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SCREENING OF DRINKING WATER FOR CONTAMINATION DIARRHOEAL DISEASE PREVALENCE AMONG CHILDREN BELOW THE AGE OF FIVE IN KADUNA METROPOLIS, KADUNA STATE, NIGERIA

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ABSTRACT

Access to water supply and sanitation facilities has considerable health and economic benefits for households and individuals. However, lack of access to safe drinking water and inadequate disposal of human excreta is associated with various diseases, including diarrhoea; diarrhoea is the second leading cause of under-five mortality in developing countries and Nigeria in particular. Microbiological water quality is typically assessed by the identification of Escherichia coli (E. coli), a fecal indicator. The hydrogen sulfide (H2S) test is an inexpensive, easy-to-use, and portable alternative field-based water quality test. This study aims to screen drinking water for contamination and prevalence of diarrhoeal diseases among children below five years of age in Kaduna metropolis, Kaduna state, Nigeria. A descriptive cross-sectional study involving 180 participants was carried out using a Modified WHO cluster sampling technique; semi-structured questionnaires were used to record bio-data and information in line with the objective of the study, drinking water from various sources were collected in orlab Hydrogen sulphide test vials, stored in an ambient temperature of about 25 ⁰ C – 35 0 C for 24hrs to confirm for blackening of water in the vial to identify faecal contamination. The prevalence of diarrhoea was 40.6% in all four local government areas that make up the Kaduna metropolis; 52.8% of the collected samples tested positive for bacteriological contamination using the test kit. 51.6% of the recorded positive test samples were obtained from employed mothers, 32.6%from unemployed mothers, and 15.8%f rom self-employed mothers. The mother's age was positively associated (p-value 0.00001 significant), the level of the mother's education (p value= 0.000915 significant), source of drinking water also showed a significant association (p-value 0.00001 significant). A high percentage of prevalence, knowledge, contaminated samples were observed. Also, all sociodemographic factors except religion and sex of child are positively associated with diarrhoea diseases.

KEYWORDS – Diarrhoea, Water, Hydrogen sulphide test, prevalence.

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Introduction

Water that is suitable for drinking and cooking is referred to as potable water because it meets approved standards for its physical, chemical, and bacteriological characteristics. The recommended amount for a person weighing 60 kg per day is 2 liters (according to WHO and UNICEF). This value is used to calculate how much exposure to potentially harmful substances in drinking water is consumed. However, the amount of water that each person really consumes varies greatly from person to person and depending on the climate, physical activity, and culture (De Zuane, 1997).

Water has influenced human health strongly and it is required in minimum amount for survival daily; it is therefore important to access good quality or potable water for life. As a result, water has an essential effect on the health and well-being of consumers. Water, however, has a considerably wider range of effects on health and happiness. The availability of water, both in terms of quantity and quality, is essential to determining both individual and societal health.(World Health Organization WHO, 2013). Having good quality water is key population health and sustainable development.80% of diseases in the tropics has been attributed to consumption of unsafe drinking water sources giving a rise to mortality rate from preventable diseases (Epundu., *et al.,* 2017).

Ensuring that everyone has access to properly managed drinking water and sanitation is essential for promoting human health and sustainable development. Clean water and proper sanitation are essential to preventing the transmission of diseases such the COVID-19 virus (Otto et al., 2020) (Prüss-Üstün et al., 2008). Despite the necessity of clean water for drinking and for maintaining human health, 2 billion and 3.6 billion people, respectively, lack access to even the most basic sanitation systems (UN-Water, 2021).

Due to the warming of the planet's ecosystems brought on by climate change, access to water is becoming more unpredictable and scarce (UN-Water, 2021). Universal access to properly managed drinking water and sanitation services is still a long way off. However, between 2000 and 2020, 2.4 billion people will receive better sanitation facilities, and 2 billion will have access to safe drinking water (WHO and UNICEF, 2021).

In order to determine if a country's water infrastructure is sufficient for protecting public health, the 2022 EPI Sanitation & Drinking Water metrics measure diseases and fatalities brought on by contact with contaminated water and sanitation systems. Nigeria is ranked 177th overall and 43rd in sub-Saharan Africa (Wolf M.J. et al., 2022).

In 2022, Environmental performance index which tracks diseases and deaths as a result of exposure to unsafe drinking water and sanitation, providing insights to countries on their water infrastructure to maintain public health. Nigeria position was 177 out of 180 countries globally with a drinking water quality of 5.0 score out of 100 from the united kingdom of 100. The EPI grades 180 countries global on fundamental issues such as environmental health, climate change, and ecosystem vitality; thus placing Nigeria in a class of public health emergency (Wolf, M.J., Emerson, J.W., Esty, D.C., De Sherbinin, A., Wendling, Z.A., et al., 2022)

The establishment of safe management of drinking water and sanitation services has not advanced very far in the world. Between 2000 and 2020, 2.4 billion more people had better sanitary conditions, and 2 billion more people had access to clean water. UNICEF and WHO, 2021

Diseases such as diarrhoea, schistosomiasis, cholera, and infective hepatitis and are transmitted as a result to the consumption and usage of unsafe water. According to the World Health Organization, use of contaminated drinking water and inadequate sanitation and hygiene caused 88 percent of the 4 million cases of diarrheal disease that occur each year. (UNICEF. 2019). An estimate of 1.8 million people die annually from diarrhoea diseases of which 94% of those deaths can be prevented through improving the availability of clean water, sanitary conditions, and hygiene.(Solomon, E.T *et al.*,2020). Therefore, encouraging water treatment and safe storage will assist at-risk offering them the tools and knowledge they need to consume clean water for drinking will assist individuals and groups in taking control of their own water security (Solomon, E.T *et al.*, 2020).

The World Health Organisation (WHO) defines diarrhoea as three or more watery or loose stools per day brought on by an excessive increase in daily bowel motions or an unusually high quantity of stomatal fluid. Diarrhoea kills more than 90% of children under the age of five in low- and middle-income countries, while in South Asia and Sub-Saharan Africa (SSA), it is responsible for 88% of all deaths in the same age group (UNICEF, 2016).

Children who experience diarrhoea may experience a number of issues, including an appetite loss, an electrolyte imbalance, malnutrition, an increased risk of contracting further infectious infections, and a delay in their physical growth and development (Demissie G. D., 2021). Diarrhoea hinders physical and cognitive development and is linked to a number of issues, such as the 72.8 million people who are disabled, adjusted loss of life, and damaged family finances and health systems (Aikins M, Armah G, Akazili J, Hodgson A., 2010; Gakidou E, Afshin A, Abajobir AA, Abate KH, Abbafati C, Abbas KM, et al.,2017).

Due to limited access to clean water, poor sanitation, and hygiene, as well as poorer health and nutritional status, diarrhoea is more common in homes with low and average incomes (Melese B et al., 2019). According to estimates, 2.5 billion people require better sanitary facilities. These unsanitary conditions allow germs that cause diarrhea to proliferate and spread more quickly (Melese B., 2019).

Pathogens associated with diarrheal diseases in developing countries correlates to quality and quantity of water, age of the child, obtainability to toilet facilities, educational level, and economic status of the households, housing conditions, feeding practices, and the general hygiene in the environment (Adeniji-Oloukoi., 2013). There is a higher risk of waterborne diseases in areas with adequate water supply, poor sanitary conditions, bad sewage pipelines, open defecation, Steep and uncovered wells used as sources of drinking water and, poor system of human waste disposal (United Nations., 2015).

Multiple investigators have recognized an array of indirect risk factors for child diarrhoea, which can be categorized as socioeconomic, environmental, and behavioral factors at the level of households (Sarker A et al., 2019). They include the mother's age, place of residence, degree of education, the number of children in the home below the age of five, access to latrines and clean water, money, and employment status, among many other things.

It is well known that factors such as the age of the child, the quality and quantity of water, access to toilets, housing status, education level, household financial situation, place of residence, eating habits, and general problems Sanitary conditions (personal or domestic hygiene) near home influence the risk of diarrheal pathogens in developing countries (Adeniji-Oloukoi, 2013). According to Farthing (2009) and the United Nations (2015), open defecation, especially near drinking water sources, and inadequate human waste disposal

systems both increase the risk of waterborne diseases in areas with insufficient water sources, poor quality water and sewage pipes, poor sanitary conditions, steep wells and uncovered wells used as sources of drinking water, and these factors.

Diarrhoea continues to be one of the most common causes of death and morbidity in children, particularly in low- and middle-income countries (LMICs). Infectious disorders claimed the lives of 6.3 million children under the age of five worldwide in 2013 (3.2 million), with diarrhoea accounting for more than 500,000 of these deaths (UUsten et al., 2008; Thiam et al., 2017). By 2030, it is anticipated that 4.4 million children under the age of 5 will die annually from infectious illnesses, with sub-Saharan Africa accounting for 60% of these fatalities. Diarrhoea accounts for 3.6% of all illnesses globally in terms of disability-adjusted life years (DALYs) (WHO, 2019; Thiam et al., 2017).

Despite a major fall in diarrhea-related mortality around the globe over the past 25 years, sub-Saharan Africa has not seen a corresponding decline in diarrhea-related morbidity because factors such as poor hygienic practices, poor sanitary, and water conditions. Early childhood diarrhoea prevalence and socioeconomic status are connected. In North Sudan, 28% of children under the age of five suffer diarrhoea, according to studies (Siziya, Muula, and Rudatsikira, 2013). Another study carried out in eastern Ethiopia found that the prevalence of diarrhoea was 21.5% (Antench et al., 2017). The World Bank categorises these nations as low-income nations. Middle-income nations tend to have lower prevalence rates; a 2016 study in Thailand revealed a prevalence of 4.9%, while a 2014 study in Vietnam recorded a prevalence of 8.6%. Out of a total of 5,478 respondents, the mean prevalence in the three East African nations chosen for the study between 2012 and 2017 was 27%, with a range of 11% to 54% (Office National de la Statistique, 2016; UNICEF, 2014).

Although the 6.1 and 6.2 Sustainable Development Goals clearly state that everyone must have access to water and sanitation by 2030 (United Nations, 2015), achieving this goal continues to be very difficult for sub-Saharan Africa (United Nations, 2016; Roche et al., 2017). Sub-Saharan Africa's access to sanitation, hygiene, and water availability has been steadily improving, but the region is falling behind other developing countries in these areas. Between 1990 and 2008, better water supply increased from 49% to 60%, whereas access to improved sanitation only increased from 28% to 31%.

Worldwide, 67% of people in 2015 had access to "basic water supply" (WASH), including 82% of urban residents and 54% of rural residents (Nigerian WASH Watch; WHO and UNICEF; 2019).

Main Source of Drinking Water (% Households)

	Hand Pump Borehole	Other	Pipe borne Water	Protected Well	Rain Water	River/ Lake/ Pond	Unpro-tected Well	Vendor / Truck	Improved Sources
Birnin Gwari	8.5	0.6	2.45	22.4	0.6	13.9	49.7	1.8	33.9
Chikun	10.6	0.6	25.7	41.3	0.6	3.3	10.1	7.8	78.2
Giwa	13.3	0.6	0.6	21.1	0.6	4.8	54.2	5.4	35.5
Igabi	18.3	0.0	0.6	18.9	0.0	3.3	55.0	3.9	37.8
Ikara	16.6	0.0	9.9	7.9	0.0	0.0	63.6	2.0	34.4
Jaba	4.7	0.0	32.7	21.3	0.7	9.3	30.7	0.7	59.3
Jema'a	19.1	0.0	13.1	51.4	0.0	7.7	7.1	1.6	83.6
Kachia	33.1	0.0	8.8	29.8	0.6	14.4	12.7	0.6	72.4
Kaduna North	10.2	0.6	50.0	4.0	0.0	0.0	10.2	25.0	64.2
Kaduna South	22.5	0.0	49.7	16.2	0.0	0.0	8.4	3.1	88.5
Kajuru	30.0	0.7	0.0	30.7	0.0	0.0	38.7	0.0	60.7
Kagarko	34.5	0.0	0.7	14.2	0.0	16.2	34.5	0.0	49.3
Kaura	14.6	0.0	34.4	28.5	0.0	9.3	13.2	0.0	77.5

Source: Kaduna State General Household Report 2015

FIGURE 1- SOURCES OF DRINKING WATER KADUNA STATE

Nigeria has a low GAPPD intervention score of 31% and ranks as the second-largest contributor to the Under-five Mortality Rate values from diarrhea in the world, which are both suggestive of the fact that the country loses over 2,300 children under the age of five every day. (International Vaccine Access Centre (IVAC)., 2015). The "GAPPD score" of a nation assesses the application of actions to safeguard against, Monitor and cure diarrhea and pneumonia. The more interventions are being employed, the higher the score is (International Vaccine Access Centre IVAC., 2015). Approximately 88% of the disease burden caused by diarrhea is attributable to an inadequate supply of clean water, basic sanitation, and hygiene; however, while the disease rate is reducing more moderately, diarrheal mortality is still abnormally high and is steadily declining by 4% year (Clasen et al., 2019). These declines must be accelerated by interventions that target the root causes and the most at-risk kids (UNICEF, 2020). These efforts must be guided by crucial knowledge concerning the fifteen loads, risk variables, and case fatality of extremely dangerous and incapacitating occurrences. However, in Nigeria, an area with the highest rates of child death, these statistics have been inadequate (UNICEF, 2020).

A study conducted by Korie FC, Ikefuna AN, and Ibe BC (2013, In Enugu, Nigeria, children under the age of five seem to get acute diarrhoea at a similar rate regardless of their sociodemographic features. In the highland state, it was discovered that family type, family size, breastfeeding, and kid sex were two factors linked to occurrences of diarrhoea. Only breastfeeding, mother education, and diarrhoea in other siblings were discovered to be significantly linked with diarrhoea, though found a link between the frequency of diarrhoea

and low mother education, infants who weren't exclusively breastfed, and siblings who had previously experienced diarrhoea (Yilgwan CS, Okolo SN., 2012).

In most cases, the microbiological water quality is assessed using Escherichia coli (E. coli), a marker of faecal contamination and waterborne pathogens. Membrane filtration requires specialized tools and knowledge for E. coli detection. The hydrogen sulphide presence/absence test has gained appeal as a low-cost assay for identifying faecal contamination since it is inexpensive, easy to use, and portable. It has been utilised on a global scale for over 20 years (Mengistu et al., 2022).

An alternate to the microbiological water quality test, which was originally developed in the early 1980s as a cost-effective field-based water quality test, is the hydrogen sulfide test (Parashar U.D, Breese Js, Glass Ri., 2003). The test screens for a change in the colour of water samples to black coloration indicating a presence/absence of fecal coliform. Utilizing molecular microbiology, the specificity of the hydrogen sulphide test for bacterial genera associated with faecal contamination is confirmed (Schnabel, Bastian & Caplin, Jonathan & Cooper, Ian., 2020).

For over 30 years, the hydrogen sulphide tests have been utilized to screen for faecal contamination in water worldwide. The test is a very effective water quality-monitoring tool for low- middle-income resource settings.

The hydrogen sulphide test kit for the microbiological quality of water is an easy-to-use instrument for assessing the mobility of drinking water in the field. There is no need for a laboratory for this test. It is a cheap, trustworthy, and practical way to determine the mobility of a water sample under field conditions. Drinking contaminated water puts one at risk for cholera, typhoid, diarrhoea, and jaundice, among other waterborne illnesses. The Test Kit medium's medium changes colour to show if it is fit for drinking or not.

A microbiologist and a well-stocked lab are required for the traditional approach of assessing the microbiological purity of water. It is also an expensive and drawn-out test. Only after roughly 72 hours is the desired outcome seen and noted. However, the hydrogen sulphide test kit gives the necessary result in just 18 hours, is inexpensive, and is particularly beneficial in rural areas where tests may be performed by even those without a college degree.

Advantages of the test

• This is a field test so water samples can be taken directly from the faucet.
• There is no need to remove chlorine from chlorinated water as the contents of the bottle remove the chlorine immediately.
• No need to measure the volume of water as the level on the label says 20 ml.
• Testing is simple, fast and inexpensive.
• No need for electricity, laboratories, cold chains or expensive and complicated equipment. • Easy to use for field testing in under-resourced, rural, disaster/emergency areas
• Incubate at room temperature of 25°C or more
• Operates at different temperatures; Constant temperature control unnecessary
• Check ambient temperature for results in 24-48 hours
• Compact and lightweight, less consumables
• An uneducated person can even take a field test.

The hydrogen sulphide test is used to identify faecal bacteria, some of which are capable of converting organic sulphur to sulphide, which is then converted into hydrogen sulphide gas. By comparing the colour of the water in the test vial to the precipitate formed when this reacts with the reagents in the vial, it is possible to visually detect faecal contamination. However, there is concern that the test may also identify bacteria and the diseases that go along with them that are not related to faecal pollution. In addition, the effectiveness of the hydrogen sulphide test as a predictor of the risk of contracting watery diarrhoea is debatable (Mahfuza et al., 2017). No correlation was identified between diarrhoea and water quality as determined by hydrogen sulphide tests in a prior study conducted in India. However, this cohort had a relatively low rate of diarrhoea (2.4%), and the study collected water samples and data on disease. Due to the absence of time, reverse causation has the potential to distort the relationship between water quality and sickness (Ercumen A., et al., 2017)

PURPOSE OF RESEARCH

Specific objectives;

1. To assess the knowledge of the link between drinking water and diarrhoea diseases using semi-structured questionnaires among the residents of the Kaduna state metropolis.
2. To ascertain the prevalence of diarrhoea disease among the residents of the Kaduna metropolis.
3. To ascertain where people in the four Local Government areas that make up Kaduna Metropolis get their drinking water.
4. To screen drinking water for contamination in various drinking water sources using the orlab Hydrogen sulphide test vials in the Kaduna state metropolis.
5. To identify the relationship between socioeconomic risk variables for diarrhoea incidence among children under five in the Nigerian city of Kaduna.

By determining the number of cases of childhood diarrhoea in the Kaduna this study aims to close these knowledge gaps about children under the age of five in the metropolis and the associated environmental and socioeconomic risk factors.

SIGNIFICANCE OF THE STUDY

This study will provide background information regarding diarrhoea for the inhabitants of Kaduna Metropolis as well as other health sector personnel to understand the current existing situation of knowledge, and perception regarding diarrhoea, water supplies, and the spectrum of bacteriological contaminants in drinking water.

The study's findings will be helpful to mothers, especially those who are expecting children, since they will give them accurate knowledge about the idea, symptoms, mechanisms of transmission, and preventative methods of childhood diarrhea. The women will be able to choose preventive measures with knowledge thanks to this. The right information will affect them and improve their practice. They can use it to inform the public about ways to reduce childhood diarrhea. A poor level of knowledge, on the other hand, will cause policymakers to step up their efforts in the fields of health education, workshops, and seminars to increase people's understanding of childhood diarrhea and its preventive measures, particularly in rural regions.

The discovery from this research will be helpful to the public, who needs appropriate information on childhood diarrhoea. Researchers can build on the output of this study for

further this area of knowledge. This study will also enrich the data pool on the subject matter (Health and Education ministries in Kaduna state and form the basis for future policy formulation and modification).

METHODOLOGY

STUDY AREA

Nigeria's North-West geopolitical zone is where Kaduna is situated. Kaduna serves as the state's capital. The largest city in the state is Kaduna, followed by Zaria and Kafanchan. It has a total size of 3,080 km2 and is situated on the Kaduna River. Its location is 10°31'23'N and 7°26'25'E. sixty or more ethnic groupings.

The state metropolis has an urban settlement, with over three health care centres (private clinics and hospitals) in each community and one primary health care centre. The Kaduna state water board is responsible for water treatment and distribution within the state metropolis and neighbouring local government areas such as Zaria. The primary water source is the Kaduna river, which the water agency treats before distribution, serving as pipe-borne water to the state's inhabitants. Borehole water sources are also on the increase as urban development continues to be on the increase.

In Northern Nigeria, Kaduna is a major industrial hub where goods like equipment, textiles, petroleum products, steel, aluminum, and bearings are produced. Mineral resources like clay, serpentine, asbestos, amethyst, and gold enrich it.

The 2006 census places the state's population at 6 113 503 persons, according to the National Population Commission. Additionally, according to the Housing Census conducted the same year, Kaduna has 3 023, 065 females and 3 090, 438 males. The yearly population growth rate was 2.47%, according to the National Bureau of Statistics (NBS).

This study was carried out in the four Local Government Areas that comprise the Kaduna state metropolis. These Local Government areas include; Chikun, Igabi, Kaduna north, and Kaduna south.

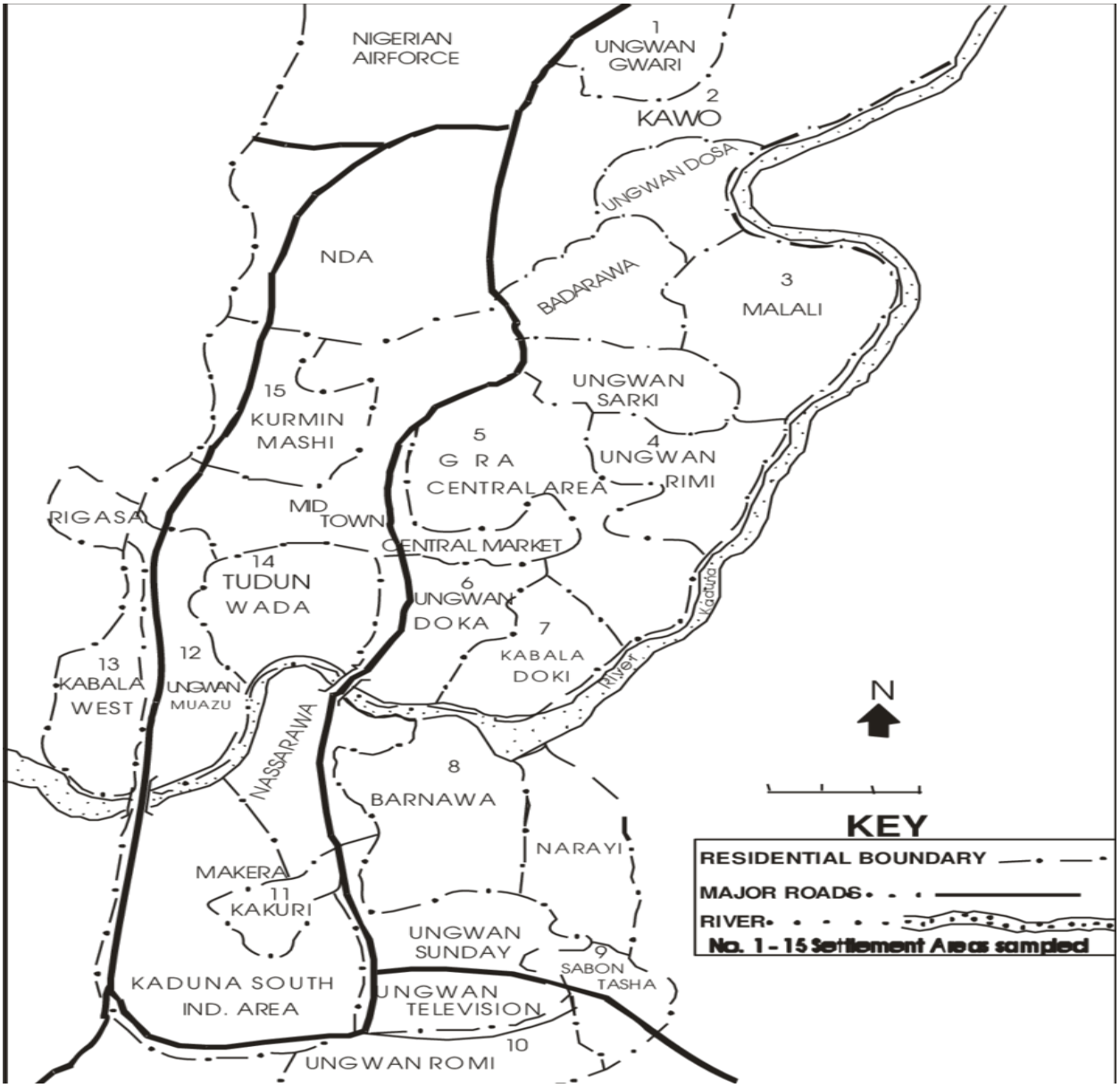


FIGURE 2 - MAP OF KADUNA METROPOLIS



FIGURE 3- A WATER SOURCE IN KADUNA NORTH FOR A COMMUNITY



FIGURE 4- WASTE DISPOSAL AREA IN A COMMUNITY

PURSUE DESIGN

This research was a descriptive cross-sectional study that looked at different drinking water sources in study region households rather than only using questionnaires as the primary data collection tool.

RESEARCH POPULATION

The study's target audience was children between 0 and 59 months old. Female residents of the study area who were consenting parents of the children.

Inclusion criteria;

Mother of children between 0 and 59 months old residing within the study area and consented to participate, were eligible.

Exclusion criteria

1. Nonparturient women, female parents who do not have any children under the age of five.
2. Children ill with persistent diarrhoea for more than two weeks.
3. Ill or suffering mothers or guardians of the index child.

SAMPLE SIZE DETERMINATION

The sample size was determined using Cochran's formula (Cochran GW and Snedecor WG., 1959).

$n=Z2. \times P, Q$
$d2$

Or

n = desired sample size
Z = normal standard deviation at 95% confidence level or 1.96,
P = The prevalence of diarrhea in Kaduna State is 13.4% (Magbagbeola D., 2017)
Q= 1-p,
d- desired precision at (0.05)

$n=Z^2. pq / d^2$

$n=1,96^{2} \times 0.134 \times (1-0.134) / (0.05)^2 = 171.11$

Value $n=171.10 \approx 180$

SAMPLING TECHNIQUE

Modified World Health Organization cluster sampling technique (Elizabeth L., 2010).

Selection of households

The Extended Program on Immunization recommendation for the first household is suitable for sampling. This means that the researcher started at the central point in the community, such as the market, using a bottle and spinning it, and when it stopped, whichever house it pointed to was the starting point. This method was used to avoid bias in the research.

On entering a community, a central point was identified using the bottle spinning method, the house/ compound, the head of the bottle face after spinning was the starting point in that community, and other houses were entered in a clockwise direction from the starting point. For example, entering the house, the Female household head was identified and interviewed with the provided questionnaire, and 20ml of water samples were collected. This was repeated in each community within the research area and selected households.

Tools for collection of sample and tests

Orlab hydrogen sulphide test vial (bacteriological test vials for drinking water) Cat number OR-BAC-01,



FIGURE 5 – ORLAB HYDROGEN SULPHIDE TEST VIAL

structured questionnaire. Samples were collected by researcher and research assistants aseptically to avoid external contamination by

- Personnel wore sterile gloves.
- Gloved hands were disinfected.
- Conversations were avoided whilst sampling.
- Personnel only touch the outside of the container.
- There was no contact with internal parts of sampling container other than from sample itself.
- Splash back were avoided
- Sampling bottle lids were secured to avoid leakage

The location, data and time of sampling were recorded

Direction for Use

- Wash hands thoroughly with soap and water.
- Remove the cap of the sampling bottle and fill the water sample up to the mark as indicated on the bottle.
- Close the cap and gently shake the bottle.
- Keep the sample bottle at ambient temperature ($25^{O}C$-$35^{O}C$) for 24hrs
- Observe the change in the color of the water sample.

RESULT

If the water samples turn black, it is an indication of unsafe for drinking

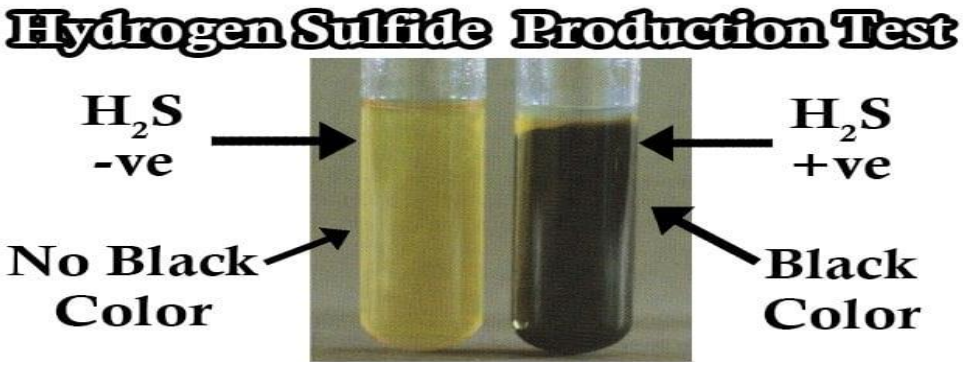


FIGURE 6 – **HYDROGEN SULPHIDE TESTS FOR WATER**

DATA COLLECTION TECHNIQUES

Data collection was collected with interviewer-administered, closed-ended, semi-structured adapted questionnaires and the orlab test kit.

Procedure for data collection

Data was procured by administering questionnaires to female head of the household (female parent) within the specified local government areas. The questionnaire contents were explained to the respondents by the investigator and the research aides and filled by the investigator or research aide.

Research Assistant

The research assistants were recruited and trained for two weeks, a minimum of an hour twice a week, and based on the objectives of the study by the researcher. In addition, two microbiology graduates were recruited to serve as research assistants.

Questionnaires Scope, Structure, Sections and Validity.

A semi-structured questionnaire was adopted and adapted from the WHO guide to developing questionnaires in Geneva, Switzerland for this study. The study's objectives (knowledge and prevalence of diarrhoea, sources of drinking water, sociodemographic factors, and test results) were divided into sections in the semi-structured questionnaire, which contained open-ended and closed-ended questions.

Section A, aims to collect bio-data of respondents such as age, educational status, employment status. Section B collects data on the sources and storage of drinking water, Section C collects data on knowledge and prevalence of diarrhea, and section D records data of the water test kit result.

By balloting, pre-testing was done using ten households from randomly selected communities within the Kachia local government area of Kaduna State. This was done to remove pre-knowledge and bias, check validity and to make a necessary adjustment based on the outcome of the results.

DATA ANALYSIS

In the Statistical Package for Social Sciences (SPSS), the coded data were entered twice. The same version 20 of the Statistical Package for Social Sciences (SPSS) was used to process, analyse, and interpret the data. With the use of the bivariate analysis, the researcher will be able to determine whether two variables are related using Chi-square and P-value.

ETHICAL CONSIDERATIONS

The Kaduna state ministry of health research and ethical committee (HREC) and Nnamdi Azikiwe University Teaching Hospital Health Research and Ethical Committee (NAUTHHREC) provided a letter of ethical approval for the study. Participants were also informed of the study's objectives and given pledges regarding the confidentiality of any data they gave. Participants received respect and dignity. Additionally, anonymity was used with codes for addresses. Last but not least, taking part in the study was entirely optional.

STUDY RESULTS

Link of Knowledge between drinking water and diarrhoeal diseases among study participants.

In Kaduna North, only 11.1% of the respondents had a good knowledge of diarrheal diseases.

In the Chikun local government area, 19.4% had a good knowledge of diarrheal diseases, 20% in Kaduna South and 16.1% in Igabi local government.

In total, only 66.7% of the respondents had good knowledge, and of the 66.7%, 25.9% obtained knowledge of diarrhoeal diseases from schools, 70.8% from hospitals or healthcare facilities, and 3.3% from healthcare personnel(s).

Prevalence of diarrhoea

The overall prevalence of diarrhoea was 40.6% in all four local government areas that make up the Kaduna metropolis.

Mothers with secondary education had the highest number of children who had been down with diarrhoea in the past two weeks at 13.9%, followed by a primary school with 13.3%, then tertiary with 8.9% and lastly 2.2% for no formal education.

27.2% of unemployed mothers recorded children who had been sick with diarrhoea in the past two weeks, 8.3% of employed mothers reported the same, and 5%of self-employed (business) mothers reported cases of diarrhoea in the past two weeks.

The highest prevalence of diarrhoea was recorded from households that used borehole drinking water sources 25.0%, followed by pipe-borne 6.1% and well-water users 5.6%.

Mothers within the age range 20-29 had the highest prevalence with 21.1%, followed by the age range 30-39 with 10.56% prevalence, and lastly, the age range 40-49 with 8.9% (this is a good trend, but what will you say is responsible for this trend? – looking at the ages, younger mothers do not have much experience like older mothers)

Igabi local government area had the highest prevalence with 16.7%, followed by Kaduna North with 11.1%, then 7.8% from Chikun local government and lastly, Kaduna South with5.0% as shown in the table below.

TABLE 1 – PREVALENCE OF DIARRHOEA

VARIABLES		DIARRHOEA POSITIVE (n) (%)	DIARRHEA NEGATIVE (n) (%)	OR (95% C.I)	X^2 P-Values
MOTHERS' LEVEL OF EDUCATION	NO FORMAL EDUCATION	4(2.22)	2(1.11)	1	
	PRIMARY EDUCATION	24(13.33)	18(10)	1.50 (0.247, 9.11)	
	SECONDARY EDUCATION	25(13.89)	43(23.89)	0.667(0.110-4.049)	11.6959 .008501
	TERTIARY EDUCATION	16(8.89)	44(24.44)	0.181(0.030-1.090)	
OCCUPATION	UNEMPLOYED	49(27.22)	20(11.11)	1	
	EMPLOYED	15(8.33)	55(30.56)	0.111(0.051-0.241)	
	BUSINESS	9(5.00)	32(17.78)	0.115(0.046-0.284)	43.0622 <0.00001
SEX OF CHILD	FEMALE	43(23.89)	60(33.33)	1	0.1419
	MALE	30(16.67)	47(26.11)	0.890(0.488, 1.627)	0.0706
SOURCE OF DRINKING WATER	BOREHOLE	45(25.00)	41(22.78)	1	
	SACHET	6(3.33)	34(22.78)	0.160(0.061-0.422)	
	PIPEBORNE	11(6.11)	3(1.67)	3.341(0.870-12.821)	33.5358 <0.00001
	BOTTLE	1(0.56)	17(9.44)	0.054(0.007-0.421)	
	WELL	10(5.56)	12(6.67)	0.759(0.297, 1.943)	
AGE OF MOTHER	20-29	38(21.11)	6(3.33)	1	

	30-39	19(10.56)	60(33.33)	0.05(0.018-0.136)	50.9103 <0.00001
	40-49	16(8.89)	41(22.78)	0.06(0.022-0.174)	
REGION	**KADUNA NORTH**	20(11.11)	25(13.89)	1	
	CHIKUN	14(7.78)	31(17.22)	0.565(0.238-1.337)	
	KADUNA SOUTH	9(5.0)	36(20.00)	0.313(0.122, 0.798)	22.5605 0.00005
	IGABI	30(16.67)	15(8.33)	2.50(1.064, 5.874)	
RELIGION	**ISLAM**	42(23.33)	36(20.00)	1	
	CHRISTIANITY	31(17.22)	71(39.44)	0.374(0.203, 0.691)	10.0854 0.001494
WATER TREATMENT	**BOILING**	1(0.56)	26(14.44)	1	
	USE OF CHEMICAL	3(1.67)	24(13.33)	3.25(0.316, 33.409)	
	NO TREATMENT	69(38.33)	57(31.67)	31.47(4.142, 239.135)	35.4676 <0.00001

Drinking water sources

In Kaduna North, 17.8% of drinking water sources were boreholes, 3.3% drank from sachet water, and 3.9% drank from bottled water which 10.56% treated their drinking water, and 14.4% did not treat their drinking water. 17.8% of respondents stored their drinking water in buckets. After drinking water analysis, 16.67% of the samples collected showed contamination.

In the Chikun local government area, 7.8% drank water from a borehole, 6.1% drank sachet water, 5.6% drank pipe-borne water, 2.2% drank from bottled water and 3.3% drank from dug wells, of which 8.3% treated their water and 16.7% did not treat their drinking water. 11.1% of respondents stored their drinking water in buckets after the analysis of drinking water, and 6.7% of collected water samples tested positive for contamination.

In Kaduna South, 8.9% drank water from a borehole, 9.4% drank from sachet water, 2.2% drank from bottled water, and 4.4% drank from dunged wells in which only 8.3% treated their drinking water, and 11.1% stored their drinking water for consumption, and after drinking water analysis was completed, 11.1% of samples tested positive to contamination.

In the Igabi local government area, 16.7% drank from boreholes, 3.3% drank from sachet water, 1.7% drank from bottled water, and 3.3% drank from dunged wells in which only 2.2% treated their drinking water, and 18.9% stored their drinking water for

consumption, 18.3% of samples collected tested positive to contamination.

In total, in the Kaduna metropolis, 51.1% drank water from boreholes, 22.2% from sachet water, 10% from bottled sources, 11.1% from protected dunged wells, and 5.5% drank from pipe-borne water sources. Only 29.4% treated their drinking water, 70.56% did not, and 58.9% stored their drinking water for consumption, while 47.2% did not, while 52.8% of samples collected tested positive for contamination.

This can be shown in the table 3 below.

Results with test kit analysis

From the analysis using the drinking water test kit, of 95 positive results, Kaduna North recorded 30 positive tests, the Chikun local government area had 12 positives, Kaduna South had 20, and the Igabi local government area had 33 positive samples. 52.8% of the collected samples tested positive for bacteriological contamination using the test kit. Of the 52.8% of the total samples collected, 41.1% positives were from households with female children and 58.9% from households with male children .55.7% of the positive test results were obtained from the households. Households with mothers with secondary school as their level of education, followed by primary school education with 32.6%, tertiary with 7% and no formal education at all.

51.6% of the recorded positive test samples were obtained from employed mothers, 32.6% from unemployed mothers, and 15.8% from self-employed mothers.

Sixty-three samples obtained from borehole sources of drinking water tested positive, followed by well-drinking water source, sachet water, and pipe-borne water. No positive sample was recorded for bottled water.

60.3% of untreated water samples tested positive, while 38% of treated water samples tested positive. Mothers in the age range of 20-29 had the highest number of water samples that tested positive with 43.2%, followed by the age range 30-39 with 37.9%, and lastly, 40-49% with 18.9%. Forty-eight samples from Christian homes tested positive, while 47 samples from Islamic homes tested positive.

52.5% of respondents that knew diarrhoea tested positive using the drinking water test kit. 74.5% of stored water tested positive for the test, and only 21.3% of people that practiced hand washing tested positive.

Characteristics of the study participants

This study was carried out in the Kaduna metropolis in which four (4) local government areas cover the research area.

In Kaduna North, 11.1% of mothers had secondary school education, 9.4%, had primary education, 1.1% tertiary education and 3.3% with no formal education. Working mothers 5.5%, 5.6% were unemployed and 5.6% were self-employed mothers. Christianity was the most common religion (13.9%), and Islam (11.1%).

Similarly, according to the Igabi local government, 11.7% had secondary school education, 7.8% had Tertiary education, 5.5% had primary education, 15% of the mothers were unemployed, (6.7%) were employed and (3.3%) were self-employed. Islam was the most common religion in the region (17.8%) and Christianity (17.2%).

In Kaduna's south local government area, 13.9% of mothers had secondary education, 5.6% had primary school education and 5.6% had tertiary school education. 16.7% of mothers were employed mothers, 5.5% were unemployed mothers and 3.3% were self-employed mothers. Christianity was the most common religion (13.9%), and Islam (11.1%).

Chikun local government area had 15% tertiary-educated mothers, 7.2% secondary school-educated mothers and 2.7% primary school education. 44.4% of the mothers were self-employed, 11.1% of the mothers were employed, and 3.9% were unemployed. Most religions were Christianity (21.67%) and Islam (3.3%).

In the Kaduna metropolis (3.3% of mothers had no formal education, 23.3% had primary school education, 43.8% had secondary school education, and 29.4% had tertiary education. 38.9% were gainfully employed, 38.3% were unemployed and 22.8% were self-employed in the Kaduna metropolis. (56.7%) Christianity and (43.3) Islam in the study area as showed in the table.

TABLE 2 - SOCIO-DEMOGRAPHIC CHARACTERISTICS OF STUDY PARTICIPANTS

VARIABLE(S)		KADUNA NORTH (n)(%)	CHIKUN (n)(%)	KADUNA SOUTH (n)(%)	IGABI (n)(%)	TOTAL (n)(%)
AGE	**20-29**	1(0.56)	10(5.55)	9(5.00)	23(12.78)	44(24.44)
	30-39	38(21.11)	12(6.67)	10(5.55)	19(10.56)	79(43.89)
	40-49	6(3.33)	23(12.78)	26(14.44)	3(1.67)	57(31.67)
	TOTAL	**45**	**45**	**45**	**45**	**180(100)**
SEX OF CHILD	**MALE**	11(6.11)	17(9.44)	18(10.00)	31(17.22)	77(42.78)
	FEMALE	34(18.89)	28(15.56)	27(15.00)	14(7.78)	103(57.22)
	TOTAL	**45**	**45**	**45**	**45**	**180(100)**
EDUCATIONAL LEVEL	**NO FORMAL EDUCATION**	6 (3.33)				6(3.33)
	PRIMARY	17(9.40)	5(2.77)	10(5.55)	10(5.55)	42(23.33)
	SECONDARY	20(11.11)	13(7.22)	25(13.89)	21(11.67)	79(43.89)
	TERTIARY	2(1.11)	27((15.00)	10(5.55)	14(7.78)	53(29.44)
	TOTAL	**45**	**45**	**45**	**45**	**180 (100)**

OCCUPATION	**UNEMPLOYED**	25(13.89)	7(3.89)	10(5.55)	27(15.00)	69(38.33)
	EMPLOYED	10(5.55)	18(10.00)	30(16.67)	12(6.67)	70(38.89)
	SELF EMPLOYED	10(5.55)	20(11.11)	5(2.78)	6(3.33)	41(22.78)
	TOTAL	**45**	**45**	**45**	**45**	**180(100)**
RELIGION	**CHRISTIANITY**	25(13.89)	39(21.67)	25(13.89)	13(17.22)	102(56.67)
	ISLAM	20(11.11)	6(3.33)	20(11.11)	32(17.78)	78(43.33)
	TOTAL	**45**	**45**	**45**	**45**	**180(100)**

TABLE 3 - CHARACTERISTICS OF THE STUDY HOUSEHOLDS

VARIABLE		**KADUNA NORTH (n) (%)**	**CHIKUN (n) (%)**	**KADUNA SOUTH (n) (%)**	**IGABI (n) (%)**	**TOTAL (n) (%)**
DRINKING WATER SOURCE	BOREHOLE	32(17.78)	14(7.78)	16(8.89)	30(16.67)	92(51.11)
	SACHET WATER	6(3.33)	11(6.11)	17(9.44)	6(3.33)	40(22.22)
	PIPEBORNE	0(0)	10(5.55)	0	0	10(5.56)
	BOTTLED WATER	7(3.89)	4(2.22)	4(2.22)	3(1.67)	18(10.00)
	WELL	0	6(3.33)	8(4.44)	6(3.33)	20(11.11)
		45	**45**	**45**	**45**	**180**
TREATMENT	YES	19(10.56)	15(8.3)	15(8.33)	4(2.22)	53(29.44)
	NO	26(14.44)	30(16.67)	30(16.67)	41(22.78)	127(70.56)
		45	**45**	**45**	**45**	**180**
STORAGE	YES	32(17.78)	20(11.11)	20(11.11)	34(18.89)	106(58.89)
	NO	13(7.22)	25(13.89)	25(13.89)	11(6.11)	74(41.11)
		45	**45**	**45**	**45**	**180**
DIARRHEA	YES	20(11.11)	14(7.78)	9(5.00)	30	73(40.56)
	NO	25(13.89)	31(17.22)	36(20.00)	15	107(59.44)
		45	**45**	**45**	**45**	**180**
KNOWLEDGE	YES	20(11.11)	35(19.44)	36(20.00)	29(16.11)	120(66.67)
	NO	25(13.89)	10(5.55)	9(5.00)	16(8.89)	60(33.33)
		45	**45**	**45**	**45**	**180**
HAND WASHING	YES	13(7.22)	38(21.1)	15(8.33)	14(7.78)	80(44.44)
	NO	32(17.78)	7(3.89)	30(16.67)	31(17.22)	100(55.56)

TEST RESULT	YES	30(16.67)	12(6.67)	20(11.11)	33(18.33)	95(52.78)
	NO	15(8.33)	33(18.33)	25(13.89)	12(6.67)	85(47.22)
TOTAL		**45**	**45**	**45**	**45**	**180**

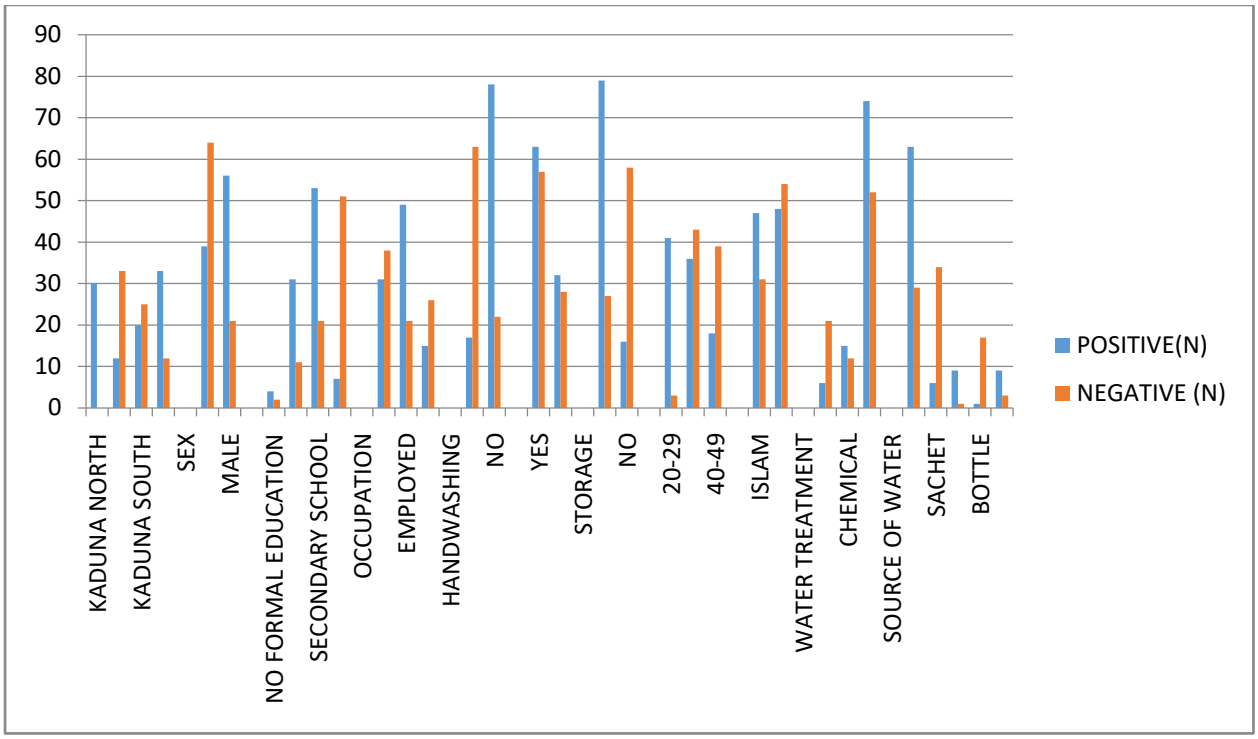


FIGURE 6 - Result of Hydrogen Sulphide Test kit

DISCUSSION

Study findings with other studies

The important risk factors linked diarrhea in children under the age of five were thoroughly discussed in this study. They covered things including the mother's age, education level, religion, employment status, drinking water source, hand washing, water treatment before consumption, and water storage before consumption. These independent factors were still significant even after removing all confounding variables from the crude analysis and adjusting for all relevant independent variables.

The under-five-year-old youngsters in this study also had a high prevalence of diarrhea in just two weeks. The high rate of childhood diarrhea highlights the need for improved reactivity in light of the significant advancements in water sources and sanitation infrastructure. These results are comparable to earlier research in the low-income African nations mentioned.

Knowledge of the Link between Drinking Water and Diarrhoea

66.7% of respondents had a good knowledge of the link between diarrhoea and drinking water; however, this knowledge or awareness of the link between diarrhoea and drinking water does not reflect in the water analysis test result.

Of the 66.7% that knew the link between diarrhoea and contaminated drinking water, 35% showed positive for drinking water test results. The bivariate analysis shows no significance between knowledge of the link and the absence of knowledge. This result agrees with the study done in Egypt in 2018 and Pakistan, India, Mali, and Western Ethiopia. The high level of knowledge can be attributed to the presence of mass media, schools and health care facilities in the area (Demissie GD, Yeshaw Y, Aleminew W, Akalu Y., 2021).

Prevalence of Diarrhea

40.6% of Children under the age of five were had experienced diarrhea in the two weeks before to the survey, including the previous 24 hours. This was higher than the prevalence of Magbagbeola et al. in 2017 in Kaduna North. This, however, can result from increased risk factors such as unsafe drinking water and poor sanitation.

Source of drinking water

It was discovered that childhood diarrhea was positively correlated with the source of drinking water in the home. Less than five kids were at risk for diarrheal episodes in homes with protected or treated water sources. Children who lived in homes with inferior resources, such as unprotected wells and untreated water, were more likely to experience diarrheal episodes.

This was in line with Mengistie et al (2013), instance, among children under the age of five in eastern Ethiopia, diarrhea was highly correlated with household water supplies from underdeveloped sources. Water source is a component of hygiene, and proper drinking water handling is a crucial element in preventing any contamination.

Therefore, household implementation programs should include purification techniques before consumption since even if the water is coming from a safe source, it could be highly susceptible to contamination owing to unsanitary well extraction or storage. Finally, explain why children who lived in homes that drank water from protected sources experienced diarrhea. Gebru et al. (2014) did not discover a connection between the water source and childhood diarrhoea, in contrast.

Mothers Education

The results of the current study highlight the relationship between maternal education level and the likelihood that a kid under the age of five may experience episodes of diarrhea. This is in line with a research by Mihrete et al. that looked at the causes of infantile diarrhea in under-fives in northwest Ethiopia and discovered that education was strongly linked to the condition. The latest study's findings are comparable to those of a 2014 study by Gibru et al., which indicated that children whose moms cannot read and write are more likely to experience diarrhea. The mother's education level gives her awareness of sanitation and hygiene procedures, which are crucial contributing factors to childhood diarrhea.

Mother's work status

In keeping with a study by Mihrete et al. (2014) that discovered a positive correlation between working moms and the risk of childhood diarrhoea, the current study established a substantial link between a mother's job status and under-five diarrhoea. This can be explained through the fact that a working woman lacks sufficient free time to care for her child because she devotes most of her time working, which could raise the chance of the child developing diarrhea. However, moms who don't work expend more time at home

caring for their children, which lowers the likelihood that the youngster would get sick with diarrhea.

Mother's Age

In children under the age of five, diarrhoea occurrence was significantly predicted by the mother's age. According to the current study, children of moms under 30 had a higher chance of developing diarrhea. This was consistent with a cross-sectional study carried out in Ghana to identify the risk factors linked to diarrhea morbidity in children under the age of five (30). This finding can be explained by the possibility that younger women have less experience with childcare and less comprehension of the spread of pathogens in the home environment as well as the manner of transmission of diarrheal sickness. This is due to the fact that even if the mother had not learned from her observations, she would still have picked up knowledge from society.

Mother's Religion

A not statistically significant predictor of infantile diarrhoea was discovered to be the mother's religion. Even though diarrheal diseases are not linked to or have any positive correlation parameters like religion, race, tribe, and status, but how one obeys the basic hygiene protocols. However, the two religions' cultures can be considered a factor relating to diarrheal disease. The Christian "culture" allows women to pursue education, particularly Western education and other training. Unlike the Islamic "culture" that tends to suppress women, particularly from the study areas, to pursue Western education.

Hand Washing

This study has shown the importance of hand washing in reducing the occurrence of diarrhoea. Furthermore, there was a significant positive ssociation between hand washing practice and childhood diarrhoea, which agrees with Bezatu Mengistie, Yemane Berhane, and Alemayehu Worku in Ethiopia.

This might be the case since utilizing modern restrooms and having a hand-washing station reduces the risk of harmful organisms contaminating food and drink. Similar to that, children in the current study were six times more likely to get childhood diarrhoea if their moms merely washed their hands with water rather than with water and soap. This result agrees with research from southwest Ethiopia (GEBRU et al., 2014). This may be because soap contains an antibacterial ingredient, which is sufficient to prevent diarrhea and other ailments associated with poor hygiene. Additionally, thorough hand washing can get rid of microbes.

Summary of Findings

Findings from this study showed that 66.7% have good knowledge of the link between drinking water diarrhoea diseases and 40.6% prevalence of diarrheal diseases within the two weeks, the sources of drinking water identified include borehole, sachet, pipe borne, bottled water, and wells with borehole being the most used source of drinking water. Using the orlab Hydrogen sulphide drinking water test kit, 52.8% of the respondents' drinking water showed a positive result to contamination. Socioeconomic and environmental risk factors such as the mother's age, occupation, level of education, sex of the child, water treatment before consumption, hand-washing, and storage all showed a significant relationship to water contamination. Only religion showed no relationship with water contamination.

Conclusion

Considering that the current study area is an urban setting, the prevalence of childhood diarrhoea was high. There is also a high knowledge of drinking water and diarrhoea. There also is a high percentage of contaminated drinking water from the results of this study. Socio-demographic elements are significantly linked to the prevalence of diarrhoea as well as the contamination of drinking water except for religion and sex of the child.

Implication of findings

The findings of this study have important policy ramifications for health promotion programs and highlight the potential significance of raising women's educational levels for children's well-being and longevity in Nigeria.

Recommendation(s)

From the data that's corresponds to this study, the following suggestions are made;

1. Teaching mothers and other caregivers about the methods of diarrheal illness transmission and how to protect themselves and their children under the age of five, emphasizing the importance of early treatment as a preventive approach.

2. To reduce exposure to diarrheal pathogens among their children, mothers and guardians are instructed in proper hand-washing, particularly after cleaning their kids after using bathroom facilities, safe storage, managing drinking water after bringing it from the source, and properly disposing of household waste.

3. Providing formal education to the rural population above the primary level, especially to mothers and caregivers, may help the situation in the long run by teaching them about the danger and prevention of diarrhea.

4. As was already said, Nigeria's diarrheal disease is a result of the increased pathogen transmission brought on by inadequate water and sanitation. The Nigerian government must therefore focus on comprehensive diarrheal disease control strategies that include improving water quality, cleanliness, and sanitation, as well as offering oral rehydration treatments.

Suggestion for further studies

Ultimately, longitudinal studies, which take into account pertinent variables, can best provide information on the changing prevalence of diarrhea and address seasonality.

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