 AGE cases were recorded within the period of the studied years (2008-2012). The highest occurrence (89 cases) of acute gastroenteritis was reported in 2012 followed by 87 cases in 2011, 73 cases in 2010, and 68 cases in 2009 while the least occurrence was reported in the year 2008 (56 cases).

Similarly, the occurrence of gastroenteritis with the highest cumulative cases was recorded at Ilare 1 as 55 cases, while the least reported case was recorded in Ilare 4 as 1 case in 2012 (Table 1). The spatial pattern and hotspots for AGE of the residences with recorded cases of Acute Gastroenteritis (AGE) are as shown for the 5 years studied in Figures. 1- 5. Acute gastroenteritis burden hotspots were identified in 6 (28.6%) of the 21 administrative units with the highest hotspots observed at Moore (2 years) and Ilare 1 (3 years).

Table 1: Number of Reported Cases of Gastroenteritis within the Period of study in Ile-Ife

Administrative units (wards)	2008	2009	2010	2011	2012	Total
Iremo 1	3	4	3	0	3	13
Iremo 2	3	3	0	4	7	17
Iremo 3	5	4	5	4	0	18
Iremo 4	5	3	8	8	10	34
Iremo 5	2	3	4	4	0	13
Ilare 1	9	12	11	14	9	55
Ilare 2	4	6	10	4	7	31
Ilare 3	3	2	0	0	3	8
Ilare 4	0	0	0	0	1	1
Moore-Ojaja	2	6	0	7	5	20
Akarabata	0	2	3	0	2	7
Ilode 1	0	2	0	2	4	8
Ilode 2	0	0	2	0	0	2
Okewere 1	2	3	3	5	5	18
Okewere 2	0	2	0	3	0	5
Okewere 3	3	3	4	4	5	19
Moore	5	8	6	11	8	38
Modakeke 1	0	0	0	0	2	2
Modakeke 2	7	5	11	12	12	50
Modakeke 3	0	0	0	3	2	5
Yekemi	3	0	3	2	1	9
Total	**56**	**68**	**73**	**87**	**89**	**373**

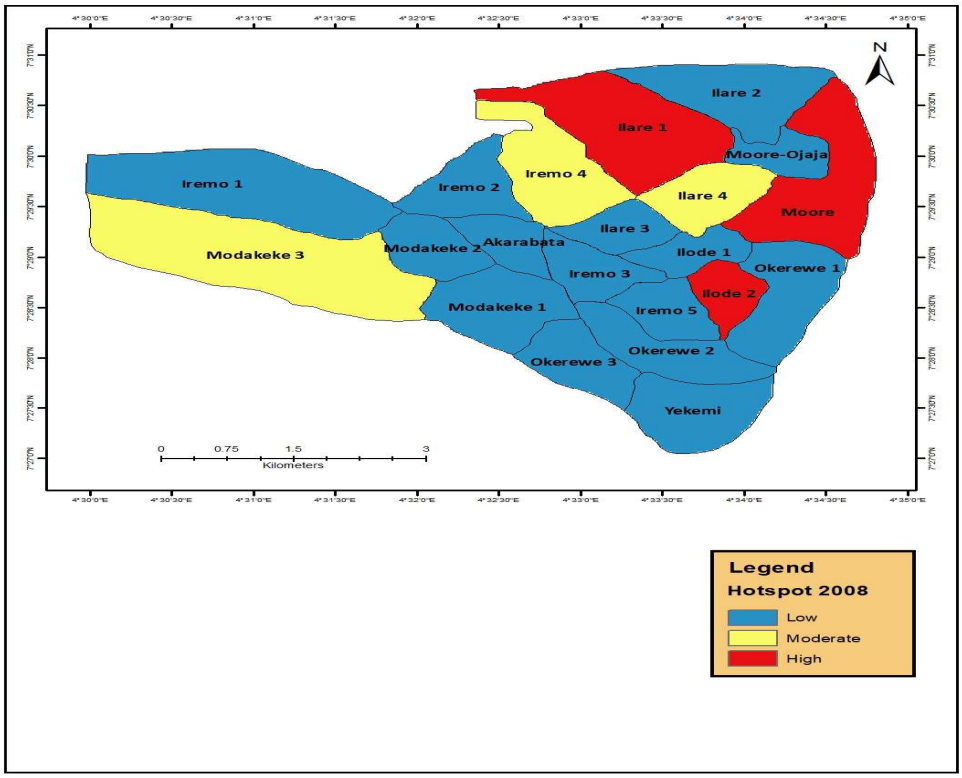

Fig 1: Spatial pattern and AGE burden hotspots in Ile-Ife for the year 2008

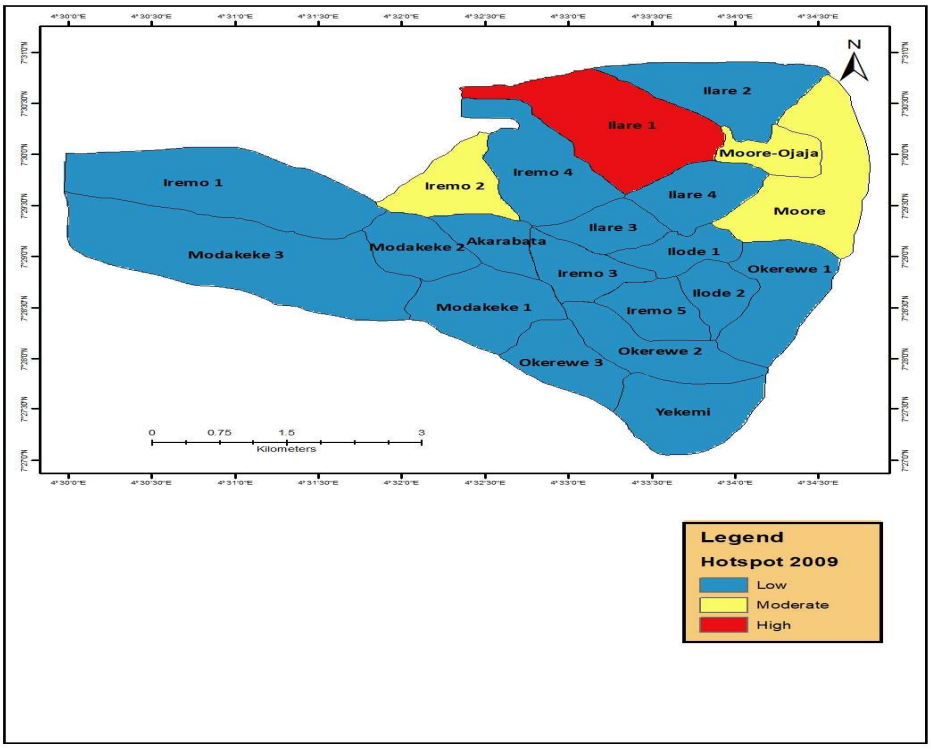

Fig 2: Spatial distribution and AGE burden hotspot in Ile-Ife for the year 2009

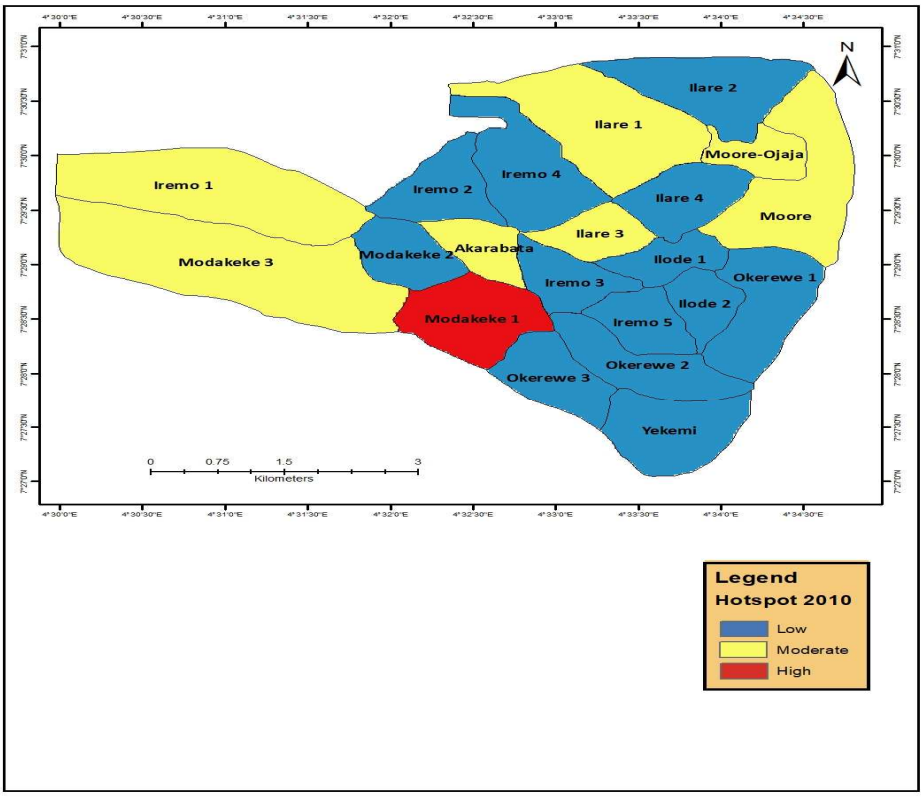

Fig. 3: Spatial pattern and AGE burden hotspot in Ile-Ife for the year 2010

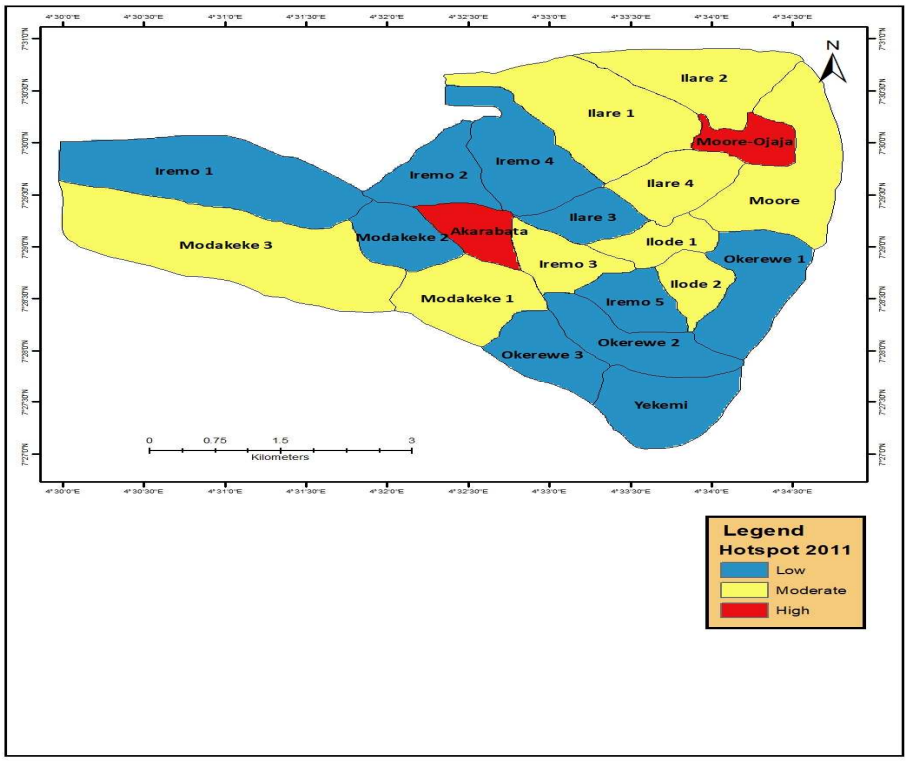

Fig. 4: Spatial pattern and AGE burden hotspots in Ile-Ife for the year 2011

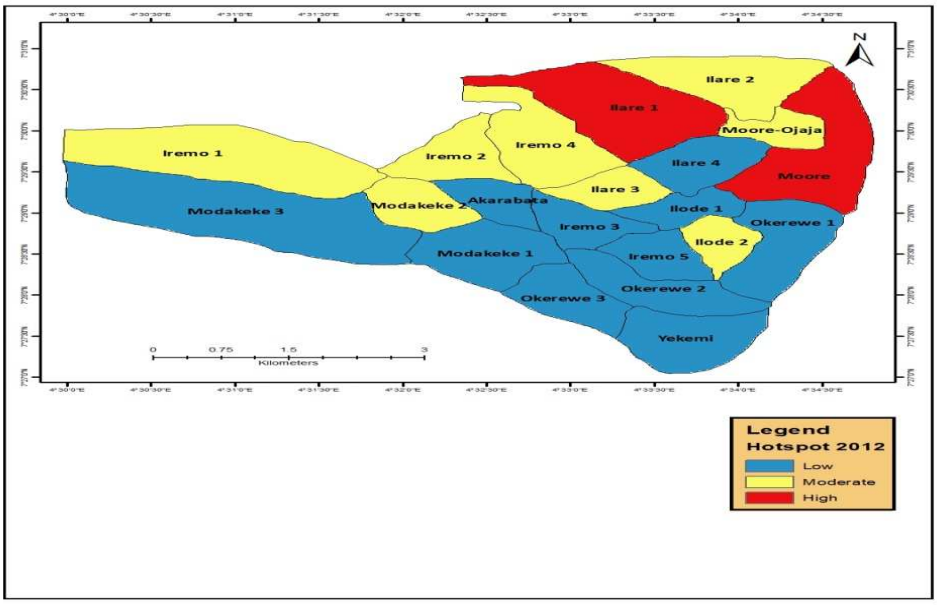

Fig. 5: Spatial pattern and AGE burden hotspots in Ile-Ife for the year 2012

The respondents' sources of water for domestic use showed that about 65 % depend on well water while 4 % still obtain water from the stream. Sewage types used by the respondents showed that 60% use flush toilets, 31% use pit latrines, while 9% use squat toilets as shown in Table 2. The total heterotrophic count of the water samples is within the range 4.0 x 10^3 to 1.05 x 10^7 while the coliform count is within the range 0.11 to >11. All the water samples were observed to have more than zero (0) faecal coliforms. A total of 201 enterobacteria belonging to 10 genera were recovered. The highest bacterial isolates identified were *Shigella* spp 40(19.9 %) as shown in Table 3.

Table 2: Water sources and sewage disposal system of the respondents

		Number			Number
Water	Hand-dug well	65	Toilet	Flush	60
Source	Tap	26	Type	Pit Latrines	31
	Stream	4		Squat Toilets	9
	Bore Hole	5			

Table 3: Frequency of the Bacterial Isolates Cultured from the Water Samples

Isolate	**Frequency (%)**
Escherichia coli	20 (10)
Shigella spp	40 (19.9)
Citrobacter spp	12 (6)
Salmonella spp	20 (10)
Klebsiella spp	20 (10)
Serratia spp	27 (13.4)
Enterobacter spp	19 (9.5)
Vibrio spp	14 (7)
Aeromonas spp	21 (10.5)
Proteus spp	8 (4)
Total	**201**

DISCUSSION

This study analysed the spatial pattern of acute gastroenteritis (AGE) cases reported in Ile-Ife between 2008 and 2012, and assessed the acute gastroenteritis disease hotspots that could serve as reservoir for outbreaks. In this study, it was observed that the hotspots vary with the years, with Ilare 1 ward credited with the highest AGE burden hotspot for 3 years of the 5 years studied. This might suggest a higher probability of AGE outbreak in this area. This finding agreed with the report of Joseph and Balasubramaniam (2014) who identified major risk areas of AGE in Coimbatore, India using AGE distributions maps. However, it has been observed that hotspots do not remain stable over time and the understanding of the stability of hotspots is important for guiding disease control strategies (Lessler *et al.,* 2017).

It was observed that 4% and 65% of the respondents depend on streams and hand dug wells respectively for their sources of water supply. This showed little or no intervention for the supply of potable drinking water in the studied areas and could be a contributing factor to the increase in acute gastroenteritis cases across the studied years. Although flush toilet was the most commonly used type of sewage system disposal recorded yet acute cases of AGE was high and this might suggest seepage into well water as a result of leakage either through proximity or poor construction practices (Iloabachie *et al.,* 2012; Aldosari *et al.,* 2017). More so, improper sewage and waste drainage outlets could be responsible for cases of AGE in several environments, creating portals for contamination of water sources by faecal materials (Jaremkow *et al.,* 2017). Ashbolt (2004) reported that the prevalence of diarrhoea can be reduced to 30% when adequate provisions are made for excreta elimination and disposal around the house.

According to WHO (2011), for water to be classified as potable, total microbial counts should not be more than 1.0 x 10^2 Cfu/ml, and a zero MPN count per 100ml of water sample. In this study, the microbial and coliform counts of the water sampled were far above the permissible water standard for domestic use. Increase in the microbial counts most importantly the coliform counts from the respective drinking water source available in the studied area could be pivotal to the increase in reported cases year-in, year-out.

Diversity of enteric and faecal bacteria recovered in the domestic water samples in this study have been implicated as causative agents of acute gastroenteritis with either a temporal or permanent form of spatial distribution in the environment (Hennani *et al.,* 2012). The high number of *Shigella spp* –a causal agent of shigellosis recovered in the study has been of worldwide concern. Shigellosis represents a significant public health burden in developing countries particularly in children that are under 5 years old (Mathers *et al.,* 2009). It has been posited that the presence of *Escherichia coli* and *Shigella spp* in water is an indication of a high probability of faecal contamination since no distinction between pathogenic and non- pathogenic strains is required to assess water quality in a non- clinical setting (Lawrence *et al.,* 1991).

CONCLUSION

In conclusion, the spatial pattern showed AGE burden hotspot is not stable in the study area which suggest various risk factors contributing to outbreaks. However, the disease hotspots identified could assist on where efforts should be concentrated in the detection of AGE outbreaks and interventions. The diversity of enteric bacterial isolates recovered suggests the water sources are reservoirs for pathogens which could influence a new cycle of AGE outbreak in the study area. The study suggests an improvement of water treatment at the point of use.

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