Journal of
Water, Sanitation & Hygiene for Development

 Journal of Water, Sanitation and Hygiene for Development Vol 13 No 11, 875 doi: 10.2166/washdev.2023.169

Research Paper

Socioeconomic predictors of access to improved water sources, sanitation facilities, and household water treatment in Nigeria

Olumayowa Azeez [a,*], Randi J. Henderson-Mitchell[a], Matthew C. LaFevor [b] and Abbey Gregg [a]

[a] Department of Community Medicine & Population Health, The University of Alabama, 1103 Northeast Medical Bldg, Tuscaloosa, AL 35487, USA
[b] Department of Geography, The University of Alabama, 204 Farrah Hall 513 University Boulevard, Tuscaloosa, USA
*Corresponding author. E-mail: oazeez@crimson.ua.edu

OA, 0000-0001-8398-2334; MCL, 0000-0002-0988-4768; AG, 0000-0001-5288-028X

ABSTRACT

In Nigeria, the widespread lack of access to water, sanitation, and hygiene (WASH) represents a critical public health challenge. Yet, the socioeconomic determinants of WASH access at the national level remain poorly understood. This study uses 2018 Nigeria Demographic and Health Surveys (NDHS) cross-sectional data to investigate the socioeconomic factors associated with WASH access. The majority of survey respondents lived in rural areas (57%); used an improved source of drinking water (73%) and an improved sanitation facility (55%); and did not treat their drinking water (92%). Binary logistic regression showed that Nigerians living in rural areas were less likely to have access to an improved water source ($p < 0.001$, OR = 0.42 [0.41, 0.44]) and less likely to have access to an improved sanitation facility ($p < 0.001$, OR = 0.79 [0.77, 0.81]). A sub-group regression analysis of respondents without access to improved WASH found that rural residence (OR = 0.84 [0.76, 0.93]), along with lower levels of education and wealth were associated with non-treatment of their unimproved drinking water. This study suggests that efforts are needed to increase WASH access in rural areas and to improve household water treatment in areas without access to improved water and sanitation.

Key words: global health, hygiene, Nigeria, sanitation, sustainable development goals, water

HIGHLIGHTS

- Underscores significant barriers related to WASH that affect Nigeria's ability to achieve SDG 6.
- Adds to the body of knowledge on WASH in underdeveloped countries.
- Examined important predictors that support policy development and program implementation in the field.
- The findings from this study are useful for practice and policy.
- Offers strong recommendations on how Nigeria's WASH sector may be improved.

INTRODUCTION

Safe water and sanitation are essential not only for health and well-being but also for their impact on everyday life. Water used for drinking, irrigation, bathing, and various household purposes can become contaminated, and consumption of contaminated or unsafe water results in poor health outcomes, such as diarrhea, neglected tropical diseases (NTDs), and even death (World Health Organization [WHO] 2022a). Therefore, having access to improved water sources and sanitation facilities is considered a right that is fundamental to enjoying other human rights (Armah *et al.* 2018; Kayser *et al.* 2019). According to WHO (2022b), an improved water source is one that is protected from outside contamination, especially from fecal matter, while an unimproved water source is not protected from outside contamination. An improved sanitation facility is one that hygienically separates excreta from human contact while an unimproved sanitation facility does not offer this protection (WHO 2022b).

Household water, sanitation, and hygiene (WASH) sources have been shown to have crucial socioeconomic development and health implications. In low-income or developing countries, most water-borne diseases have been associated with drinking unsafe water. In Africa, more than 2,000 people die every day from illnesses that are related to poor sanitation and

hygiene, and drinking unsafe water (Abubakar 2019). Limited access to safe drinking water and improved sanitation facilities, as well as improper or lack of water treatment practices, can promote the spread of water-borne diseases (Omole & Ndambuki 2014; Prüss-Üstün *et al.* 2018).

Household water treatment (HWT) is an important public health intervention for improving drinking water quality and reducing the incidence of water-borne diseases (WHO 2023a). HWT is the process of removing or inactivating microbial pathogens at the point of collection or consumption to improve water safety (WHO 2009). HWT serves as an intervention for those who may use unimproved or contaminated water (WHO 2011). According to the WHO, chlorination, alum, filters, allowing water to settle, straining water through a clean cloth, boiling, and solar disinfection are suitable HWT methods (WHO 2011). Chlorination chemically disinfects water by removing pathogenic bacteria and viruses; however, it does not remove protozoa (WHO 2011; Flanagan *et al.* 2013; Mengistie *et al.* 2013). Using alum is an effective coagulant that destabilizes tiny particulate matter suspended in water, and sedimentation allows suspended particles in turbid water to settle and get separated from the water (Lantagne *et al.* 2006; Abubakar 2021, p. 2). The use of filters and straining water through cloth expels microorganisms through size exclusion, though this is a time-consuming process (Sobsey & WHO 2002; Kohlitz *et al.* 2013; Nair & Kani 2017). Boiling water is a common and effective method of killing most water-borne microorganisms (Brown & Sobsey 2012). Solar disinfection for at least 6 h is an affordable method that effectively inactivates water-borne pathogens; however, this is a very time-consuming process (Dessie *et al.* 2014). Using an ultraviolet lamp also eliminates germs; however cost, lack of electricity, and maintenance may make this a less feasible option. Boiling and chlorination kill organisms that cause diarrhea, and solar disinfection inactivates them, while filtering, alum, and straining water can only help remove them (Albert *et al.* 2010; Blanton *et al.* 2010; Simukonda *et al.* 2018). Unfortunately, 2.1 billion people around the world do not have access to improved water sources, 2.3 billion do not have improved sanitation facilities (Emenike *et al.* 2017; Kayser *et al.* 2019), and many do not have adequate means of treating water to make it safe for use.

Nigeria is one of the 46 sub-Saharan African countries that has been most impacted by the global WASH issue. According to the Federal Ministry of Water Resources (FMWR) 2011 report, 42% of the Nigerian population did not have access to safe water supply while 62% did not have access to sanitation. By 2015, roughly 67% of Nigeria's population had access to improved drinking water sources (which was about 10 percentage points away from its Millennium Development Goal (MDG) water target of 77%; Emenike *et al.* 2017). In addition, more than 40% of the Nigerian population uses water sources with a very high risk of contamination (Abubakar 2019; WHO & UNICEF 2021). In Nigeria, poor access to improved water and sanitation continues to be a dominant contributing factor to elevated morbidity and mortality rates among children under five (Ezeh *et al.* 2014; UNICEF 2018; Nwokoro *et al.* 2020; Arowosegbe *et al.* 2021). According to UNICEF (2018), the use of contaminated drinking water and poor sanitary conditions have led to increased susceptibility to water-borne diseases such as diarrhea which leads to the deaths of more than 70,000 children under five annually. Nwokoro *et al.* (2020) conducted a study in Enugu, southeast Nigeria, which found that the prevalence of diarrhea in the 2 weeks preceding the study was 7.47% among all ages and 10.77% among children under five. Currently, 29% of the Nigerian population is fulfilling SDG target 6.1.1 of using safely managed drinking water, and 44% is fulfilling SDG 6.5.1 water management target (United Nations 2023a, 2023b).

Socioeconomic factors, such as *poverty level*, *education level*, and *residence type* (urban or rural), have important implications for access to safe water and sanitation and health behavior (Adams *et al.* 2016; Emenike *et al.* 2017; Abubakar 2019; Rodriguez 2019). In a secondary data analysis of the 2008 Ghanaian Demographic and Health Surveys (GDHS), Adams *et al.* (2016) found that poverty level, education level, and region/type of residence were among significant predictors of access to an improved drinking water source. In another study conducted by Irianti *et al.* (2016) using 2007 Indonesian family life survey data, the researchers found education, wealth, toilet type, and place of residence to be among significant determinants of household drinking water sources in Indonesia.

A study conducted by Akoteyon (2019) focused on rural settlements in parts of southwest Nigeria found that the majority of the households – of which most were low-income – relied on unimproved water sources and sanitation facilities. Emenike *et al.* (2017)'s study on southwest Nigeria found that increased income was correlated with access to improved water sources. Similarly, Rotowa *et al.* (2015) in Akure, a city in southwestern Nigeria, found that Nigerians who earned higher income used improved sanitation facilities and that Nigerians in Akure whose education level was below tertiary education used unimproved sanitation facilities. That study also found that the least proportion of Nigerians who used unimproved sanitation facilities had a tertiary level of education and that the use of unimproved sanitation facilities decreased as the level of education increased.

Despite the poor state of WASH-related affairs in the country, it is important to highlight efforts that country leadership is taking to rectify WASH-related issues in Nigeria. When President Muhammadu Buhari declared the State of Emergency in 2018, the Nigerian government also launched a National Action Plan (NAP). The NAP is a 13-year strategy for the Revitalization of Nigeria's WASH sector 'aimed at ensuring universal access to sustainable and safely managed WASH services by 2030, commensurate with the SDGs' (World Bank 2021, p. 5). In addition to that, the government has also created initiatives to address the factors that have restricted Nigerians from accessing safe and portable water. This effort is supported by the World Bank and other development partners (World Bank 2021).

One of these initiatives is the National Urban Water Sector Reform Program (NUWSRP), which includes objectives pertaining to 'sector reform, water utility sustainability and commercial viability, infrastructure improvement, service reliability and performance enhancement, and increased access to quality piped water networks in urban areas nationwide' (World Bank 2021, p. 7). According to the World Bank (2021), program achievements include the construction of more than 2,300 additional water points, and 6,546 sanitation compartments and hygiene facilities across Nigeria; the creation of 12,435 direct and 24,870 indirect jobs since 2015; and the certification of 33 Local Government Areas (LGAs) within 9 States as Open Defecation Free (ODF).

Another effort is the Nigeria Sustainable Urban and Rural Water Supply, Sanitation and Hygiene (SURWASH) Program, also supported by the World Bank, which is designed to enact essential policy reforms and strengthen the capacity of important institutions for sustainable and effective service delivery (World Bank 2021). This facilitates investments that increase access to and use of WASH services in urban and rural areas, as well as small towns. This includes the development of priority infrastructure to improve water supply service delivery and WASH infrastructure in institutions (schools and healthcare facilities) and public places such as markets and motor parks. The SURWASH Program is expected to provide 6 million Nigerians with basic drinking water services, support 1.4 million Nigerians in accessing improved sanitation services, advance improved WASH services in 2,000 schools and health care facilities, and aid 500 communities in achieving ODF status (World Bank 2021).

In studies similar to this current one that were conducted on other developing countries, poverty level has been strongly associated with the use of unimproved WASH sources as wealthier households have been found to have more access to clean water and improved sanitation facilities, and are thus more likely to use improved sources (Arouna & Dabbert 2010; Adams *et al.* 2016; Irianti *et al.* 2016; Mulenga *et al.* 2017; Abubakar 2019). According to Armah *et al.* (2018), lower level of education has been determined to specifically have 'direct influence on affordability and decision-making capacity of households regarding access to water and sanitation services' (p. 9). Additionally, households in rural areas and urban slums have less access to improved water and sanitation facilities compared to urban households (Armah *et al.* 2018). Overall, socioeconomic factors, such as education level, poverty level, and residence type, can influence the type of resources that people have access to. The review of the literature revealed a dearth of research on the relationships between socioeconomic factors and WASH in Nigeria and that the relevant studies on Nigeria are focused on southwestern Nigeria. This current study has not been conducted on Nigeria holistically. Therefore the objective of this study was to investigate the socioeconomic factors associated with access to improved drinking water sources and sanitation facilities, and HWT in Nigeria.

METHODOLOGY

Data source

We used cross-sectional data from the 2018 Nigeria Demographic and Health Surveys (NDHS) for this study. This was the latest NDHS at the time of this study. Data collection occurred from 14 August to 29 December 2018. The Population and Housing Census of the Federal Republic of Nigeria (NPHC) was the sampling frame used for the 2018 NDHS. The sampling frame for the DHS is a list of enumeration areas (EAs) from a recent population census. Prior to sample selection, all neighborhoods were classified into urban and rural areas, based on predetermined minimum sizes of urban areas (any neighborhood exceeding a minimum population size of 20,000 was classified as urban; NPC & ICF 2019). The 2018 NDHS included people aged 15–49 in the sample households; 40,427 households were successfully interviewed, yielding a response rate of 99% (NPC & ICF 2019).

Study variables

The independent variables in this study were *residence type (urban or rural)*, *highest level of education attained (No education/preschool, Primary, Secondary, Higher, and Don't know)*, and *poverty level (Poorest, Poorer, Middle, Richer,*

Richest). All of the independent variables were categorical. In the NDHS, wealth/poverty level is a measure of household economic status using ownership of 'assets: bank account, vehicle, air conditioner, television, radio, computer, cell phone, farmland and livestock' (Abubakar 2019). The wealth quintiles were constructed from the raw data files after the data had been collected. Each household asset for which information was collected was assigned a weight or factor score which was determined through principal components analysis. The resulting asset scores were standardized relative to a standard normal distribution with a mean of 0 and a standard deviation of 1. These standardized scores were then used to establish the break points that define wealth quintiles (DHS, n.d.-b).

The dependent variables in this study were *source of drinking water*, *type of sanitation facility*, and *HWT*. All of the dependent variables were categorical. Based on WHO and UNICEF's categorization, the *source of drinking water*, and *type of sanitation facility* variables (Croft *et al.* 2018) were recoded into two categories: improved sources (1) and unimproved sources (0). Improved water sources included piped water into dwelling, yard or plot, public tap or standpipe, tube-well or borehole, protected dug well, protected spring, and rainwater. Unimproved water sources included unprotected dug well, unprotected spring, and surface water sources (i.e., rivers, ponds, and streams). Improved sanitation facilities included flush toilet, septic tanks, pit latrine with slab, ventilated improved pit (VIP), and compost toilet. Unimproved sanitation facilities included pit latrines without slab, bucket latrines, publicly shared latrines, and open defecation in bush or field (Croft *et al.* 2018; NPC & ICF 2019).

Data analysis

Descriptive statistics was used to describe the variables in the study. Binary logistic regression was conducted on the entire study population, after which two sub-group analyses were conducted based on household responses, to understand the impact of the predictor variables on HWT among Nigerians who reported not having access to improved water sources. The first sub-group analysis was conducted on those who reported not having access to improved water sources, and the second sub-group analysis included those who reported not having access to improved water sources and also not having access to improved sanitation facilities. Missing data were identified through descriptive statistics. DHS Survey documentation and consultation indicated that missing data are missing at random (MAR; DHS n.d.-a) In order to properly identify data that were not MAR, I used the *exclude cases pairwise* option in SPSS. This option excluded the case only if it was missing the data required for analysis. The case was still included in any of the analyses for which it had complete data for the independent and dependent variables. In total, five logistic regression models were conducted to investigate the socioeconomic factors associated with HWT and access to improved drinking water sources and sanitation facilities in Nigeria. All data analyses were performed in IBM® SPSS Statistics for Windows, version 28.

RESULTS

For this study examining the socioeconomic factors associated with access to improved drinking water sources and sanitation facilities, and HWT in Nigeria, we used logistic regression analyses to determine how *residence type*, *education level*, and *poverty-level* affect access to improved water sources and sanitation facilities, and HWT in Nigeria. We also used descriptive statistics to determine the proportion of Nigerians who treated their drinking water to ensure that it was safe, and of those that did – what approach they implemented to do so. Table 1 provides a descriptive breakdown of the study variables and Table 2 displays the proportion of Nigerians that implemented specific types of measures to ensure that their drinking water was safe. The majority of surveyed Nigerians lived in rural areas (56%), used an improved source for drinking water (73%), used an improved sanitation facility (55%), and did not treat their drinking water (92%).

Table 3 displays the results of the logistic regression and shows that Nigerians who lived in a rural area were significantly less likely to have access to an improved water source. The results also showed that those who had a primary level, secondary level, or higher level education, were significantly more likely to have access to an improved water source compared to those with no education/preschool-level education. Likewise, Nigerians in the *poorer*, *middle*, *richer*, and *richest* wealth quintiles were significantly more likely to have access to an improved water source compared to those in the *poorest* wealth quintile.

With regard to access to improved sanitation facilities, the results indicate that Nigerians who lived in a rural area were significantly less likely to have access to an improved sanitation facility. The results also showed that those who had a primary level and secondary level education were significantly less likely to have access to an improved sanitation facility compared to those with no education/preschool-level education. Nigerians with higher level education were significantly more likely to

Table 1 | Descriptive statistics of the independent variables

Residence type	*N* (%)
Urban	82,444 (43.50)
Rural	107,212 (56.50)
Educational level	
No education/preschool	84,728 (44.70)
Primary	45,652 (24.10)
Secondary	45,352 (23.90)
Higher	13,867 (7.30)
Poverty level	
Poorest	37,831 (19.90)
Poorer	37,879 (20.00)
Middle	37,916 (20.00)
Richer	38,019 (20.00)
Richest	38,012 (20.00)
Source of drinking water	
Unimproved	51,719 (27.30)
Improved	137,708 (72.60)
Type of sanitation facility	
Unimproved	86,280 (45.50)
Improved	103,316 (54.50)
Anything done to make water safe?	
No	174,691 (92.10)
Yes	14,849 (7.80)

have access to an improved sanitation facility compared to those with no education/preschool-level education. Additionally, Nigerians in the *poorer*, *middle*, *richer*, and *richest* wealth quintiles were significantly more likely to have access to an improved sanitation facility compared to those in the *poorest* wealth quintile (Table 3).

With regard to HWT, the results in Table 3 showed that among the entire study population, Nigerians who lived in a rural area were significantly less likely to treat their drinking water. The results also showed that those who had a primary level, secondary level, and higher level education were significantly more likely to treat their drinking water compared to those with no education/preschool-level education. Also, Nigerians in the *richest* wealth quintile were significantly more likely to treat their drinking water compared to those in the *poorest* wealth quintile. Nigerians in the *middle*, and *richer* wealth quintiles had the same likelihood as the *poorest* to treat their drinking water, while Nigerians in the *poorer* wealth quintile were less likely than the *poorest* Nigerians to treat their drinking water (Table 3).

Since having access to improved water might influence the decision to treat drinking water, sub-group analyses were conducted. These sub-group analyses revealed that Nigerians without access to improved drinking water sources who lived in a rural area were significantly less likely to treat their drinking water. The results also showed that for this sub-group, those who had at least a primary level of education were significantly more likely to treat their drinking water compared to those with no education/preschool-level education. Additionally, Nigerians in the *poorer* and higher wealth quintiles were significantly more likely to treat their drinking water compared to those in the *poorest* wealth quintile (Table 4). As far as Nigerians living in rural areas who did not have access to improved drinking water sources and improved sanitation facilities, sub-group analyses revealed that those who had a primary or secondary level of education were significantly more likely to treat their drinking water compared to those with no education/preschool-level education. Finally, Nigerians in the *middle* and higher wealth quintiles were significantly more likely to treat their drinking water compared to those in the *poorest* wealth quintile (Table 4).

Table 2 | Methods of household water treatment

Residence type	Boil *N* (%)	Add bleach/ chlorine *N* (%)	Strain through a cloth *N* (%)	Use water filter *N* (%)	Solar disinfection *N* (%)	Let it stand and settle *N* (%)	Alum *N* (%)
Urban	2,934 (3.60)	1,841 (2.20)	1,126 (1.40)	861 (1.00)	96 (0.10)	431 (0.50)	1,148 (1.40)
Rural	1,276 (1.20)	464 (0.40)	2,650 (2.50)	790 (0.70)	8 (0.00)	690 (0.60)	1,559 (1.50)
Highest educational level							
No education/ Preschool	1,199 (1.40)	548 (0.60)	1,953 (2.30)	515 (0.60)	33 (0.00)	598 (0.70)	920 (1.10)
Primary	985 (2.20)	480 (1.10)	868 (1.90)	382 (0.80)	16 (0.00)	242 (0.50)	763 (1.70)
Secondary	1,299 (2.90)	717 (1.60)	775 (1.70)	456 (1.00)	38 (0.10)	223 (0.50)	730 (1.60)
Higher	723 (5.20)	557 (4.00)	179 (1.30)	296 (2.10)	17 (0.10)	59 (0.40)	293 (2.10)
Poverty level							
Poorest	195 (0.50)	19 (0.10)	1,398 (3.70)	131 (0.30)	0 (0.00)	337 (0.90)	346 (0.90)
Poorer	281 (0.70)	89 (0.20)	849 (2.20)	411 (1.10)	24 (0.10)	206 (0.50)	439 (1.20)
Middle	487 (1.30)	287(0.80)	784 (2.10)	168 (0.40)	5 (0.00)	267 (0.70)	741 (2.00)
Richer	878 (2.30)	472 (1.20)	549 (1.40)	176 (0.50)	1 (0.00)	174 (0.50)	577 (1.50)
Richest	2,369 (6.20)	1,428 (3.80)	197 (0.50)	764 (2.00)	74 (0.20)	137 (0.40)	603 (1.60)

Table 3 | Logistic regressions results: access to improved water source and sanitation facility

	Improved water source			Improved sanitation facility		
Variables	**OR[a]**	**SE**	**95% CI**	**OR[a]**	**SE**	**95% CI**
Residence type						
Urban	1.00			1.00		
Rural	0.42***	0.02	[0.41, 0.44]	0.79**	0.01	[0.77, 0.81]
Highest educational level						
No education/Preschool	1.00			1.00		
Primary	1.19**	0.02	[1.15, 1.22]	0.85**	0.02	[0.82, 0.87]
Secondary	1.20**	0.02	[1.16, 1.24]	0.83**	0.02	[0.81, 0.86]
Higher	1.17**	0.04	[1.09, 1.27]	1.13**	0.03	[1.06, 1.20]
Wealth level						
Poorest	1.00			1.00		
Poorer	1.69**	0.02	[1.64, 1.74]	3.76***	0.02	[3.62, 3.90]
Middle	3.19***	0.02	[3.09, 3.30]	8.25***	0.02	[7.93, 8.58]
Richer	10.27***	0.02	[9.81, 10.76]	23.07***	0.02	[22.09, 24.10]
Richest	66.62***	0.05	[60.12, 73.82]	170.81***	0.03	[159.77, 182.61]

[a]Adjusted odds ratio.
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

DISCUSSION

Findings in context

In this study, we analyzed the socioeconomic factors associated with access to improved WASH and HWT in Nigeria. The results of this study confirmed the hypothesis that Nigerians living in rural areas who had lower levels of education, or were

Table 4 | Logistic regressions results of sub-group: household water treatment

	Household water treatment[a]			Household water treatment[b]			Household water treatment[c]		
Variables	**OR[d]**	**SE**	**95% CI**	**OR[d]**	**SE**	**95% CI**	**OR[d]**	**SE**	**95% CI**
Residence type									
Urban	1.00			1.00					
Rural	0.90**	0.02	[0.86, 0.93]	0.79**	0.04	[0.73, 0.86]	0.84	0.05	[0.76, 0.93]
Highest educational level									
No education/preschool	1.00			1.00					
Primary	1.14**	0.02	[1.09, 1.20]	1.24**	0.04	[1.15, 1.34]	1.21**	0.05	[1.11, 1.32]
Secondary	1.17**	0.02	[1.11, 1.22]	1.32**	0.05	[1.21, 1.44]	1.30**	0.05	[1.17, 1.44]
Higher	1.61**	0.03	[1.52, 1.71]	1.55**	0.10	[1.28, 1.88]	1.29	0.14	[0.98, 1.69]
Wealth level									
Poorest	1.00			1.00					
Poorer	0.91*	0.03	[0.85, 0.96]	0.89*	0.04	[0.82, 0.96]	0.92	0.04	[0.84, 1.00]
Middle	0.99	0.03	[0.93, 1.06]	1.13***	0.04	[1.04, 1.23]	1.22**	0.05	[1.10, 1.35]
Richer	1.01	0.03	[0.95, 1.08]	1.39**	0.06	[1.22, 1.57]	1.90**	0.09	[1.60, 2.25]
Richest	2.05***	0.03	[1.92, 2.18]	1.58**	0.14	[1.20, 2.08]	6.88**	0.40	[3.15, 15.00]

[a]Entire study population.
[b]People w/o access to improved drinking water sources.
[c]People w/o access to improved drinking water sources AND w/o access to improved sanitation facilities.
[d]Adjusted odds ratio.
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

poorer, had less access to improved water and sanitation sources, and were less likely to treat their water. Analyses conducted on the entire study population showed that Nigerians living in an urban area were 2.38 times more likely to have access to an improved water source, and 1.27 times more likely to have access to an improved sanitation facility. Nigerians who had at least a primary level of education were about 1.20 times more likely than those with no education to have access to an improved water source, while Nigerians who had the highest level of education were 1.13 times more likely to have access to improved sanitation than those who had no education (Table 3).

Nigerians with a primary and secondary level of education were 1.19 and 1.20 times less likely to have access to improved sanitation compared to those with no education, respectively – an unusual finding that came as a surprise. The richest Nigerians were 67 times more likely to have access to an improved water sources and 171 times more likely to have access to an improved sanitation facility compared to the poorest Nigerians.

With regard to HWT, for the entire study population, Nigerians living in an urban area were 1.11 times more likely to treat their water compared to Nigerians living in a rural area. Those who had at least a primary level of education were at least 1.14 times more likely to make their water safe for use. The richest Nigerians were also twice as likely to take measures to treat their water compared to the poorest Nigerians. The results of the sub-group analyses were consistent with those seen in the entire study population. Sub-group analyses revealed that Nigerians living in an urban area were more likely to treat their water compared to Nigerians living in a rural area. Those who had at least a primary level of education were also more likely to treat their water, and the odds of HWT increased successively with an increased level of education. This pattern can also be seen for wealth level, in which the odds of HWT increased with increased wealth level.

Overall findings from this study are consistent with other studies in that that Nigerians living in rural areas, who have lower levels of education, and are poorer, are less likely to have access to improved water sources and sanitation facilities; and are less likely to treat their water (Arouna & Dabbert 2010; Rotowa *et al.* 2015; Adams *et al.* 2016; Irianti *et al.* 2016; Emenike *et al.* 2017; Mulenga *et al.* 2017; Armah *et al.* 2018; Abubakar 2019; Akoteyon 2019; Rodriguez 2019) and it comes as no surprise that Nigerians who have attained a higher level of education and wealth have the better outcomes. Education and poverty level, as well as geographical region, are socioeconomic factors that have a direct impact on the type of resources that people have access to and their ability to afford resources to achieve safe water. It is not surprising that those who have

less education likely have lower paying occupations and are therefore poorer and live in less developed (i.e., rural) areas. In turn, they do not have the same access to developed infrastructure that makes way for improved water sources and sanitation facilities. This is not to say that people in rural areas or with less education are incapable of implementing HWT – rather, it is likely because they cannot afford to and do not have the necessary resources readily available.

Population health in Nigeria as it pertains to WASH

Poor or limited access to improved WASH in Nigeria is a leading contributing factor to high morbidity and mortality rates among children under the age of five (UNICEF 2018). The use of contaminated drinking water and poor sanitary conditions make Nigerians more vulnerable to water-borne diseases including diarrhea – the cause of more than 70,000 cases of mortality among children under five each year (UNICEF 2018). Additionally, 73% of the diarrheal and enteric disease burden is linked with poor access to adequate WASH – a disparity faced by poorer children (UNICEF 2018).

According to the World Bank (2021), Nigeria's WASH sector was declared to be in a state of emergency by the government in 2018. In 2019, a combination of 'inadequate infrastructure, a lack of required human capital, poor investment, and a deficient enabling regulatory environment – amongst other challenges – meant that approximately 60 million Nigerians were living without access to basic drinking water' (World Bank 2021, p. 2). In addition to that, 80 million Nigerians did not have access to improved sanitation facilities, while 167 million could not access basic handwashing facilities in 2019 (World Bank 2021).

Nigeria's health indicators are among the worst in Africa, yet Nigeria has one of the fastest-growing populations in the world. As stated prior, the population of Africa is estimated to reach 1.7 billion by 2030 (Emenike *et al.* 2017; USAID 2022), and with Nigeria's expected growth, there are bound to be implications on population health indicators of the entire continent of Africa such as infectious disease, environmental quality, and maternal and child morbidity and mortality (Gaffan *et al.* 2023; ISS African Futures 2023). Therefore, it is important to address population health and development challenges, so that Nigeria has a fighting chance of successfully achieving Sustainable Development Goal (SDG) 6.

Limitations

Because we did not collect this data on our own or have any input on the kind of data collected, we could not examine potential characteristics that may have influenced the outcome variables in this study.

Conclusion & recommendations

This study assessed the socioeconomic factors associated with access to improved drinking water sources and sanitation facilities, and HWT in Nigeria. Our findings show that Nigerians living in rural areas, who had no/preschool-level of education, or were poorer, had significantly less access to WASH, either through public works or other forms of water treatment. Findings largely confirm smaller-scale, local- and regional-level studies identifying *poverty level*, *education level*, and *residence type* as important factors in WASH access. Achieving SDG 6 by 2030 will require exceptional efforts, namely increased funding and implementation of policies that support international health efforts such as those discussed prior (i.e., NUWSRP, NAP, etc.). Fortunately, there are ongoing efforts by the Nigerian government. Unfortunately, these efforts fall short as reflected by this study's findings, existing research, and other literature. The government still has a long way to go in developing Nigeria's WASH sector. Support from the World Bank and other development partners is seemingly a vital aspect of moving the needle with regard to financial support, but this is not enough as funding for the WASH sector in particular is weak. The World Bank estimates that Nigeria will have to triple its budget or at least allocate 1.7% of the current Gross Domestic Product (GDP) specifically to WASH alone (UNICEF 2018). The need is highest for rural populations where the gap for improved services is widest.

The Nigerian government should develop targeted approaches that focus on the more socioeconomically disadvantaged populations in order to decrease the disparities in access to improved WASH services and resources. For example, the efforts of the SURWASH program to improve water supply service delivery are primarily focused on institutions such as schools and healthcare facilities. These efforts should be expanded to rural households in Nigeria. To that end, more focus should be placed on HWT interventions – specifically to address the lack of resources that are required to perform HWT, i.e., chlorine, water filters, etc. Because this would be a costly and herculean task, it is advisable that interventions are also focused on more affordable resources that are relatively easier to scale up throughout time, specifically chlorination.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories at https://dhsprogram.com/data/dataset/Nigeria_Standard-DHS_2018.cfm?flag=0.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Abubakar, I. R. 2019 Factors influencing household access to drinking water in Nigeria. *Utilities Policy* **58**, 40–51. https://doi.org/10.1016/j.jup.2019.03.005.

Abubakar, I. R. 2021 Understanding the socioeconomic and environmental indicators of household water treatment in Nigeria. *Utilities Policy* **70**, 101209. https://doi.org/10.1016/j.jup.2021.101209.

Adams, E. A., Boateng, G. O. & Amoyaw, J. A. 2016 Socioeconomic and demographic predictors of potable water and sanitation access in Ghana. *Social Indicators Research* **126** (2), 673–687. https://doi.org/10.1007/s11205-015-0912-y.

Akoteyon, I. S. 2019 Inequalities in access to water and sanitation in rural settlements in parts of southwest Nigeria. *Ghana Journal of Geography* **11** (2), 2. https://doi.org/10.4314/gjg.v11i2.

Albert, J., Luoto, J. & Levine, D. 2010 *End-User Preferences for and Performance of Competing POU Water Treatment Technologies among the Rural Poor of Kenya (World) [News]*. ACS Publications; American Chemical Society, Berkeley, CA. https://doi.org/10.1021/es1000566.

Armah, F. A., Bernard, E., Yawson, D. O., Odoib, J. O., Afitiri, A. & Nyieku, F. E. 2018 Access to improved water and sanitation in sub-Saharan Africa in a quarter century. *Heliyon* **4** (11), e00931. https://doi.org/doi.org/10.1016/j.heliyon.2018.e00931.

Arouna, A. & Dabbert, S. 2010 Determinants of domestic water Use by rural households without access to private improved water sources in Benin: A seemingly unrelated tobit approach. *Water Resources Management* **24** (7), 1381–1398. https://doi.org/10.1007/s11269-009-9504-4.

Arowosegbe, A. O., Ojo, D. A., Shittu, O. B., Iwaloye, O. & Ekpo, U. F. 2021 Water, sanitation, and hygiene (WASH) facilities and infection control/prevention practices in traditional birth homes in Southwest Nigeria. *BMC Health Services Research* **21**, 912. https://doi.org/10.1186/s12913-021-06911-5.

Blanton, E., Ombeki, S., Oluoch, G. O., Mwaki, A., Wannemuehler, K. & Quick, R. 2010 Evaluation of the role of school children in the promotion of point-of-use water treatment and handwashing in schools and households – Nyanza Province, Western Kenya, 2007. *The American Journal of Tropical Medicine and Hygiene* **82** (4), 664–671. https://doi.org/10.4269/ajtmh.2010.09-0422.

Brown, J. & Sobsey, M. D. 2012 Boiling as household water treatment in Cambodia: A longitudinal study of boiling practice and microbiological effectiveness. *The American Journal of Tropical Medicine and Hygiene* **87** (3), 394–398. https://doi.org/10.4269/ajtmh.2012.11-0715.

Croft, T. N., Marshall, A. M. J. & Allen, C. K. *et al.* 2018 *Guide to DHS Statistics*. https://www.dhsprogram.com/pubs/pdf/DHSG1/Guide_to_DHS_Statistics_DHS-7.pdf

Demographic and Health Surveys n.d.-a *Analyzing DHS Data*. https://dhsprogram.com/data/Guide-to-DHS-Statistics/Analyzing_DHS_Data.htm (Retrieved 14 August 2022).

Demographic and Health Surveys n.d.-b *Wealth Index*. https://dhsprogram.com/topics/wealth-index/ (Retrieved 7 March 2023).

Dessie, A., Alemayehu, E., Mekonen, S., Legesse, W., Kloos, H. & Ambelu, A. 2014 Solar disinfection: An approach for low-cost household water treatment technology in southwestern Ethiopia. *Journal of Environmental Health Science and Engineering* **12** (1), 1–6. https://doi.org/10.1186/2052-336X-12-25.

Emenike, C. P., Tenebe, I. T., Omole, D. O., Ngene, B. U., Oniemayin, B. I., Maxwell, O. & Onoka, B. I. 2017 Accessing safe drinking water in sub-Saharan Africa: Issues and challenges in south–west Nigeria. *Sustainable Cities and Society* **30**, 263–272. https://doi.org/10.1016/j.scs.2017.01.005.

Ezeh, O. K., Agho, K. E., Dibley, M. J., Hall, J. & Page, A. N. 2014 The impact of water and sanitation on childhood mortality in Nigeria: Evidence from demographic and health surveys, 2003–2013. *International Journal of Environmental Research and Public Health* **11** (9), 9. https://doi.org/10.3390/ijerph110909256.

Federal Ministry of Water Resources 2011 *Executive Summary of the Nigeria Water Sector Roadmap*. https://nesgroup.org/download_po licy_drafts/EXECUTIVE%20SUMMARY%20OF%20THE%20NIGERIA%20WATER%20ROAD%20MAP%202011-2025_1661856981.pdf

Flanagan, S. V., Meng, X. & Zheng, Y. 2013 Increasing acceptance of chlorination for household water treatment: Observations from Bangladesh. *Waterlines* **32** (2), 125–134.

Gaffan, N., Kpozehouen, A., Degbey, C., Ahanhanzo, Y. G. & Paraïso, M. N. 2023 Effects of household access to water, sanitation, and hygiene services on under-five mortality in Sub-Saharan Africa. *Frontiers in Public Health* **11**, 1–13. https://www.frontiersin.org/articles/10.3389/fpubh.2023.1136299

Irianti, S., Prasetyoputra, P. & Sasimartoyo, T. P. 2016 Determinants of household drinking-water source in Indonesia: An analysis of the 2007 Indonesian family life survey. *Cogent Medicine* **3** (1), 1151143. https://doi.org/10.1080/2331205X.2016.1151143.

ISS African Futures 2023 5 Health and WaSH. https://futures.issafrica.org/thematic/05-health-and-wash/

Kayser, G. L., Rao, N., Jose, R. & Raj, A. 2019 Water, sanitation and hygiene: Measuring gender equality and empowerment. *Bulletin of the World Health Organization* **97** (6), 438–440. https://doi.org/10.2471/BLT.18.223305.

Kohlitz, J., Hasan, T., Khatri, K., Sokota, A., Iddings, S., Bera, U. & Psutka, R. 2013 Assessing reported use and microbiological performance of a point-of-use household water filter in rural Fiji. *Journal of Water, Sanitation and Hygiene for Development* **3** (2), 207–215. https://doi.org/10.2166/washdev.2013.061.

Lantagne, D. S., Quick, R. & Mintz, E. D. 2006 *Household water treatment and safe storage options in developing countries: A review of current implementation practices*. Wilson Center, Washington, DC.

Mengistie, B., Berhane, Y. & Worku, K. 2013 Household water chlorination reduces incidence of diarrhea among under-five children in rural Ethiopia: A cluster randomized controlled trial. *PLOS ONE* **8** (10), e77887.

Mulenga, J. N., Bwalya, B. B. & Kaliba-Chishimba, K. 2017 Determinants and inequalities in access to improved water sources and sanitation among the Zambian households. **17**, 746–762.

Nair, C. S. & Kani, K. M. 2017 Evaluating the performance of locally made ceramic filters for household water treatment. *International Journal for Research in Technological Studies* **4** (6).

National Population Commission & Inner City Fund 2019 *Nigeria Demographic and Health Survey* 2018. https://www.dhsprogram.com/pubs/pdf/FR359/FR359.pdf

Nwokoro, U. U., Ugwa, O., Onwuliri, C. D., Obi, I. F., Ngozi, M.-O. & Agunwa, C. 2020 Water, sanitation and hygiene risk factors associated with diarrhoea morbidity in a rural community of Enugu, South East Nigeria. *The Pan African Medical Journal* **37**, 115. https://doi.org/10.11604/pamj.2020.37.115.17735.

Omole, D. O. & Ndambuki, J. M. 2014 Sustainable living in Africa: Case of water, sanitation, air pollution and energy. *Sustainability* **6** (8), 8. https://doi.org/10.3390/su6085187.

Prüss-Üstün, A., Bos, R., Gore, F. & Bartram, J. 2018 *Safe Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. World Health Organization, Geneva. https://apps.who.int/iris/handle/10665/43840

Rodriguez, L. 2019 *4 Factors Driving the Water & Sanitation Crisis in Africa*. https://www.globalcitizen.org/en/content/water-and-sanitation-crisis-sub-saharan-africa/

Rotowa, O. O., Olujimi, J., Omole, K. & Olajuyigbe, A. E. 2015 *Socioeconomic Factors Affecting Household's Sanitation Preferences in Akure, Nigeria*. https://www.semanticscholar.org/paper/Socioeconomic-Factors-Affecting-Household-%E2%80%99-s-in-%2C-OmoleF-Olajuyigbe/5addee9a4e0dbb4a61fcd2bf7bbb694a6814ae42

Simukonda, K., Farmani, R. & Butler, D. 2018 Intermittent water supply systems: Causal factors, problems and solution options. *Urban Water Journal* **15** (5), 488–500. https://www.tandfonline.com/doi/abs/10.1080/1573062X.2018.1483522

Sobsey, M. D. & World Health Organization. Water, S. and H. T. 2002 *Managing Water in the Home: Accelerated Health Gains from Improved Water Supply* (WHO/SDE/WSH/02.07). Article WHO/SDE/WSH/02.07. https://apps.who.int/iris/bitstream/handle/10665/67319/WHO_SDE_WSH_02.07.pdf?sequence=1&isAllowed=y

The United States Agency for International Development. 2022 *Global Health*. U.S. Agency for International Development, Washington, DC. https://www.usaid.gov/nigeria/global-health

United Nations 2023a *Ensure Availability and Sustainable Management of Water and Sanitation for All*. https://sdgs.un.org/goals/goal6

United Nations 2023b *Progress on Drinking Water (SDG target 6.1)*. Progress on Drinking Water (SDG Target 6.1). https://sdg6data.org/en/indicator/6.1.1

United Nations International Children Emergency Fund 2018 *Water, Sanitation and Hygiene*. https://www.unicef.org/nigeria/water-sanitation-and-hygiene

United Nations International Children's Emergency Fund 2022 *Water, Sanitation and Hygiene National Outcome Routine Mapping Report* 2021. https://www.unicef.org/nigeria/reports/water-sanitation-and-hygiene-national-outcome-routine-mapping-report-2021

World Bank 2021 *Nigeria: Ensuring Water, Sanitation and Hygiene for All*. World Bank, Washington, DC. https://www.worldbank.org/en/news/feature/2021/05/26/nigeria-ensuring-water-sanitation-and-hygiene-for-all

World Health Organization 2009 *Scaling Up Household Water Treatment Among Low-Income Populations*. https://www.who.int/publications-detail-redirect/WHO-HSE-WSH-09.02

World Health Organization 2011 *Evaluating Household Water Treatment Options: Health-Based Targets and Microbiological Performance Specifications*. World Health Organization, Geneva. https://apps.who.int/iris/handle/10665/44693

World Health Organization 2022a *Improved Sanitation Facilities and Drinking-Water Sources*. https://www.who.int/data/nutrition/nlis/info/improved-sanitation-facilities-and-drinking-water-sources

World Health Organization 2022b *Water, Sanitation and Hygiene (WASH)*. https://www.who.int/health-topics/water-sanitation-and-hygiene-wash

World Health Organization 2023a *Household Water Treatment and Safe Storage*. https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/household-water-treatment-and-safe-storage

World Health Organization 2023b *Water, Sanitation and Hygiene Burden of Disease*. https://www.who.int/data/gho/data/themes/topics/water-sanitation-and-hygiene-burden-of-disease

World Health Organization and the United Nations Children's 2021 *Progress on Household Drinking Water, Sanitation and Hygiene 2000–2020: Five Years into the SDGs*. https://www.unwater.org/app/uploads/2021/07/jmp-2021-wash-households-LAUNCH-VERSION.pdf

First received 1 June 2023; accepted in revised form 28 October 2023. Available online 9 November 2023