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CROSS-SECTIONAL STUDY ON WATER, SANITATION, HYGIENE AND HOUSING CONDITIONS IN RURAL NORTH-CENTRAL NIGERIA: IMPACT ON INFECTIOUS DISEASE INCIDENCE AND CONTROL

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ABSTRACT

Lack of access to potable water, poor sanitation and hygiene, and ineffective vector control measures catalyse the spread of infectious diseases. This study aimed to assess access to safe water, sanitation and hygiene practices, and housing conditions in a rural community in North-Central Nigeria. Additionally, it sought to examine the interplay between these factors and the incidence of infectious diseases. This was a cross-sectional observational study set in the rural Mangu community. Ethical approval was obtained from the Plateau State Ministry of Health, and informed consent was sought from an adult representative of each sampled household. Data were collected using interviewer-administered questionnaire during walk-through home visits. A total of 772 individuals from 139 households and 100 houses were surveyed. Household sizes ranged from two to 26 individuals, and rooms had between one and seven occupants. One-fifth of the houses (n=19/100) had no access to improved sources of drinking water and relied on unprotected dug wells and streams. Sewage disposal was largely through open defecation (n=73/100) and nearly all houses (n=98) practised open dumping/burning. Febrile illness and diarrhoea were reported in residents of 71% and 40% of the houses, respectively, in the previous six months. Residents who used water from unimproved sources were four times more likely to experience a febrile illness (OR: 3.99; 95% CI: 1.11-15.7). In Mangu community of North-Central Nigeria, prioritising access to safe drinking water and improving sanitation and hygiene practices would reduce the burden of infectious diseases, especially in children.

Keywords: *Environmental Health, Hygiene, Safe Water, Sanitation, Control, Infectious Disease, Vector, WASH*

INTRODUCTION

According to the World Health Organization (WHO), access to safe water and good hygiene and sanitation practices are essential for good health. This is because unsafe drinking water and poor environmental health habits contribute to many diseases (WHO, 2023a). Access to improved water sources is crucial for ensuring safe and clean drinking water in Africa. Improved water sources include piped water, boreholes, protected wells, and rainwater collection systems. On the other hand, unimproved water sources refer to surface water, unprotected wells, and water from rivers or lakes (Wolf *et al*., 2022). Studies have shown that accessing improved water sources significantly reduces the risk of diarrheal diseases, which are a leading cause of morbidity and mortality, especially among children under five years of age in low- and middle-income countries (Merid *et al*., 2023).

Furthermore, factors related to environmental health have been estimated to contribute to about one-quarter of all global deaths, and 22% of global disability-adjusted life years (Prüss-Ustün *et al*., 2017). Currently in Nigeria, infectious diseases are the leading causes of death with malaria alone accounting for about 12% of all deaths (Statista, 2021; WHO, 2023b). Poor water, sanitation, and hygiene (WASH) indices are significant drivers of infectious disease morbidity and mortality, especially among children, because they promote the development and transmission of deadly faeco-oral, vector-borne, and air-borne diseases. For instance, the three leading causes of under-5 mortality in Nigeria are of infective origin, accounting for over a quarter of all deaths. Diarrhoea, malaria, and pneumonia account for about two-thirds of deaths in children and are linked to poor WASH status of homes and communities, especially in rural settings (Adewemimo *et al*., 2017; Smith *et al*., 2018; Yaya *et al*., 2018; Azuh *et al*., 2021).

Millions of people are exposed to poor environmental conditions, especially in rural communities, and this predisposes them to high morbidity and mortality (WHO, 2019). Unsafe water alone results in an estimated 1.5 million deaths annually, while other environmental conditions such as bad sanitation practices and overcrowding significantly affect morbidity (Prüss-Ustün *et al*., 2017; Pal *et al*., 2018; Islam *et al*., 2021; Wolf *et al*., 2023). In addition, malaria, which leads to the death of approximately 200,000 Nigerians annually (representing one-third of global malaria deaths), is associated with an untidy living environment and unchecked activity of the malaria parasite's vector (mosquito) (WHO Newsroom, 2023). Indeed, the intersection of infectious disease and environmental health is a pressing public health issue, particularly in rural Nigeria. However, there is limited publicly available data on the environmental health status of rural North-Central Nigeria (WHO, 2022).

This study aimed to explore the environmental health status of a rural community in North-Central Nigeria by assessing WASH indices, overcrowding, and the use of insecticide-treated nets (ITN). It also aimed to explore the association between these environmental health conditions and the occurrence of fever and diarrhoeal diseases.

MATERIALS AND METHODS

The study is set in the rural Mangu community of North-Central Nigeria. Mangu is one of the 17 local government areas in Plateau State. With an area of 1,653 km², Mangu is dispersed into clusters of village settlements (Plateau State Government, 2022).

Mangu's local government has a projected population size of 442,100 for 2022; using the formula for sample size of cross-sectional studies, we calculated a representative sample size of 384, permitting a 5% margin of error and a 95% confidence level (Pourhoseingholi *et al*., 2013; City Population, 2022). Convenience sampling was thereby carried

out in the Kungtup rural settlement, and household data was collected by interviewers using semi-structured questionnaires during a community walk-through between November and December 2022.

Institutional ethical approval was obtained from the Plateau State Ministry of Health (MOH/MIS/202/VOL.T/X), while permissions were obtained from the district/village heads and informed consent was obtained from individual heads of household. Houses with no occupants or those that were locked at the time of the visits were excluded. We define a house as a built-up housing unit and a household as a group of people who share expenses or "eat from the same pot" (Sou, Shaw and Aponte-Gonzalez, 2021).

Analyses were performed in conjunction with a medical statistician using Microsoft Excel, SPSS version 28.0.0.0, and R statistical software (for multivariate regression analysis). Descriptive statistics were applied to sociodemographic characteristics including household size and number of persons per room, and water, sanitation and hygiene characteristics. Multivariate regression analysis was carried out to define the relationship between environmental factors and history of febrile illness and diarrhoea in the Mangu population.

RESULTS

A total of 772 individuals from 139 households and 100 houses were surveyed in Mangu rural community of North-Central Nigeria. (Kingpriest, 2023)

Housing

Houses surveyed consisted of one to four households (one household = 73, 73%; two households = 17, 17%; three households = 8, 8%; and four households = 2, 2%), average household sizes ranged between two and 26 people (5 or less = 33, 33%; 6-10 = 44, 44%; and more than 10 = 23, 23%) and rooms contained between one and seven persons (Figure 1).

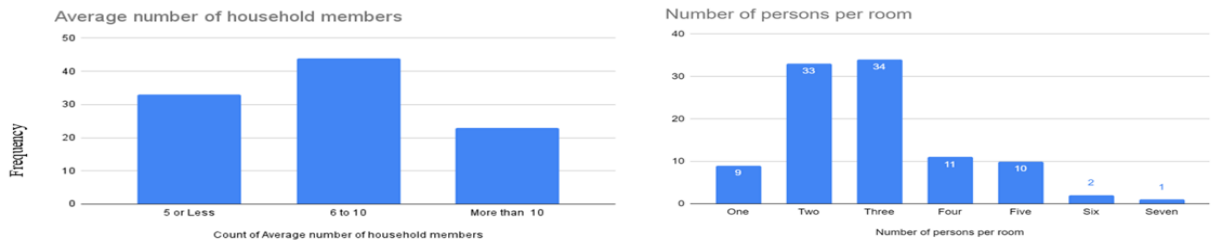

Figure 1: Household size and number of persons per room

Water

Wells (71%) and boreholes (24%) were the most common sources of water for household use. Most residents drank from boreholes (81%) and used wells (71%) for other household activities. Unimproved water sources (open wells, streams, and lakes) served as sources of water for day-to-day household uses in 76% of houses, and sources of drinking water in 19% of the houses in the village (Table 1).

Table 1: Sources of water for household use and drinking, among the 100 sampled houses

	Improved water source Number of houses (%)	**Unimproved water sources Number of houses (%)**			
	Borehole	Open Well	Stream	Lake	Total (100)
Source of water for household use	24 (24%)	71 (71%)	5 (5%)	0 (0%)	100 (100%)
Source of drinking water	81 (81%)	16 (16%)	2 (2%)	1 (1%)	100 (100%)

Solid Waste and Sewage Disposal

Eighty-four (84%) of the houses visited had surroundings that appeared to be dirty or had puddles, and none of them had a sanitary waste bin with a lid or access to a central waste collection system. Two percent of the villagers buried their solid waste, while the remaining 98% practiced open dumping/burning. Most (73%) of the residents did not have access to a toilet facility (Table 2).

Nature of the house environment	**Number of houses (%)**
Clean and Neat	16 (16%)
Dirty/With puddles	84 (84%)
Total	**100 (100%)**
Availability of a central waste collection system	
Yes	0 (0%)
No	100 (100%)
Total	**100 (100%)**
Availability of a sanitary waste bin with a lid	
Yes	0 (0%)
No	100 (100%)
Total	**100 (100%)**
Solid Waste Disposal Method	
Burying	2(2%)
Open dumping and open burning	98 (98%)
Total	**100 (100%)**
Sewage disposal method	
Pit toilet/Latrine	4 **(**4%)
Water system	23 **(**23%)
Open defecation	73 **(**73%)
Total	**100 (100%)**

Vector Control

ITNs were available for all pregnant women and children in 73 (73%) of the 100 houses visited, and 60 (82.2%) of those houses used the nets regularly (Table 3).

Incidences of Fever and Diarrhoeal Diseases in the Last Six Months and Their Relationship with Environmental Health Indices.

Residents in 71% of the houses had febrile illnesses in the last 6 months with more than half of these involving children under five years of age. Up to 40 of the 100 houses had residents with diarrhoeal diseases in the last six months (Table 4).

Regression analyses showed that overcrowding was associated with an increased likelihood of a history of fever among children under five years of age (odds ratio 2.61; 95% confidence interval: 1.10-6.53) (Table 5). In addition, a history of fever was 3.99 times higher among villagers who used water from unimproved sources, compared to those who used improved water sources (odds ratio: 3.99; 95% confidence interval: 1.11-15.7) (Table 6).

Table 3: Availability of ITNs and the frequency of use

Availability of insecticide-treated nets for under-fives and pregnant women, n=100	
Yes	73 (73%)
No	27 (27%)
Total	100
Frequency of the ITN use, n=73	
Always	60 (82.2%)
Sometimes	12 (16.4%)
Never	1 (1.4%)
Total	100

Table 4: History of febrile illness and diarrhoeal disease in the last 6 months

	Response	Number of houses (%)
Total history of febrile illness	Yes	71 (71%)
	No	29 (29%)
	Total	100 (100%)
History of febrile illnesses in under 5s	Yes	37 (37%)
	No	63 (63%)
	Total	100 (100%)
Total history of diarrhoea	Yes	40 (40%)
	No	60 (60%)
	Total	100 (100%)
History of diarrhoea in under 5s	Yes	23 (23%)
	No	77 (77%)
	Total	100 (100%)

Table 5: Univariate regression analysis showing the relationship between environmental factors and history of febrile illness and diarrhoea

		Total history of febrile illness in the last (OR, 95% CI)	**History of febrile illness in under 5s (OR, 95% CI)**	**Total history of diarrhoea (OR, 95% CI)**	**History of diarrhoea in under 5s (OR, 95% CI)**
Household size	≤ 5 people (n=32)	6 (Reference)	3 (Reference)	5 (Reference)	2 (Reference)
	6 – 10 people (n=43)	6 (0.86, 0.30-2.42)	3 (1.51, 0.57-4.18)	6 (0.71, 0.27-1.83)	3 (0.69, 0.22-2.10)
	≥ 10 people (n=23)	4 (0.63, 0.19-2.04)	3 (2.79, 0.92-8.85)	4 (1.90, 0.65-5.75)	2 (1.31, 0.39-4.38)
Effect of overcrowding	< 3 people per room (n=76)	53 (Reference)	24 (Reference)	27 (Reference)	17 (Reference)
	≥ 3 people per room (n=24)	18 (0.91, 0.37-2.22)	**13 (2.61, 1.10-6.53)**	13 (1.51, 0.66-3.52)	6 (1.40, 0.54-3.84)
Source of water for household use	Improved water source (n = 24)	14 (Reference)	6 ((Reference)	8 (Reference)	5 (Reference)
	Unimproved water source (n=76)	52 (2.22, 0.83-5.87)	29 (2.16, 0.80-6.53)	30 (1.52, 0.59-4.17)	17 (1.22, 0.42-4.10)
Source of drinking water	Improved water source (n=81)	56 (Reference)	28 (Reference)	33 (Reference)	17 (Reference)
	Unimproved water sources (n=19)	15 (2.27, 0.67-10.40)	9 (1.86, 0.66-5.29)	7 (0.91, 0.31-2.55)	6 (1.85, 0.58-5.55)
Household sewage disposal Method	Toilet facility (n=27)	21 (Reference)	11 (Reference)	13 (Reference)	7 (Reference)
	Open defecation (n=73)	50 (0.51, 0.15-1.43)	26 (0.77, 0.31-1.95)	27 (0.60, 0.24-1.49)	16 (0.78, 0.28-2.27)
Nature of Surrounding	Dirty/With puddles (n=84)	62 (2.26, 0.73-6.84)	34 (3.07, 0.91-14.1)	35 (1.64, 0.54-5.99)	19 (0.90, 0.28-3.53)
	Clean/Neat (n = 16)	9 (Reference)	3 (Reference)	5 (Reference)	4 (Reference)
Frequency of ITN Use	No ITN) (n=27)	18 (0.68, 0.25-1.88)	10 (0.92, 0.35-2.34)	13 (1.69, 0.59-4.97)	5 (0.61, 0.18-1.80)
	Often/Sometimes (n=12)	8 (0.80, 0.19-4.05)	4 (0.67, 0.13-2.68)	5 (1.12, 0.26-4.37)	2 (0.67, 0.09-3.04)
	Always (n=61)	45 (Reference)	23 (Reference)	22 (Reference)	16 (Reference)

OR = Odds Ratio, CI = Confidence Interval, ITN = Insecticide-treated net

Table 6: Multivariate regression analysis showing the relationship between environmental factors and history of febrile illness and diarrhoea

		Total history of febrile illness in the last (OR, 95% CI)	History of febrile illness in under 5s (OR, 95% CI)	Total history of diarrhoea (OR, 95% CI)	History of diarrhoea in under 5s (OR, 95% CI)
Household size	≤ 5 people (n=32)	6 (Reference)	3 (Reference)	5 (Reference)	2 (Reference)
	6 – 10 people (n=43)	6 (0.90, 0.24-3.18)	3 (1.20, 0.37-4.07)	6 (0.55, 0.18-1.67)	3 (0.54, 0.14-1.97)
	≥ 10 people (n=23)	4 (0.67, 0.16-2.69)	3 (2.42, 0,65-9.32)	4 (1.63, 0.47-5.74)	2 (1.50, 0.37-6.12)
Effect of overcrowding	< 3 people per room (n=76)	53 (Reference)	24 (Reference)	27 (Reference)	17 (Reference)
	≥ 3 people per room (n=24)	18 (0.71, 0.21-2.32)	13 (2.92, 0.98-9.36)	13 (1.35, 0.48-3.89)	6 (1.95, 0.59-6.87)
Source of water for household use	Improved water source (n = 24)	14 (Reference)	6 ((Reference)	8 (Reference)	5 (Reference)
	Unimproved water source (n=76)	**52 (4.15, 1.13-16.6)**	29 (1.59, 0.46-5.91)	30 (1.65, 0.50-5.68)	17 (1.10, 0.28-4.78)
Source of drinking water	Improved water source (n=81)	56 (Reference)	28 (Reference)	33 (Reference)	17 (Reference)
	Unimproved water sources (n=19)	15 (1.54, 0.35-8.64)	9 (2.23, 0.63-8.25)	7 (0.96, 0.28-3.22)	6 (2.59, 0.65-10.7)
Household sewage disposal Method	Toilet facility (n=27)	21 (Reference)	11 (Reference)	13 (Reference)	7 (Reference)
	Open defecation (n=73)	50 (0.31, 0.07-1.10)	26 (0.47, 0.14-1.49)	27 (0.44, 0.15-1.26)	16 (0.79, 0.24-2.68)
Nature of Surrounding	Dirty/With puddles (n=84)	62 (1.90, 0.52-6.81)	34 (3.29, 0.81-18.2)	35 (1.34, 0.39-5.07)	19 (0.77, 0.21-3.28)
	Clean/Neat (n = 16)	9 (Reference)	3 (Reference)	5 (Reference)	4 (Reference)
Frequency of ITN Use	No ITN) (n=27)	18 (0.80, 0.25-2.58)	10 (0.84, 0.27-2.55)	13 (1.69, 0.59-4.97)	5 (0.48, 0.12-1.69)
	Often/Sometimes (n=12)	8 (0.55, 0.10-3.58)	4 (0.61, 0.09-3.21)	5 (1.33, 0.27-6.20)	2 (1.02, 0.12-5.88)
	Always (n=61)	45 (Reference)	23 (Reference)	22 (Reference)	16 (Reference)

OR = Odds Ratio, CI = Confidence Interval, ITN = Insecticide-treated net

DISCUSSION

This study revealed that the evaluated environmental health indices were generally poor in this rural community. Cases of diarrhoeal disease and fever were high and were associated with environmental health factors such as unimproved sources of water for household use and a level of overcrowding. It is necessary to improve environmental conditions in rural Nigeria to reduce the burden of diseases and improve residents' quality of life. Addressing these environmental health conditions could reduce the risk of diarrhoeal diseases by half and significantly lower the burden of other diseases such as respiratory infections and helminthiasis (Wolf *et al*., 2023).

To begin with, there was no central tap water system in the entire setting. Over 70% of the households surveyed lacked access to sanitary or improved water sources and one-fifth drank from uncovered wells or streams. According to the WHO, over two billion of the world's population have difficulties accessing clean and safe drinking and the majority of them are in low-income settings like Mangu. This increases their susceptibility to febrile illnesses and water-borne diseases such as cholera, typhoid fever and other diarrhoeal diseases which are a leading cause of death in children (Egbon *et al*., 2022; WHO Factsheets, 2023). It was also observed that residents in our study location used well water more for all general uses, while borehole water seemed to be reserved for drinking. This may largely be because the sanitary borehole wells are few and far from most households, hence, their water is usually stored and reserved for drinking, while water for other household uses is often obtained from nearby wells. As one of the sustainable development goals is achieving safe and equitable access to clean water monitored through on-premise availabilities, a starting point for improving access to safe water for these rural dwellers may be to either make the readily available well water sanitary or provide more boreholes (WHO, 2023a)

Furthermore, we observed poor sewage disposal methods with less than a quarter of the dwellers having flush toilets with a sewage system, and the majority practicing open defecation as they did not have a toilet facility. Another WASH study in rural south-eastern Nigeria revealed more than half of the population practiced open defecation, and similarly, had poor access to clean potable water (Nwokoro *et al*., 2020). While the poor sewage disposal situation might be related to the water availability problem, both conditions tend to increase the population's susceptibility to faeco-oral diseases such as cholera, typhoid, diarrhoeal diseases and helminthiasis (Belay *et al*., 2022). According to the United Nations International Children's Emergency Fund, over a quarter of the world's population does not have access to good toilet facilities and over 300,000 die each year from diseases related to WASH (UNICEF, 2014). The practice of open defecation in rural Nigeria is influenced by a number of factors such as the family's socioeconomic situation, education level, ethnicity and gender of the household head; some of which are likely problems in our study setting (Abubakar, 2018). Community-led interventions and health promotion campaigns have been suggested as effective means of improving toilet ownership and reducing open defecation (Rotondo *et al*., 2009; Abramovsky *et al*., 2023).

Solid waste disposal was another problem noticed in Mangu; none of the villagers used sanitary waste bins or had access to a central waste collection system, and most houses had untidy environments or surroundings with puddles. Poor solid waste disposal methods increase the activities of pests/vectors, causing air pollution and contamination of water bodies, thereby spreading diseases (Ogunniran, 2022). Meanwhile, the solid waste problem in Nigeria is not unique to rural Nigeria as a number of the major cities are overrun by poor waste disposal practices.(Ike *et al*., 2018) Public education outreaches and better waste management policies have been recommended as likely ways of curbing solid waste management problems.(Aliu *et al*., 2014)

Although most residents had and used ITN regularly, a sizeable number either did not have ITNs or did not use the nets regularly. This finding corroborates a recent national study on ITN uptake in Nigeria where usage was observed

to be higher (77.9%) in rural areas than in urban areas (Ujuju *et al*., 2022). This may be telling of the effectiveness of the malaria prevention programs that target rural populations where the disease burden has been higher (Yusuf *et al*., 2010).

Similar to findings in rural southern Nigeria where the average family size was more than seven, our study showed that household size was more than five in about two-thirds of the homes. It has been postulated that large family size may increase the dependency ratio and reduce food availability (Olayemi, 2012). A family size of four or above has been associated with multidimensional poverty and the severity increases with direct proportionality (Abu and Soom, 2016). While the large family size in itself has an association with an increased spread of disease because of the bidirectional relationship between poverty and disease, it may also be indicative of increased morbidity and limited access to quality health services among respondents (Anser *et al*., 2020). Furthermore, room occupancy indicates overcrowding (more than two persons per room) in more than half of the population which may contribute to disease transmission (Kouadio *et al*., 2012; Statistics Explained, 2021). Nigeria is one of the African countries with a notable overcrowded population, and efforts towards reducing infectious disease in this country would not be complete without addressing housing conditions (Chipeta *et al*., 2022).

Based on our results, the generally high incidence of fever and diarrhoea (Table 4) and the proportionately higher cases in settings of poor environmental health indices (Table 5), are not surprising. The high symptom rates are indicative of a high incidence of infection. Poor access to improved water sources, poor sanitary state, overcrowded housing conditions as well and unwholesome vector control practices can individually as well as collectively increase the incidence of infections (Nkosi *et al*., 2019; Makungo *et al*., 2020; Uhomoibhi *et al*., 2022). Furthermore, from this study, a significant relationship was particularly observed between the use of unimproved water sources and the history of fever. Previous studies have established similar findings while highlighting poor infection control knowledge and practices as associated factors (Mogasale *et al*., 2018).

Although we have reported a high incidence of diarrhoea and fever, there may be recall bias in the respondents' reporting of these symptoms. Additionally, the subjective nature of these symptoms may not accurately represent infections, as conditions such as malabsorption syndrome and neoplastic diseases could also be responsible for diarrhoea and fever, respectively. Future studies could examine the sociocultural factors that may be responsible for the poor WASH indices, which may not necessarily be economical, as an evidence base for interventions.

In conclusion, this study gives insight into the WASH and housing indices and the availability/use of ITN in a rural community of North-Central Nigeria. Overall, access to safe drinking water and sanitary sewage disposal methods is poor. Additionally, many of the residents live in overcrowded conditions and a significant number of the population either does not have access to or does not use ITN regularly. All of these factors culminated in high cases of fever and diarrhoeal diseases, which merits a holistic intervention to reduce the disease burden.

DECLARATIONS

CONFLICT OF INTERESTS: None

FUNDING: None

AUTHORS' CONTRIBUTION: Conceptualization; PK, HL, EO, EA, BA. Methodology; PK, HL. Data analysis; PK, JO, AU. Validation; PK, HL, JO. Writing-original draft; PK, HL, JO. Writing-review and editing; PK, HL, JO, EA, BA, AU. Project administration: PK, HL. Supervision: BA

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