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Assessment of Water Usage Practices and Associated Risk of *Salmonella* among Residents of some Communities of Obio/Akpor Local Government Area, Rivers State, Nigeria

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ABSTRACT

Water is essential for human nutrition, both as drinking water and as a component of food. However, it also serves as a major vehicle for disease transmission, especially in developing and even advanced countries. The study aimed to assess Water Usage Practices and Associated Risk of *Salmonella* among Residents of some Communities of Obio Akpor Local Government Area, Rivers State, Nigeria**.** Well-structured questionnaire was distributed to check for exposure to borehole water and random sampling was adopted in selecting the respondents. The questionnaires were administered in February 2024. The study revealed that 63.3% of the respondents were males while 36.7% were females. Most respondents (73.3) were unaware of the water transmission of *Salmonella*. As regards safety of borehole water for consumption 73.3% of the respondents agreed that borehole water is their major source of drinking water. The exposure and outcome relationship showed a relative risk of 1.21 (95% CI, 0.73 – 1.99). The overall analysis showed 17.7% attributable risk percent for Obio-Akpor Local Government Area. The study indicates that residents of Obio-Akpor LGA mainly use borehole water with low awareness of its health risks. Public health education and improved access to safe water are needed.

Keywords: Socio-demographic, Borehole Water, *Salmonella*, Disease Transmission, Questionnaire, Exposure.

Introduction

A borehole is a deep, narrow hole drilled into the ground to access natural resources such as water, oil, or other subsurface liquids (Boak & Kleinberg, 2020; Mitali *et al.*, 2022). In water resource management, boreholes are primarily used to extract groundwater from aquifers underground layers of water-bearing materials that may consist of permeable or fractured rock, gravel, sand, or silt (Bangura, 2019). These structures are often constructed using specialized drilling equipment to reach depths where cleaner and safer water can be obtained.

Boreholes provide a reliable source of water for domestic, agricultural, and industrial purposes, especially in areas with limited access to surface water. They also play a crucial role in promoting water security, supporting public health, and sustaining livelihoods in both rural and urban communities.

A borehole typically involves the use of a narrow pipe that channels water from below the ground surface (Daniel & Daodu, 2016). In many regions across Nigeria, obtaining safe and clean drinking water remains a major challenge due to factors such as high cost, limited availability, long distances to water sources, and poor infrastructure. Consequently, individuals and communities are often forced to rely on whatever water source they can afford or access, regardless of its quality.

There are two major sources of water used domestically or industrially. These two sources are surface water such as streams, rivers, ponds, and lakes, and groundwaters such as wells, boreholes. Both types are used domestically and industrially, but it was reported that groundwater is safer for domestic use and less susceptible to contamination (Okeola *et al.,* 2010). It is used not only for domestic purposes, but also for irrigation farming (Haruna *et al.,* 2008; Shymala *et al.,* 2008).

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The government, at both federal and local levels, continues to make efforts to improve water supply systems because of the essential role water plays in human survival and development.

Water is a fundamental necessity for sustaining life and serves as a vital component in virtually all economic, social, and environmental projects, whether temporary or permanent. Despite the fact that the human body consists of more than 70% water (Popkin *et al.,* 2010), access to clean and safe drinking water remains insufficient in many parts of the country. In Nigeria, borehole water represents the major source of potable water. Due to the acute shortage of water supplies, the last decade has witnessed a rapid increase in sinking of boreholes. The quality of borehole water can fluctuate contingent on factors such as location, contamination risks, and treatment. Borehole water is generally viewed as safe for domestic use, including drinking, cooking, and bathing, because it is naturally filtered through layers of chalk or sand (Amoah, 2017). However, the purity and safety of borehole water cannot always be guaranteed. Contamination from nearby sources such as pit latrines poses significant health risks, particularly in regions with high rainfall and shallow water tables (Makoae *et al*., 2015).

Furthermore, the inadequacy of reliable water infrastructure and the overdependence on self-supplied sources such as boreholes and wells increase the risk of contamination from environmental pollutants and improper waste disposal. This highlights the urgent need for improved water management policies, regular monitoring of water quality, and community-based awareness programs to promote hygienic practices and safeguard public health.

The study aimed at assessing the socio-demographic factors and exposure to water sources among residents of Obio/ Akpor Local Government Area, Rivers State

Materials and Methods

Study location

The study was carried out in Obio Akpor Local Government Area. The study locations were Rumuokparali, Eliozu and Elelenwo communities in Obio Akpor Local Government Area.

It is one of the 23 Local Government Areas in Rivers State. The LGA lies within 4.8776° North, 7.0283° East. The Local Government Area covers 260km^2 and at 2006 census held a population of 462,789. Its postal or zip code is 500102 and it is constituted mainly by the people of the Ikwerre ethnic nationality.

Population and Sampling Technique

A total of 30 questionnaires were completed, with participants aged 15 years and above from Obio Akpor Local Government Area. The study collected anonymous responses from a diverse demographic, capturing various exposure to water sources. The questionnaire was designed to gather data on sociodemographic characteristics, as well as participants' knowledge of *Salmonella,* water treatment method and safety of borehole water. In total, the questionnaire comprised 8 sections, including 6 questions on demographic information, 2 questions on knowledge and awareness *Salmonella* contamination, 3 questions on water quality and safety, 2 questions on behavior and practices and 3 questions on health and symptoms.

Results

Socio-demographic Survey

The socio-demographic survey across the different sampling location is shown in Table 1 – Table 3. The data in Table 1 shows the socio-demographic information of the responents, the study showed that 20% of the respondents were between the ages of 0 to 20 years; 30% were between 21 to 30 years; 23.3% were of age group 31-40 years and 26.7% were above the age of 40 years.

The male respondents constituted 63.3% while 36.7% were females.

For the educational background 56.7% of the respondents were graduates; 3.3% were undergraduate; 26.7% were secondary school leavers and others accounted for 13.3%.

For the occupation of the respondents, 26.7% of the respondents were students; 16.6% were civil servants and others were 56.7%.

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Table 1: Socio-demographic Information in Obio/Akpor Local Government Area

Variables		Rumuokparali No/%	Eliozu No/%	Elelenwo No/%	Overall
Age Group (yr) of Respondents	0-20	1 (10)	2 (20)	3 (30)	6 (20)
	21-30	4 (40)	3 (30)	2 (20)	9 (30)
	31-40	3 (30)	2 (20)	2 (20)	7 (23.3)
	≤40	2 (20)	3 (30)	3 (30)	8 (26.7)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Gender	Male	6 (60)	6 (60)	7 (70)	19 (63.3)
	Female	4 (40)	4 (40)	3 (30)	11(36.7)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Educational Level	Graduate	6 (60)	8 (80)	3 (30)	17 (56.7)
	Undergraduate	1 (10)	0	0	1 (3.3)
	SSCE	1 (10)	2 (20)	5 (50)	8 (26.7)
	Others	2 (20)	0	2 (20)	4 (13.3)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Occupation	Student	3 (30)	3 (30)	2 (20)	8 (26.7)
	Civil Servant	1 (10)	2 (20)	2 (20)	5 (16.6)
	Health worker	0	0	0	0
	Other	6 (60)	5 (50)	6 (60)	17 (56.7)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)

The data in Table 2 shows that 73.3% of the respondents agreed that borehole water is their major source of drinking water while 26.7% had a contrary view. For the awareness of the water transmission of *Salmonella*, the study revealed that 26.7% of the respondents have the awareness of transmission of *Salmonella* through water while 73.3% had no idea about the relationship between *Salmonella* transmission and water.

In relation to water quality and safety, 43.3% held the view that borehole water is safe for consumption while 56.7% of the respondents were of contrary opinion as shown in Table 3. 40% affirmed that they wash their water reservoir monthly, 30% of the respondents wash the reservoir yearly while 30% rarely wash the water reservoirs. In respect of water treatment method, 10% of the respondents boil their water before use; 13.3% adopt the use of filter and treatment with chemicals; 6.7% adopt other treatment methods while 70% do not treat water before use as shown in Table 4. The result in table 4 also shows how often the respondents have experienced typhoid fever in the past one year. While 76.7% have experienced typhoid fever in the last one year while 23.3% have not.

Table 2: Use of Borehole as Source of Drinking Water and Awareness of Water Transmission of *Salmonella*

	Variables	Rumuokparali No. (%)	Eliozu No. (%)	Elelenwo No. (%)	Overall
Use of Borehole as source of drinking water	Yes	9 (90)	6 (60)	7 (70)	22 (73.3)
	No	1 (10)	4 (40)	3 (30)	8 (26.7)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Awareness of water transmission of *Salmonella*	Yes	5 (50)	2 (20)	1 (10)	8 (26.7)
	No	5 (50)	8 (80)	9 (90)	22 (73.3)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)

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Table 3: Water Quality and Safety in Obio/Akpor LGA

Variables		Rumuokparali No. (%)	Eliozu No. (%)	Elelenwo No. (%)	Overall
Is borehole water safe for consumption?	Yes	3 (30)	3 (30)	7 (70)	13 (43.3)
	No	7 (70)	7 (70)	3 (30)	17 (56.7)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Washing of water reservoir	Weekly	0	0	0	0
	Monthly	2 (20)	2 (20)	8 (80)	12 (40)
	Yearly	5 (50)	3 (30)	1 (10)	9 (30)
	Rarely	3 (30)	5(50)	1(10)	9 (30)
	Total (%)	10 (100)	10 (100)	10 (100)	30 (100)

Table 4: Water Treatment Method and History of Typhoid Fever in the Last One Year in Obio/Akpor LGA

Water Treatment Method	Rumuokparali No. (%)	Eliozu No. (%)	Elelenwo No. (%)	Overall
1. Boiling	1 (10)	0	2 (20)	3 (10)
2. Use of water filters and treatment chemicals	2 (20)	1 (10)	1 (10)	4 (13.3)
3. Other methods	2 (20)	0	0	2 (6.7)
4. Don't treat water	5 (50)	9 (90)	7 (70)	21 (70)
Total (%)	10 (100)	10 (100)	10 (100)	30 (100)
Experienced Typhoid fever in the last one year				
Yes	8 (20)	9 (90)	6 (60)	23 (76.7)
No	2 (20)	1 (10)	4 (40)	7 (23.3)
Total (%)	10 (100)	12 (100)	6 (100)	30 (100)

Table 5 shows the prevalence of *Salmonella* species with respect to washing of water reservoir. The study revealed that a 100% prevalence of *Salmonella* was recorded in water samples from respondents who wash their water tanks yearly, followed by 88.9% prevalence from those who rarely wash their water tanks followed with the least prevalence of 16.6% from those who wash their water tanks monthly.

The risk of *Salmonella* infection with respect to exposure to borehole water is shown in Table 6. The study revealed that 61.9% prevalence was recorded among respondents who use borehole water as source of drinking water and 66.7% in those who do not.

The association between the incidence of typhoid fever reported by the participants and the exposure to the borehole water samples is recorded in Table 7.

Data recorded revealed the relative risk (RR) was 1.75 (95% CI, 0.43 – 7.17), 1.33 (95% CI, 0.8 – 2.31) and 0.87 (95% CI, 0.31 – 2.41) for Rumuokparali, Eliozu, and Elelenwo, respectively. In the overall, the exposure and outcome relationship showed a relative risk of 1.21 (95% CI, 0.73 – 1.99), indicating a higher risk among those exposed to the water samples.

The attributable risk (AR) percent was determined to be 42.9, 25 and -16.8 percent for Rumuokparali, Eliozu, and Elelenwo, respectively, as recorded in Table 7. The overall analysis showed 17.7% attributable risk percent for Obio-Akpor Local Government Area.

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Table 5: Prevalence of *Salmonella* with respect to Washing of Water Reservoir

Frequency	Monthly		Yearly		Rarely	
Locations	**No. Pos. (%)**	**No. Neg. (%)**	**No. Pos. (%)**	**No. Neg. (%)**	**No. Pos. (%)**	**No. Neg. (%)**
Rumuokparali	1 (50)	1 (50)	5 (100)	-	3 (100)	-
Eliozu	1 (50)	1 (50)	3 (100)	-	4 (80)	1 (20)
Elelenwo	-	8 (100)	1 (100)	-	1 (100)	-
Overall (Obio/Akpo)	2 (16.6)	10 (83.3)	9 (100)	-	8 (88.9)	1 (11.1)

Table 6: Risk of *Salmonella* Infection with respect to Exposure to Borehole water

Locations	Use of Borehole water			
	Yes		No	
	No. Pos. (%)	**No. Neg. (%)**	**No. Pos. (%)**	**No. Neg. (%)**
Rumuokparali	7 (87.5)	1 (12.5)	2 (100)	-
Eliozu	5 (83.3)	1 (16.7)	3 (75)	1(25)
Elelenwo	1 (14.3)	6 (85.7)	1 (33.3)	2 (66.7)
Overall (Obio/Akpo)	13 (61.9)	8 (38.1)	6 (66.7)	3 (37.5)

Table 7: Association between incidence of typhoid fever and risk of exposure to the borehole water samples

Locations	Exposed		Unexposed		Relative risk (RR)	AR %
	Had typhoid (%)	**No typhoid (%)**	**Had Typhoid (%)**	**No typhoid (%)**	**RR** (95% CI)	
Rumuokparali	7 (87.5)	1 (12.5)	1 (50)	1 (50)	1.75 (0.43 – 7.17)	42.9
Eliozu	6 (100)	-	3 (75)	1 (25)	1.33 (0.8 – 2.31)	25
Elelenwo	4 (57.1)	3 (42.9)	2 (66.7)	1 (33.3)	0.87 (0.31 – 2.41)	-16.8
Overall (Obio/Akpor)	17 (81)	4 (19)	6 (66.7)	3 (33.3)	1.21 (0.73 – 1.99)	17.7

Discussion

In determining the exposure of the respondents to various water sources, respondents from the communities where the borehole water samples were collected were consulted. In this study, majority of the respondent were young adult of active working age within the age group 21-30 years (30%) followed by matured adult age group >40years (26.7%), followed by young adult of age 31-40 (23.3%) while 20 adolescents of ≤ 20 years. Majority of the respondents constituting 86.6 % had formal education ranging from primary education to tertiary education while 13.4 % had other form of formal education; however, 56.7% had tertiary education (graduate), 26.7% had secondary education and 3.3% were undergraduate.

Since majority had one form of education and are young, it can be said that there will be appreciable knowledge of the consequences of using non-potable water as a result of microbial contamination. Research suggests that education level significantly influences disease management, but has moderate impact on disease transmission rates (Njoya *et al*., 2021). A total of 73.3% of the respondents agreed that borehole water is the major source of drinking water, while 26.7% had a contrary view; hence, it could be attributed to great awareness about waterborne infection and disease, and thus, will result in increased patronage and consumption of safe and potable water. A total of 8 (26.7%) of the respondents are aware of the transmission of *Salmonella* through water while 22 (73.3%) had no idea about the relationship between *Salmonella* transmission and water.

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The implication of low knowledge of transmission of *Salmonella* by water could lead to an increase in the incidence of *Salmonella* infection and a tendency to abuse drugs which leads to antibiotic resistance, as knowledge of the mode of transmission is importance in the prevention of Salmonellosis (Njoya *et al.*, 2021).

The survey showed that 40% of the respondent wash their water reservoir monthly, 30% wash it yearly while 30% rarely wash the water tank. In all, 10% of the respondents boil their water before use, 13.3% adopt the use of filter and treatment with chemicals, 6.7% adopt other treatment methods while 70% do not treat water before use. A study carried out in Enugu state revealed that urban households were likely to treat water before use (Okpasuo *et al.,* 2020). Access to treated water is important in reducing waterborne disease (Omoregie *et al.*, 2025). The appreciable number of users who wash the water storage tank and treat the water before can be attributed to the knowledge of waterborne disease and the need for clean and potable water as identified by other studies. According to the study of Omoregie *et al*. (2025), the frequency of cleaning water storage facilities will help in the maintenance of water quality and also highlighted that monthly cleaning is the most common practice, hence reflecting a balance between effort and effectiveness.

The reservoirs and sources of transmission of *Salmonella* infection have been well documented. The association between exposure to these sources and the incidence of Salmonella infection can be determined using different epidemiological models, including odds (cross product) ratio, Risk ratio or relative risk, as well as attributable risk percent, depending on the study design adopted (Vollard *et al.,* 2004).

This present study evaluated a cohort group of persons exposed to borehole water as a source of drinking water and the incidence of typhoid fever in the past one year. The study used the risk ratio (due to the study population size) and attributable risk percent to associate the exposure risk and the incidence of typhoid fever reported by the study group. The study observed that the risk of typhoid fever was higher in the exposed groups than the unexposed groups in the study area and locations, except for Elelenwo Community where the risk was not associated exposure to borehole water as drinking water sources. The difference in the risk ratio obtained from Elelenwo and the other locations may be due to difference in sanitation and hygiene practice as well as other confounding factors (Vollard *et al.,* 2004). This indicates that the incidence of typhoid fever experienced in Elelenwo, is attributable to other sources other than borehole water.

The study further revealed that the association between exposure to borehole water expose and the reported incidence of typhoid fever was higher in Rumuokparali Community than other study stations, indicating the need for more community protection and public health intervention measures, in including enlightenment programmes in this community. The higher association noted for Rumuokparali community is however attributable to water use practices, as most of the residents don't wash their water reservoir frequently and do not adopt good water treatment protocols in the use of their water for domestic services such as drinking.

The study which noted that the risk of typhoid fever is 1.75 times higher in the exposed group than the unexposed group had 45% of the cases attributable to exposure to borehole water. This implies that any intervention targeting the control of borehole water transmission of typhoid fever will have 45% of the Rumuokparali community population free from typhoid fever infection. This study further showed that the proportion of individuals at the risk of borehole water transmission of typhoid fever is higher at Rumuokparali than the other study stations. A different attributable risk percent was determined for Elelenwo, having a negative attributable risk percent, indicating a lower risk in the exposed group than the unexposed group. This therefore implicates other confounding factors in the causality of typhoid fever. The other confounding factors may include fruits, dairy products and other food sources.

The observed association in this study is in line with previous studies (Vollaard et al., 2004; Dhadwal & Shetty, 2008) that have reported similar higher ratios among the exposed population than the unexposed group. An investigation of typhoid fever among school children of a school in military station in central India, Dhadwal & Shetty (2008), noted an attack rate of the affected school was 2.62 percent (RR 13.38, 99% CI of RR 10.8, 16.12).

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Their study also revealed fecal contamination of water supply leading to the outbreak. In a related study by Vollaard et al., (2004), independent risk factors for typhoid fever using the community control group were mostly related to the household, i.e, to recent typhoid fever in the household (OR, 2.38; 95% CI, 1.03-5.48); no use of soap for hand washing (OR, 1.91; 95% CI, 1.06-3.46); sharing food from the same plate (OR, 1.93; 95% CI, 1.10-3.37), and no toilet in the household (OR, 2.20; 95% CI, 1.06-4.55). The difference in the values obtained for the risk models (RR or OR) is however, attributed to differences in population types and size.

Conclusion

The study highlights that a substantial proportion of residents in Obio-Akpor Local Government Area depend on borehole water as their primary source of drinking water, with limited awareness of its potential role in *Salmonella* transmission. Although the relative risk of 1.21 indicates a higher risk of infection among those exposed to borehole water, the association was not statistically significant within the confidence interval. The attributable risk of 17.7% highlights a measurable public health concern. Strengthening health education on water safety, improving water quality monitoring, and promoting alternative safe water sources are essential to reduce the risk of waterborne infections in the area.

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