WEST AFRICAN JOURNAL ON SUSTAINABLE DEVELOPMENT

PREFERRED DRINKING WATER SOURCES AND WATERBORNE INFECTIONS AMONG HOUSEHOLDS IN A RURAL COMMUNITY IN ANAMBRA STATE, SOUTHEAST, NIGERIA

[1]Collins Alutu, [2]Nkiru Ezeama, [3]Prosper Adogu

[1,2&3]Department of Community Medicine and Primary Health Care, Nnamdi Azikiwe University, Nnewi campus
[1]alutucollins@gmail.com, [2]nn.ezeama@unizik.edu.ng, [3]po.adogu@unizik.edu.ng,

[1]https://orcid.org/0009-0004-6144-5924, [2]https://orcid.org/0000-0002-7122-0006, [3]https://orcid.org/0000/0001/6589/6555,

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Abstract

Background: The global demand for freshwater is increasing at an alarming rate, outpacing population growth. Access to safe water is a critical sustainable development issue, with 2.1 billion people worldwide and over half of the population in developing countries lacking a "safely managed" water supply. This study aimed to investigate the microbiological quality of preferred drinking water sources and its association with waterborne infections (WBIs) among households in Ebenebe, a rural community in Anambra State, Nigeria. **Methodology:** A cross-sectional descriptive survey and laboratory analysis were conducted among 504 households. Data on preferred drinking water sources, determinants, and symptoms of WBIs were collected using a questionnaire. Water and faecal samples were collected from randomly selected household members for laboratory analysis. **Results:** The findings revealed that borehole water (74%) was the most commonly accessed and preferred drinking water source. Borehole water samples contained 74.3% of all isolated bacteria, while spring and lake samples had the least (2.9%). *Escherichia coli* (295, 19%) was the most frequently detected bacterium, with no parasites seen. Faecal analysis showed that 427 respondents (85%) had WBIs, with those aged 15-64 years (332, 77.8%) and females (253, 59.3%) being the most affected. Helminthes were the most frequently detected parasite (203, 93%), and hookworm (81, 37%) was the most common parasite ova seen. Overall, *E. coli* was the most frequently isolated microorganism. However, the association between preferred drinking water sources and WBIs was not statistically significant. **Conclusion:** The preferred drinking water of households in Ebenebe contained pathogenic organisms capable of causing WBIs and diseases. Therefore, health education on user-friendly, point-of-use filtration and disinfection methods is recommended to improve the water quality and reduce the risk of WBIs and diseases.

Key words: drinking water, waterborne infections, Ebenebe, Anambra State, Nigeria.

1.0 Introduction

Safe drinking water is crucial for human health and is a basic human right (World Health Organization, 2017). However, rural communities often rely on contaminated water sources, leading to waterborne infections and epidemics (Sundaravadivel & Vigneswaran, 2009).

Waterborne infections is of utmost importance, as they are a major cause of mortality and morbidity worldwide (Clasen et al.,2017).

They can be caused by various microorganisms, including protozoa, viruses, bacteria, and intestinal parasites (Cheesbrough, 2006). These infections can be spread through contaminated water and food, and poor sewage management and improper sanitation contribute to their spread (Forstinus et al., 2016). According to the World Health Organization, WBIs characterized by diarrhoea are the second leading cause of death in children under five years old. Each year, diarrhoea kills around 525,000 children under five. Globally, there are nearly 1.7 billion cases of childhood diarrhoeal disease every year (World Health Organization, 2017).

However, a significant proportion of WBIs can be prevented through safe drinking water and adequate sanitation and hygiene. Studies have shown that improving water supply, hygiene, and sanitation can reduce diarrhoea by 26% (World Health Organization, 2017).

Despite progress, many people lack access to safe drinking water and sanitation, with 2.1 billion people lacking "safely managed" drinking water services, 4.2 billion lacking adequate sanitation services, and 3 billion lacking basic hand-washing facilities (World Health Organisation, 2019).

Furthermore, there is a lack of data on the relationship between water sources and waterborne diseases in Nigeria, particularly in Anambra State (Ezenwaji et al., 2015). Therefore, this study aims to investigate the relationship between water sources and waterborne infections in a rural community in Nigeria.

2.0 Methodology

2.1 Description of study area

Ebenebe, a rural town in Awka North Local Government Area of Anambra State, Nigeria, has an estimated population of 45,897 according to the 2006 Nigerian census (Wikipedia, 2021). The town is comprised of eight villages, each containing hamlets, and is bordered by Amansea, Mgbakwu, Ugbene, and Agbaja. Ebenebe is divided into three political wards and has a traditional ruler, HRH Igwe Christopher Nnaegbuna. The majority of the population is Christian, with a few practicing African Traditional Religion, and speaks Igbo, English, and Pidgin English. The literacy rate in Awka North Local Government Area is 62% (Agu-Aguiyi et al., 2018).

Ebenebe has a few schools, including nursery, primary, and secondary schools, with some owned privately and others by the government. The major hospital in the area is the Mobile Hospital, which serves the surrounding villages, along with other health centers and clinics. The town experiences a tropical climate with two distinct seasons, rainy and dry, and has few streams, rivers, and undeveloped springs, relying on boreholes, springs, wells, sachet water, and surface water for drinking, domestic, and agricultural purposes.

As an agrarian community, Ebenebe survives mainly on agriculture, with no industries present. The town is one of the highest producers of agricultural commodities in Anambra State, with favorable climate and soil conditions for farming. The community has large, open-air markets, including the largest market, Oye Ebenebe, which is named after one of the four market days in Igboland.

2.2 Household selection

This study utilized a quantitative research approach, incorporating two complementary methods: a household survey and laboratory analysis of water and faecal samples. The study focused on households in Ebenebe, excluding individuals who were unable to communicate in Igbo, provide informed consent, or had mental disabilities. The sample size was calculated using the Cochrane formula (Cochrane, 1977), considering the population size, confidence level, and desired precision, and was adjusted to 500 to account for potential non-response (Araoye, 2004). A total of 504 participants were selected through a multi-stage sampling technique, which ensured representativeness and randomness. The sampling process involved first including all eight villages in Ebenebe, then randomly selecting 63 households from each village using a table of random numbers, and finally choosing one eligible member from each household to participate.

2.3 Household survey

A questionnaire was used to gather information on the prevalence, distribution, determinants, and symptoms of waterborne infections. The questionnaire was adapted from previously validated instruments and tailored to fit the study's objectives (Sridhar et al., 2020; United States Agency For International Development, 2020; World Health Organization and United Nations Children's Fund, 2006). It was administered to household members, with permission obtained from parents or guardians for those under 18 years, and parents or guardians responded on behalf of those less than 12 years. The questionnaire covered various aspects, including demographic factors such as age, sex, and family size, socio-economic factors like education and household income, environmental factors related to water sources and waste disposal, behavior-cultural factors like hand washing practices, and symptoms of waterborne diseases like diarrhoea and abdominal discomfort. The questionnaire was administered by an interviewer, and follow-up visits were made to households by the research assistant or researcher to collect the data.

2.4 Water sample collection and analysis

Water samples were collected from preferred drinking water sources in sterile 200ml bottles, taking precautions to prevent contamination. Multiple samples were collected from each source, with surface water samples taken from different points to ensure representative results. Samples were collected from various water sources, including boreholes, rivers, streams, lakes, and springs, using specialized procedures to prevent contamination (Cheesbrough, 2006). The samples were then labeled and transported in an insulated cold box to the laboratory for analysis. In the laboratory, the water samples were examined for bacteriological contaminants using the membrane filtration method (Cheesbrough, 2006), which detects *Escherichia coli* (*E. coli*) and other pathogens. The presence of *E. coli* was confirmed by culturing the membrane filter on a selective broth, and the number of coliform colonies was counted. If *E. coli* was detected, the water sample was further analyzed for other bacteria and parasites using various selective media and incubation techniques. The laboratory analysis aimed to detect a range of bacteria, including *Salmonella spp*, *Shigella spp*, *Vibrio cholera*, and other microorganisms that may be present in the water samples.

2.5 Faecal sample collection and analysis

Faecal samples were collected in a suitable container and promptly transported to the laboratory within a one-hour timeframe. A portion of the specimen, approximately 100g especially that which contains mucous, pus, or blood, was then transferred to a clean, dry, leak-proof container without preservatives. In the laboratory, parasitological examination was conducted using a microscope and various reagents, including Lugol iodine, acetic acid, sodium chloride, methylene blue, and eosin (Cheesbrough M, 2006; World Health Organization, 2003). This involved preparing slides with saline and iodine-acetic acid solutions, mixing with stool samples, and examining under a microscope for parasite eggs and cysts. Additionally, bacteriological examination was performed by culturing the faecal specimens to detect *Escherichia coli*, *Salmonella spp, Shigella spp,* and *Vibrio cholera*. Presumptive and confirmatory tests were conducted using selective media, including McConkey agar, Brilliant green broth, Xylose lysine Deoxycholate agar, Salmonella-Shigella agar, and Thiosulphate citrate bile salt sucrose agar.

3.0 Results

3.1 Sources of preferred household drinking-water

According to this study, households in the area use various water sources, including boreholes, surface water, and undeveloped springs, for different purposes, consistent with most of the literatures reviewed. Boreholes were found to be the most preferred source of drinking water, followed by surface water and an undeveloped spring, which is supported by a previous study (Kumar & Mandal, 2010). This preference may be due to the growing awareness of the importance of safe and potable water or preferences may be driven by availability and accessibility of the borehole water. However, other studies (Bwire et al., 2020; Daud et al., 2017; Eshete et al., 2020; Misati, 2016; Orlando et al., 2020) contradict these findings. The discrepancy may be due to the unavailability and inaccessibility of borehole water, leading residents to use available water sources. Despite this, borehole water is expected to be microbial-free, reducing the likelihood of waterborne infections (WBIs) among residents.

Table1a. Demographic and socioeconomic characteristics of the respondents

Socio-demographic characteristic	Frequency	Percentage
Age (Years)		
<5	6	1.2
5-14	56	11.1
15-64	390	77.4
≥ 65	52	10.3
Mean	35.5	
SD	18.6	
Sex		
Male	208	41.3
Female	296	58.7
Marital Status		
Single	166	32.9
Married	265	52.6
Divorced	35	6.9
Widowed	38	7.5
Family Size		
< 5	297	58.9
≥ 5	207	41.1

Table1b. Demographic and socioeconomic characteristics of the respondents contd

Socio-demographic characteristics	Frequency	Percentage
Highest level of education		
Informal	84	16.7
Primary	128	25.4
Secondary	264	52.4
Post-secondary	28	5.6
Religion		
Christianity	401	79.6
Islam	27	5.4
African Traditional Religion	76	15.1
Occupation		
Student	157	31.2
Unemployed	65	12.9
Self Employed	127	25.2
Farmer	132	26.2
Civil Servant	16	3.2
Retired	7	1.4
Gross Household Income (Naira)		
<50,000	437	86.7
50,000 – 100,000	53	10.5
>100,000	14	2.8

Table 2. Sources of preferred household drinking-water

S/No	Village	Borehole (N)	Stream (N)	River (N)	Spring (N)	Lake (N)	Total (N)
1	Obiuno	3	-	-	-	-	3
2	Okpuno	4	-	-	-	-	4
3	Umuajana	10	1	1	-	-	12
4	Umuji	2	-	1	-	-	3
5	Umuogbuefi	-	1	-	-	-	1
6	Umuoye	1	1	-	1	-	3
7	Uwani	2	1	1	-	1	5
8	Umuaba	5	-	-	-	-	5
Total		27(75%)	4(11%)	3(8%)	1(3%)	1(3%)	36

N = number of the sources

3.2 Bacteriological composition of the preferred drinking-water sources

Contrary to expectations, borehole water, which is considered less vulnerable to pathogen contamination due to its underground location and natural filtration through soil layers (Katsanon, 2019), was found to contain microbial organisms. In fact, 74.3% of the bacteria isolated came from borehole water samples, followed by surface water sources (22.9%) and spring water (2.9%). Moreover, *E. coli*, an indicator of recent faecal contamination, was present in 31% of the drinking water samples analyzed. This suggests the presence of other disease-causing pathogens, including *V. cholera* (21%), *S. typhi* and *S. paratyphi* (12% each), *S. dysentriae* (10%), *V. parahaemolyticus* (8%), and *Proteus spp* (4%). These pathogens can cause outbreaks of highly infectious diseases like cholera, typhoid fever, salmonellosis, and shigellosis.

The study suggests that the contamination of borehole water may be due to the presence of burst pipes, open defecation by children, and indiscriminate refuse disposal around boreholes, leading to the introduction of wastewater into the underground water supply. Additionally, inhabitants of the study area may engage in practices such as defecating and bathing in surface waters, open defecation on farmlands and bushes, and dumping garbage and sewage into drainage systems, which can contaminate surface water bodies. These practices may have contributed to the presence of pathogens in the surface water samples analyzed.

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ISSN (ONLINE): 3026-8923

Table 3. Microbiological qualities of preferred household drinking-water sources

Village	Number of water sources	Number contaminated	S. typhi	S. paratyphii	S. dysentriae	E. coli	V. cholera	V. parahaemolyticus	Proteus spp	Total bacteria isolated
Obiuno	3	3	0	0	0	3	1	0	1	5
Okpuno	4	4	2	2	2	4	3	2	0	14
Umuajana	12	11	3	3	3	8	7	1	0	25
Umuji	3	3	0	0	0	2	2	1	0	5
Umuogbuefi	1	1	0	0	0	1	1	1	0	3
Umuoye	3	3	2	2	2	2	2	1	0	11
Uwani	5	5	3	3	2	4	2	0	2	17
Umuaba	5	5	2	2	1	5	2	2	1	15
Total	36	35	12 (13%)	12 (13%)	10 (10%)	30 (31%)	20 (21%)	8 (8%)	4 (4%)	96

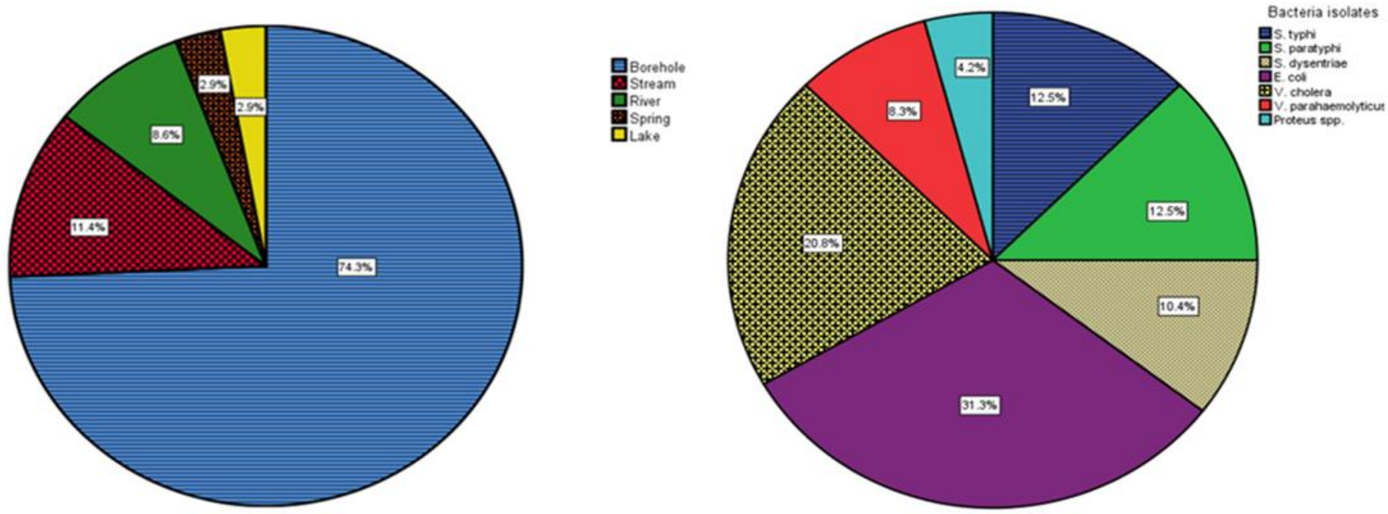

Figure 1. Bacteriological composition of the preferred drinking-water sources of 504 households in Ebenebe, Anambra state, Nigeria

3.3 Distribution of waterborne microorganisms in faecal samples according to age and sex characteristics

The distribution of waterborne infections (WBIs) in this study showed that inherent and acquired characteristics of individuals, their activities, and living conditions play a significant role in determining who is at risk of infection (Richard , 2005). Although there was no statistically significant difference in the age-sex distribution of WBIs, the working-age group (15-64 years) was most affected (77.8%), followed by the young child group (5-14 years) (11.2%), the aged group (≥65 years) (9%), and the school-age group (<5 years) (1.4%). A study (Abdulkadir et al., 2019) in Sokoto State, Nigeria supports these findings, attributing it to the high risk of acquiring WBIs due to water usage in activities like farming. However, studies in the Islamic Republic of Iran (Sayyari et al., 2005) and Uganda (Abdulkadir et al., 2018; Bashini, 2016)found a higher prevalence of WBIs among the school-age group, possibly due to poor hygiene and low immunity.

The working-age group being most affected implies a decrease in workforce, work output, and productivity, potentially impacting family well-being if the breadwinner is affected. After adjustment, the school-age and young child groups had higher chances than the aged group. This may be due to poor hygiene, voracious eating habits, and children's involvement in water collection and domestic activities in the company of their mothers.

Although WBIs were more prevalent in females than males, there was no statistically significant difference between sex groups. The reason may be attributed to the fact that more females responded through the provision of their faecal samples for analysis. A study in Uganda (Abdulkadir et al., 2018; Bashini, 2016) supports this finding, attributing it to females' roles in water collection, domestic activities, and caring for sick family members. However, another study (Abdulkadir et al., 2019) in Sokoto State, Nigeria found a higher prevalence of WBIs among males, possibly due to their increased exposure to surface water during farming activities. This study's findings imply that women's illness may increase the risk of reduced family functioning, social, emotional, and behavioral problems in children and adolescents.

3.4 Preferred source of drinking water and waterborne infections

While this study found no statistically significant link between preferred drinking water sources and waterborne infections (WBIs), it surprisingly revealed that consuming borehole water may actually protect against WBIs, despite the microbial analysis indicating otherwise. Additionally, no correlation was found between WBIs and other preferred drinking water sources. Notably, all bacteria isolated from water samples were also present in faecal samples, possibly due to participants' confidence in their water sources' purity and lack of disinfection before consumption. This suggests that the preferred drinking water sources may not be safe or potable, leading to the presence of organisms in faecal samples capable of causing WBIs.

Consequently, the study found that respondents experienced symptoms of WBIs, such as watery stool (69.5%), vomiting (25.1%), abdominal discomfort (72.1%), and rectal prolapse (15.9%), in the weeks leading up to the study, regardless of other confounding factors. Although no parasites capable of causing WBIs were found in the water samples, their presence in faecal samples suggests that respondents may have been infected through a food-borne route. This study's findings contradict previous studies that found a significant association between WBIs and preferred drinking water sources. However, the results align with studies that highlight the importance of proper water treatment and hygiene practices to prevent WBIs.

3.5 Conclusion

The study found that residents in Ebenebe, Anambra State, Nigeria use various water sources, including borehole, stream, river, spring, and lake water, which contain pathogenic organisms that can cause waterborne infections (WBIs). Despite this, no association was found between the preferred drinking water source and the occurrence of WBIs, which had a prevalence rate of 85%, mostly affecting working-age individuals and females.

3.6 Recommendation

Appointing caretakers for existing boreholes and educating residents on user-friendly, point-of-use filtration and disinfection methods were recommended.

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