

The Assessment of Drinking Water Sources, Treatment Practices, and Their Impact on Health in Calabar Municipality, Cross River State, Nigeria: A Cross-Sectional Study

Kolawole Isaac A.¹, Alao Adenike S.¹, Adika Onyedikachi A.², Nwaehujor Chinaka O.^{3,*}

¹Department of Public Health, Faculty of Basic Medical Sciences, Adeleke University Ede, Osun State, Nigeria

²Department of Animal Production and Health, Faculty of Agriculture, Federal University Oye-ekiti, Ekiti State, Nigeria

³Edbecker Company Nigeria Limited, B28, First Floor Flat 3, Golf Estate Port Harcourt, Rivers State, Nigeria

*Corresponding author: chinaka_n@yahoo.com

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Abstract Access to safe drinking water is the most basic level of requirement for public health; however, most communities in the country rely on various and possibly unsafe water sources. The current study looks into water sourcing and treatment practices of Calabar municipality, Cross River state, Nigeria. A survey of water sourcing and treatment practices from 336 respondents was conducted, studying how demographic factors such as age, sex, educational level, and occupation affected water safety practices. This analysis encompasses age and sex distribution, main sources of drinking water, methods of treatment, educational and occupational categories, and the relation between the education level and water treatment practices. The results indicate that both boreholes and combined sources, such as borehole and packaged water, are in common usage, while only a small proportion of the respondents reliably use any form of treatment, such as boiling. Education level significantly influences the treatment of water, $p < 0.05$; secondary- and tertiary-educated individuals treat their water more frequently. In both cases, good water safety was associated with formal occupations, of which civil service is included, and less reliable purification with informal jobs and low education. These findings suggest that targeted public health intervention in water safety knowledge, especially at the lower levels of education and in the informal sector, could reduce waterborne health risk.

Keywords: Drinking water, Calabar, Boreholes, Water-borne diseases, Milton, Chlorine

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1. Introduction

Safe drinking water supply is an important factor in sustaining good public health in urban residents [1]. Provision of good quality drinking water is paramount for sustaining public health in urban residents; access to safe drinking is considered an essential need for existence, livelihood and wellbeing oedema. By the year 2030, one of the targets for this sixth SDG, 2016, on ensuring availability and sustainable management of water and sanitation for all, is universal access to safe and affordable drinking water.

A large proportion of the rural population in the developing world takes water from natural sources directly for drinking [2]. The water is usually not treated at all or treated insufficiently to ensure acceptability according to International Guidelines [3]. Natural water is

therefore never pure and water being a universal solvent dissolves many chemical substances and also carries in suspension many impurities [4]. Every year more than one billion people resort to using potentially harmful sources of water. Two in every ten people of the world have no source of safe drinking water and to improve this appalling state of affairs the MDGs include a specific target to cut in half, by 2015 the proportion of people without sustainable access to safe drinking water [3].

An estimated 144 million people use surface water for drinking, and half a billion people consume water from unprotected wells and underground sources [5]. Two billion people in the world drink water that is contaminated with faeces. Consumption of water that is contaminated by microorganisms is estimated to account for up to 485,000 diarrheal deaths annually. A total of 4 billion cases of diarrhoea are recorded annually, and about 88 % of these result from unsafe water consumption coupled with inadequate sanitation practices [6].

2. Materials and Method

Study Area: The study area was Calabar Municipality, Cross River State. It has a land mass of 141.33 square kilometers. It is bordered in the North by Odukpani Local government area, in the West by Calabar River, in the South by Calabar South Local government area and in the East by Akpabuyo Local government area and Great Kwa River.

Study Design: The study is cross-sectional and analytical consisting primarily of key informant interviews, questionnaire surveys, and water treatment analysis. Inventory of sources of drinking water in Calabar Municipality was taken. The target population was the residents of Calabar Municipality.

Data Collection: A structured questionnaire was developed and administered on the consumers. The questionnaire was drafted in English language and included information. The questionnaire administered to adult-heads of households. The Demographic data (age, sex, size of household, marital status, level of education, occupation and religion), sources of drinking water and water treatment methods were recorded. Sample Size was determined by statistical method described by Kadiveti et al., 2019 [7]. By this method, three hundred and twenty three (323) sample sizes were obtained but three hundred and fifty (350) sample sizes were used to make up for questionnaires that might not be correctly filled or returned. Thirty-five (35) questionnaires were administered per ward with the inventory of the names of streets per ward obtained. Three (3) streets were randomly selected per ward.

Data Analysis: Data were analyzed using percentages, range, and arranged in tabular form and inferential analysis using Chi-square test.

3. Results

Table 1. Distribution of Respondents by Age Group and Sex (n=336)

Age Group (yrs)	Males (%)	Female (%)	Total (%)
21-30	87 (45.3)	105(54.7)	192(57.1)
31-40	40 (46.0)	47(54.0)	87(25.9)
41-50	10 (40.0)	15(60.0)	25 (7.4)
51-60	10 (52.6)	9 (47.4)	19 (5.7)
61-70	5 (71.4)	2 (28.6)	7 (2.1)
> 70	1 (20.0)	5 (80.0)	6 (1.8)
Total	153 (45.5)	183 (54.5)	336 (100)

The table illustrates that the largest group of respondents is the age group 21 - 30 years, at 57.1 %, followed by the 31 - 40 years bracket, at 25.9 %, while the older age groups were less represented. Overall, the majority of the respondents are females, at 54.5 %, especially in the 21 - 30 and 41-50 years age brackets, while males are a little higher in the 51 - 60 and 61-70-year brackets. The findings are strongly biased towards younger participants, since 83 % are below 40 years of age.

By Table 2 above, the various sources of drinking water that the respondents use are as follows: Borehole and Pipe-borne water at 19.6 %, while Borehole, Pipe-borne, and Rainwater are both at 17.6%. The second most common source of water involves those who avail themselves of the combinations Borehole, Pipe-borne, and Rainwater at 17.6%, at 59 respondents, showing a large number of the population using multiple sources possibly because of accessibility or quality concerns. Since it was a case where no single source was solely satisfactory for the consumer's needs, with only 4.8 % depending on borehole water alone, it would be fair to assume that this is the case. Rainwater is a common complementary source through many combinations like Borehole and Rain (9.5%), Stream and Rain (3.3%), probably arising out of seasonal availability or just from cost-effectiveness. Indeed, quite a significant number of respondents used Borehole and Packaged Water-40 respondents (11.9%)- and Pipe-borne and Packaged Water-28 respondents (8.3%). This therefore, means there is a preference or need for packaged water either for perceived impurities, or inconvenience.

Table 2. Use of Different Drinking Water Sources (n=336)

Drinking Water Source	No of Respondents (%)
Borehole only	16 (4.8)
Borehole and Pipe-borne	66 (19.6)
Borehole and Rain	32 (9.5)
Borehole and Packaged Water	40 (11.9)
Pipe-borne and Packaged Water	28 (8.3)
Pipe-borne and Hand dug Well	22 (6.5)
Spring and Rain	17 (5.0)
Stream and Rain	11 (3.3)
Stream, Borehole and Rain	20 (6.0)
Borehole, Spring and Rain	15 (4.5)
Borehole, Packaged Water and Pipe-borne	10 (3.0)
Borehole, Pipe-borne and Rain	59 (17.6)
Total	336 (100)

Table 3. Distribution of Respondents by Water Treatment Methods (n=66)

Water Treatment Methods	No of Respondents (%)
Filtration with Cloth	8 (12.1)
Filtration with Sand	Nil (0)
Addition of Alum	4 (6.1)
Addition of Milton/Chlorine	9 (13.6)
Covered Earthenware Pots	Nil (0)
Boiling	45 (68.2)
Total	66 (100)

Boiling is the major method of treating water, with 45 respondents (68.2 %), possibly because it is an accessible and highly effective method in the destruction of pathogens. Addition of Milton/Chlorine and filtration with cloth come second at 13.6% and 12.1%, respectively. This depicts that there are concerns not only for microbiological safety but also for visible impurities. Filtration with sand and covered earthenware pots are not used by any respondents probably due to limited access or lack of awareness about such methods, while addition of alum is utilized by 4 respondents or 6.1%.

Table 4. Distribution of Respondents by Level of Education and Occupation (n = 336)

Level of education	Civil servant	Business or Trade (%)	Craftsman (%)	Farmer (%)	Fishermen (%)	Factory worker (%)	Student (%)	Full time house wife	Unemployment (%)	Others (%)	Total (%)
No formal education	4 (10.3)	16 (41.0)	4 (10.3)	4 (10.3)	Nil (0)	Nil (0)	Nil (0)	7 (17.9)	2 (5.1)	2 (5.1)	39 (11.6)
Primary	4 (9.5)	20 (47.6)	4 (9.5)	2 (4.8)	Nil (0)	2 (4.8)	Nil (0)	1 (2.4)	4 (9.5)	5 (11.9)	42 (12.51)
Secondary	9 (6.6)	56 (40.9)	Nil (0)	2 (1.5)	Nil (0)	11 (8.0)	28 (20.4)	6 (4.4)	11 (8.0)	14 (10.2)	137 (40.8)
Tertiary	29 (24.6)	19 (16.2)	Nil (0)	3 (2.5)	Nil (0)	1 (0.8)	47 (39.8)	2 (1.7)	6 (5.1)	11 (9.3)	118 (35.1)
Total	46	111	8	11	Nil (0)	14	75	16	23	32	336 (100)

Table 4 Illustrates the distribution of Sampled Households by Educational Level and Occupation. From the table, it can be observed that those with no formal education are mainly involved in business or trade, 41.0%; household-related activities, 17.9%; farming, 10.3%, while a fair proportion, 5.1%, are unemployed. Those with primary education are mainly involved in business or trade, 47.6%, and craftsmanship, 9.5%, while the ones with secondary education are mainly into business or trade, 40.9%; housewifery, 20.4%, and fairly into civil service, 6.6%. Tertiary education results in a significant number of the respondents being in civil service 24.6% or still students 39.8%, while fewer were in business or trade 16.2% and farming 2.5%.

Table 5. Chi-square showing relationship between Respondents' level of education and practice of drinking water treatment (n = 66)

	Yes	No	P-value	Total
Level of education				
None	1	12	X = 32.120 P = 0.000	13
Primary	4	4		8
Secondary	20	2		22
Tertiary	20	3		23
Total	45	21		66

The table also indicates that with more years of schooling, the likelihood of practicing water treatment increases. Of the respondents who have never had any formal education, only 1 out of 13 practices water treatment, while 12 do not. Also, among those with primary education, 4 out of 8 practice water treatment while the rest do not. Of those with secondary education, 20 out of the 22 practice water treatment; for those with tertiary education, 20 out of the 23 do water treatment. The X-value is large: $X = 32.120$, while the p-value is highly significant: $P = 0.000 < 0.05$, showing that the level of education and practice of drinking water treatment are significantly related. This suggests that education level is a strong factor in determining whether the respondents treat their drinking water. This presumes that the influence of education is significantly affecting the likelihood of practicing water treatment, which becomes more pronounced with an increase in the level of education.

4. Discussion

This shows that households obtained drinking water from many sources, the purity of which can be questioned. **Table 1** presents the younger age groups, 21 - 30 and 31 -

40 years, constituting the majority of the respondents at about 83 % (279 out of 336). This may be a function of the demography of the target population or accessibility factors that make it more feasible for younger age groups to respond. The minority of the sample are those over 50 years of age at 9.6 %. A finding that corroborates studies showing that measures for health, behavior, or opinion can vary with age and sex. It also mentioned that both gender and age are factors which contribute to health related beliefs and behaviors [8]. Thus, the slight over representation of younger females may affect the study findings or the interpretation.

As shown in **Table 2**, the diversity of sources used by respondents likely reflects real variations in levels of access to clean, reliable drinking water. The use of multiple sources indicates that no single source is adequate or reliably available. Reliance on packaged water-as is commonly seen in areas where there is concern over the purity of the water-suggests that consumers may not have a high degree of confidence in the quality of either borehole or pipe-borne water. That is evidenced by research showing that packaged water standards across most of Nigeria are susceptible to public health issues and microbial, as well as non-microbial, contaminants. Tests for commercially available water in Nigeria indicated extraordinary levels greater than the highest allowable limit set by the World Health Organization, which makes the water samples unfit for human use [9]. During a similar research carried out in Benin city belonging to the same geopolitical region of Nigeria with the view of studying the bacteriological and physico-chemical quality of some water from borehole using five boreholes from Ekosodin, it was discovered that two borehole were fit for direct consumption while three boreholes failed to meet the bacteriological standard for potable water. [10]. Spatial variation in the water quality with depth to boreholes was evaluated in a study where samples were collected from a functioning borehole in Uyo Municipal, the state Capital of Akwa Ibom, which falls within the same geopolitical zone as Calabar municipality. Results obtained using standard procedures were compared with the Nigeria Standard for Drinking Water quality. The percentage compatibility of water quality to the standard varied with depths, hence giving a strong correlation of $r = 98$ percent between the depths of the boreholes and their water qualities. This has also been involved in the illustration that heavy metals and possible pollutants of groundwater fall with an increase in depth, which signified that surface pollutants found it difficult to infiltrate very deep down into the groundwater aquifer as

the depth increases beyond the certain threshold value [11]. This might explain the reasons why there is vulnerability in contaminants from sources such as rainwater, streams, and hand-dug wells. Health education and an improvement in infrastructure may be required to ensure safer ways of obtaining drinking water. Rainwater, spring, and stream sources perhaps reflect the explanation for the dependency of the residents of the municipality on these natural sources as alternative sources; this could be because of inadequacy in infrastructure or the cost involved in borehole and packaged water quality.

As illustrated in Table 3, results showed a very high reliance on boiling, which likely reflects a preference for this simple, low-cost treatment that is probably perceived as very effective. In one research, it was indicated that boiling itself has a number of limitations within low middle-income communities: boiled water is susceptible to recontamination, boiling does not remove chemical or metal contaminants, the fuels needed for boiling can be relatively costly, and many of the fuels currently used to boil drinking water produce hazardous air pollutants [12]. Lack of development in filtration methods may be indicative of limited access to these resources. Whereas boiling and the addition of chlorine are very effective against such pathogens, reliance on cloth filtration may indicate that some respondents might not totally address waterborne microorganisms impacting health, even though a research in Bangladesh showed use of 1 to 4 layers of cotton sari cloth, a material readily available, was able to filter successfully pond and river water that contained *V. cholerae* attached to small crustacean zooplanktonic copepods and particulate matter, reducing the number of *V. cholerae* bacteria by 2 log units, indicating a 90% success rate [13]. Given the low adoption of alum often added to water to improve clarity by coagulating suspended particles [14], which may appeal to respondents with turbidity issues and non-usage of sand filtration or earthenware pots, educational programs could raise awareness about effective yet affordable water treatment options, helping communities make informed choices. This reliance on simple, widely available methods suggests opportunities for the introduction of other low-cost options to improve water safety and tackle different water quality concerns. As the table also demonstrated, cloth filtration and the use of the chemical method effectively killed pathogens, thus showing these consumers did care about microbiological safety.

Table 4 shows that there is a leaning towards the fact that as the level of education increases, the informal employment drifts towards formal employment like civil services and skilled occupations. Individuals in tertiary education or civil servant positions may be more informed about sources of safe water and methods of purification. They may, therefore, be more aware of water treatment methods such as chlorination or boiling, probably because they had some access to formal health education. This confirms a study in Jos Plateau State that shows consumers are willing to pay for household water treatment products when supported with good marketing and education [15]. The educated group may prefer water sources which are cleaner, like borehole or even packaged water, to those which could be contaminated, such as

streams or rainwater. Their formal education would have endowed them with the necessary judgmental ability to assess water for quality and take actions to purify it. Those with more years of formal education may be more aware of the dangers of unsafe water and more likely to treat their water [16]. More higher education is likely to be associated with more sophisticated knowledge of and better practices in sourcing and purification of water, while lower levels of education or less formal occupations may constrain one's activities to less effective or informal methods of assessment and treatment of water. Poor people are usually those who have primary or no formal education. While formal education is taken to a low level, poverty can be so rife it reaches endemic levels [16]. In addition, the large number of respondents that had informal education and trades or manual work had a low-income level. Studies have proved that low-income households are less likely to treat water compared to households that have higher incomes [17]. Purifying water by traditional education that usually comes with such responsibilities may include sedimentation or cloth filtration. However, these methods may not fully address microbial contaminants and might, therefore, pose health risks if relied upon exclusively.

Table 5 Shows Chi-square test results testing the association between the level of education and practice of water treatment among the 66 respondents by grouping them into those practicing water treatment (Yes) and those not practicing it (No), and by the level of education. The data showed that only a very negligible percentage of the people who have informal education practice water purification to their drinking water. It could be attributed to lack of awareness, poverty, or low level of education which may indicate that people without formal education are less likely to treat their drinking water. These findings align with research carried out in China where it was noticed that young people in villages with access to treated water had better education than those without such access [18]. For primary education, 4 out of 8 respondents practice water treatment while the remaining 4 do not. There was also significant response from those with secondary and tertiary education to the practice of water treatment and purification. This was similar to findings from a research conducted in Sokoto state of Nigeria where it was revealed statistically significant association between practice of household purification technique and level of education of the respondents [19]. The obtained Chi-square value is large $X = 32.120$, and the p-value is highly significant $P = 0.000$ less than 0.05; therefore, there is a significant statistical relationship between the level of education and the practice of drinking water treatment. The fact that education and water treatment are related to one another is not due to random chance. This means there is a strong association: the better the educational level, the higher the percentage of people treating their drinking water.

It indicates that education can play a role in influencing better practices in the treatment of water. Public health campaigns and education programs could be targeted at people with lower levels of education to increase awareness and improve the safety of the water, especially where communities commonly make use of untreated water.

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