RESEARCH ARTICLE

ASSESSMENT OF THE PREVALENCE AND CONTROL OF WATERBORNE DISEASES IN SELECTED SEMI-URBAN COMMUNITIES OF SOUTHWEST NIGERIA

Z. A. ALIU [1], I. B. LAWAL [2], S. A. TIJANI [3] & L. K. AJAO [4]

[1,2]Department of Office Technology and Management, Federal Polytechnic Ayede, Oyo State
[3]Department of Business Administration and Management, Federal Polytechnic Ayede, Oyo State
[4]Department of Procurement, Federal Polytechnic Ayede, Oyo State

ABSTRACT

This study examines the epidemiology of waterborne diseases, related risk determinants, and control limitations among sampled semi-urban areas within Southwest Nigeria. A cross-sectional mixed-methods research protocol asserted. Data were captured among 450 households through the help of structured questionnaires, water quality analysis (for E. coli, turbidity, pH, residual chlorine, and TDS), and analysis of the records from the health facilities. Furthermore, institutional and community-level control strategies were examined through 18 key informant interviews. Data were descriptively illustrated using descriptive stats, chi-square tests, and multivariable regression analysis, and qualitative interviews through thematic analysis. Over half the households (52.8%) experienced at least one episode of waterborne diseases within the last three preceding months, with the most common ones being diarrhea (34.7%) and typhoid (22.8%). Laboratory analysis indicated that 67% of the water sources exceeded WHO thresholds on E. coli levels and 72% provided suboptimal residual chlorine concentration. Multivariable regression analysis highlighted the utilization of the protected water places (AOR = 2.84, p = 0.001) and the lack of the householder's toilets (AOR = 2.21, p = 0.002) and poor hand washing (AOR = 1.87, p = 0.015) to significantly predict the occurrence of the diseases. Most prominent limitations to control included substandard infrastructure, the lack of effective policy enforcement on sanitation and limited information on the proper drills on the ostensible hygiene. Controls need to place emphasis on the improved infrastructure on watersides, effective policies on sanitation enforcement and the provision on low-cost household interventions on the treatable waters.

Keywords: waterborne diseases, prevalence, WASH, semi-urban communities, Southwest Nigeria, public health

Corresponding Author
Z. A. Aliu
Email Address: aliuza@federalpolyayede.edu.ng

INTRODUCTION

Waterborne diseases continue to be an international public health issue and an especially chronic concern among low- and middle-income nations where the accessibility of safe drinking water, proper sanitation, and hygiene (WASH) is low. Worldwide, over 2 billion do not have proper drinking water to be safely managed and almost half the world's population has not adequate sanitation services to cater to its needs, which increases the vulnerability to diseases related to waters like cholera, typhoid, diarrhea, hepatitis A, and dysentery by quite some noticable margins (WHO & UNICEF, 2021). Annually, these waterborne diseases cause over 485,000 fatalities due to diarrheal diseases and disproportionately affect children under the age of five (Troeger et al., 2020). Besides causing direct health impacts, these diseases also affect lost production along with producing financial distress and long-term developmental return.

In Sub-Saharan Africa, the incidence of waterborne illnesses is aggravated by urbanization, frail infrastructure, climatic variability, and poverty. Research determines that semi-urban and peri-urban areas—transitional zones between urban and rural areas—are especially susceptible because these tend to combine the lack of sanitation common to rural areas with the congestion of urban areas (Nnaji et al., 2022). While in Nigeria, communicable disease morbidity is mainly caused by waterborne diseases and these diseases represent many outpatient consultations and admission to the hospitals, leading causes including the typhoid fever, cholera and diarrhoeal diseases (Ademiluyi & Okeke, 2023). Semi-urban areas within Southwest Nigeria are especially challenged by the dependency on shallow wells and surface waters together with the lack of proper waste disposal and the inadequacy on the part of the government to provide the waters to the people, all adding to the popularity among the people by the infectious waterborne pathogens (Olowe et al., 2022).

The disease burden of waterborne diseases in Nigeria is also influenced by socio-environmental and behavioral risk factors. According to studies, unsafe drinking water sources, open defecation, lack of proper hand hygiene, indiscriminate dumping of waste, and lack of awareness about safe drinking water behaviors are the leading causes of transmission (Adesina et al., 2021). Seasonal floods and climate change complicate the problem further by polluting the water sources and facilitating the circulation of pathogens (Afolabi et al., 2022). Despite interventions by the government and donors involving the construction of rural water supplies, public awareness initiatives on diseases related to drinking water and cholera control measures, the rates of prevalence still remain high among many populations and thus calls the interventions and controls used now to task.

Responding to waterborne diseases calls for an interdisciplinary strategy extending beyond biomedical interventions to cover enhancements to water infrastructure, sanitation systems, the involvement of the community, and health education. The socio-ecological theory of

health highlights the interplay between individual behaviors and community and wider institutional and environmental determinants and recommends multi-level and contextual prevention strategies that are effective (Bronfenbrenner, 1979; revised in Agyeman et al., 2023). For semi-urban Nigeria, this entails the resolution of social inequalities in social determinants to clean water accessibility alongside the improvement of local disease surveillance, the system of the community's health, and interventions on behavioral change.

Southwest Nigeria is an analytical critical case to study the incidence and control of waterborne diseases. The area, with its burgeoning semi-urban centers, still reports sporadic cholera outbreaks and regular instances of typhoid and diarrhea (Ogunyemi & Adebayo, 2023). Nevertheless, there is little systematic information on the burden of waterborne diseases and the efficacy of interventions by the community and the government in the semi-urban areas. This study thus aims to evaluate the incidence of waterborne diseases among sampled semi-urban areas of Southwest Nigeria, study the socio-environmental determinants leading to the continuation of the diseases, and appraise the efficacy of control measures put in place. By bringing to the fore context-specific information, the study will facilitate evidence-informed interventions and help further the more universal goal of the realization of Sustainable Development Goal (SDG) 6: Ensure availability and sustainable management of water and sanitation for all.

Despite international and national efforts to enhance water, sanitation, and hygiene (WASH) to date, waterborne diseases continue to be very common in Nigeria, especially within semi-urban areas where urbanization places pressure on infrastructure that is not keeping pace. Semi-urban towns in Southwest Nigeria lack safe and consistent supplies of clean drinking water related to clean and reliable-access-to-pipes systems but rely on shallow wells and surface streams and unregulated boreholes many of which contain diseases-causing contaminants due to linked-back-impoverishment-sanitisystems and improper waste mismanagement systems (Olowe et al., 2022).

 Seasonal torrents and climatic variations also increase the pollution of waters causing the constant upsurge of cholera, typhoid disease, and diarrheal diseases (Afolabi et al., 2022). While various interventions ranging from public health camps to water distribution projects have been put on the ground, these only have limited effectiveness due to the lack of strong institutional capacity and uptake on monitoring systems along with socio-behavioral constraints. With these challenges, waterborne diseases continue to take an enormous toll on the health and socio-economic progress of semi-urban Nigeria.

Against the stated background, this research study therefore seeks to scientifically review the status and control of waterborne diseases among selected semi-urban areas in Southwest Nigeria. By being specific, the objectives are: (i) to establish the prevalence of major waterborne diseases; (ii) to determine socio-environmental risk factors leading to their endemicity; (iii) to assess the efficacy of available control and public health interventions

measures; and (iv) to provide recommendations on strategies towards improved control and prevention of the diseases. Having these objectives in mind, the research study hopes to answer the following research queries accordingly: What is the status of the incidence of waterborne diseases among the semi-urban areas of Southwest Nigeria? What socio-environmental indicators would most likely affect the occurrence of the diseases? How effective are available controls and prevention measures at lowering the incidence rates of the diseases? What are the context-invariant strategies to boost sustainable control measures against the diseases among the semi-urban populations?

LITERATURE REVIEW

Waterborne diseases are generally characterized as diseases brought on by pathogenic microorganisms transmitted by contaminated waters. They consist of cholera, typhoid fever, hepatitis A, giardiasis, and diarrheal illnesses and are mainly transmitted through the ingestion of unsafe drinking water or food contaminated with human or animal faeces (WHO, 2021). Conceptually, waterborne diseases connect to the wider arena of environmental health where the availability of safe drinking water, sanitation, and hygiene (WASH) are the determinants of the outcome of health (UNICEF & WHO, 2022).

In Sub-Saharan Africa, the continued existence of waterborne diseases is an indication of the systematic failure of the infrastructure that supplies water and urban planning and the public's healthcare system (Nnaji *et al.,* 2022). Semi-urban areas—situated by quick growth within the populace, unregulated habitations and mixed urban services—have high-risk areas where the expose to waterborne diseases is heightened through the lack of proper sanita-tion facilities and unsafe drinking water-source areas (Adesina *et al*., 2021).

At the theoretical level, two models are especially applicable. The Germ Theory of Disease (Pasteur, 19th century) grounds the interpretation of contagious diseases by associating microorganisms with sickness. For water-carried diseases, the theory supports the approval of water treatment, chlorine disinfection, and hygiene promotion as key control measures. Nevertheless, transmitting infectious diseases is not only through biological but is also influenced by social and environmental circumstances. Socio-Ecological Model of Health constitutes a wider setting that focuses on various levels of influences: individual behaviors (e.g., hygiene behaviors), social norms at the social organization level (e.g., sanitation behaviors), institutions and systems (e.g., healthcare and drinking water boards), and environmental policies (e.g., regulations about the WHO's WASH) (Agyeman et al., 2023). Conclusively, these theories indicate that control efforts to be effective against water-borne diseases combine biomedical measures and system changes among social and environmental determinants.

Empirical research throughout Sub-Saharan Africa indicates that waterborne illnesses continue to be an overriding healthcare burden. Mensah et al. (2021) identified that poor

sanitation and consumption of unimproved water supplies markedly elevated the prevalence of diarrhea among peri-urban populations in Ghana. Otieno and Wekesa (2022) reported that Kenyan informal settlements served by shallow wells and surface waters continued to suffer cholera epidemics in the face of government efforts.

Ogunyemi and Adebayo (2023) report similar evidence from Nigeria. They identified typhoid and diarrhea to be the most common and dominant waterborne diseases among semi-urban Lagos and Oyo populations, where precipitation seasonally intensified epidemics. Olowe et al. (2022) reported that uncollected waste disposal, unregulated boreholes and open defecation strongly predicted the incidence of waterborne diseases among the populations within the state of Osun. Furthermore, Ademiluyi and Okeke (2023) reported that although government borehole initiatives increased accessibility to safe drinking water supplies, lack of maintenance and spate monitoring attenuated the efficacy thereof.

The writing also identifies the risk factors behind the continuation of waterborne diseases in Nigeria. They consist of the pollution of the water sources by industrial effluents and agricultural runoff and inadequately treated drainage (Afolabi et al., 2022); institutional incapacity to monitor the quality of the waters (Olawale & Adeyemi, 2021); and lack of awareness within the affected populations about the hygiene behaviors (Adesina et al., 2021). Climate variability and the occurrence of flooding also enhance the exposure to contaminated waters and facilitate the occasioning of epidemics of cholera and diarrhea (UNEP, 2022).

These risk factors are usually being aggravated by the socio-economic disparities due to the more dependence on unsafe waters and an inability to purchase treatments or prevention technologies by the poorer households (Nnaji et al., 2022). On control and prevention measures, various strategies have been reported. Biomedical measures, such as oral rehydration therapy, vaccine (e.g., oral cholera vaccine), and antimicrobial chemotherapy, are key to disease control. Long-term control is also dependent on structural measures like provision of pipe-borne water, regular chlorine disinfection, improved sanitation disposal and sewage system, and community-led total sanitation initiatives. While awareness has been increased through community health campaigns in Nigeria, challenges remain with the scale of implementation.

For instance, Adepoju et al. (2021) described how increased awareness about safe drinking water behaviors among semi-urban residents did not translate promptly to behaviors owing to deep-seated culture and improper sanitarian policy enforcement. Global evidence is that the greatest success is observed through the integration of communal-level interventions. For example, Beyene et al. (2022) in Ethiopia demonstrated the effectiveness through the combination of infrastructure improvement and health education on reducing the prevalence of diarrhea. Existing literature identifies that waterborne diseases remain a significant public health concern in Nigeria and other Sub-Saharan African countries, especially among semi-urban populations where infrastructure deficiencies and socio-behavioural determinants

overlap. Conceptual and theoretical models highlight the necessity to control not only the biological routes of transmission but also socio-environmental determinants. Empirical research points to the entrenchment of typhoid and cholera and diarrheal diseases among other diseases in the region. Some common risk factors among them are unsafe drinking water, poor sanitation, flood incidence and lack of strong governance. Nonetheless, previous research is biased either towards the rural or purely urban areas with marginal consideration to the semi-urban areas within Southwest Nigeria settings where the semi-urban areas are highly exposed. This justification is the basis and objective of the current study to create evidence on the burden and pattern of the distribution of the control measures among the transitional populations.

METHODOLOGY

This cross-sectional mixed methods study was carried out in six semi-urban communities spanning three states of Southwest Nigeria which were selected purposively from the documented WASH gaps and frequent occurrence of diarrhoea and typhoid. Households resident for at least six months and local health or WASH officials for the study population. Adopting Yamane's formula at 95% confidence level, a sample size of 450 households was targeted using multistage sampling technique, whereas 18 key informants (medical officers, disease surveillance officers and water board officials) were purposively selected. 8 Other data collection approaches were used.

A structured questionnaire elicited information on socio-demographics, water source, sanitation practice and hygiene behaviours and recent history of diarrhea and typhoid-like illness which was validated wherever possible against clinic cards. Water samples collected from the main drinking sources in homes were analysed for E. coli, turbidity, pH, total dissolved solids and residual chlorine using WHO field standard protocols. Records in health facilities were also reviewed to receive information on cases of waterborne diseases that have been reported within the last 12 months. Semi-structured interviews with key informants examined measures for control, infrastructure and response strategies at local level. Instruments were ratified by experts through piloting them in a community not participating in the study, and Cronbach' alpha coefficient reliability value of 0.80 was obtained for validity and internal consistency of the instruments.

English and Yorùbá speaking enumerators who were trained collected the data after taking informed consent from respondents. An ethics approval was attained from an established Institutional Review Board. Data analysis included descriptive statistics for prevalence, chi-square tests to test associations and multivariable logistic regression to examine predictors of waterborne disease after adjusting for clustering at the community level. The values of water quality indicators were compared with WHO guideline value, and the spatial distribution of unsafe sources was mapped out. Thematic analysis of qualitative data was triangulated with the quantitative results, in order to assess the efficacy of the control measures.

PRESENTATION OF RESULTS AND DISCUSSION

Presentation of Results

Results more than half of the households (52.8%) had suffered from at least one waterborne disease in 3 months before the survey, with diarrhea 34.7% and typhoid 22.8% being commonest.

Table 1: Prevalence of Waterborne Diseases in Semi-Urban Communities (n = 450)

Disease Type	Two-week Prevalence (%)	Three-month Prevalence (%)	Verified in Health Records (%)
Diarrhoea	19.3	34.7	28.1
Typhoid-like illness	12.6	22.8	19.4
Cholera (suspected/confirmed)	1.8	4.2	3.3
Hepatitis A / Jaundice	2.4	6.1	4.5
Any waterborne disease	**29.5**	**52.8**	**43.0**

These high prevalence are also in line with Ogunyemi & Adebayo (2023) where diarrheal prevalence was reported over 30% in semi-urban Lagos, and Mensah et al. (2021) in Ghana where peri-urban diarrhea prevalence was over 25%. A significant proportion of cases (43%) were verified against clinic files, which supported the reliability.

Table 2: Water Quality Parameters of Household Sources Compared to WHO Guidelines

Parameter	Mean Value	WHO Guideline	% Samples Above Limit
E. coli (cfu/100ml)	58.4	0	67%
Turbidity (NTU)	9.2	≤5	41%
Residual chlorine (mg/L)	0.1	0.2–0.5	72% below
pH	6.2	6.5–8.5	29%
TDS (mg/L)	260	≤500	12%

Microbiological contamination was pervasive: 67% of water sources had E. coli levels beyond WHO guidelines, indicating unsafe drinking water. Turbidity was high in 41% samples, whereas inadequacy of residual chlorine in 72% samples indicated poor disinfection. This result also agrees with Olowe et al. (2022) in Osun wells with evidence of high E. coli contamination, and Otieno & Wekesa (2022) in Kenya, where microbial contamination is associated with repeated cholera outbreaks.

Table 3: Multivariable Logistic Regression of Predictors of Waterborne Diseases

Predictor Variable	Adjusted Odds Ratio (AOR)	95% CI	p-value
Use of unprotected wells/streams	2.84	1.71–4.71	0.000
Absence of household latrine	2.21	1.34–3.64	0.002
Poor handwashing practice	1.87	1.12–3.12	0.015
Household crowding (>5 persons/room)	1.52	0.89–2.60	0.120
Prior health education exposure	0.68	0.42–1.11	0.105

Households with unprotected sources of water were almost three times more likely (AOR = 2.84, p < 0.001) to have reported WBDs and absence of latrine facility (AOR = 2.21), as well as poor hand hygiene (1.87), also remained significant risk factors. These are in line with Adesina et al. (2021) in Nigeria reported that unsafe wells and sanitation were significantly related with the occurrence of diarrhoeal. The present study is based on a large survey covering heterogeneous urban neighborhoods. The health education effectiveness is protective (AOR = 0.68) despite not significant which may have an implication to reduce the prevalence with increasing coverage.

Table 4: Barriers to Effective Waterborne Disease Control (n = 450 households + 18 key informants)

Barrier	Mean Score (1–4)	Rank
Inconsistent water supply infrastructure	3.46	1st
Poor waste management	3.32	2nd
Weak enforcement of sanitation policies	3.18	3rd
Limited health education/awareness	3.05	4th
Financial barriers to safe water access	2.89	5th

Infrastructural deficiencies were the greatest constraint (3.46), then improper waste management and poor enforcement of sanitation policies. Households also pointed to inappropriateness in HEALTH EDUCATION (3.05) and cost constraints (2.89) as the limitations. These results are similar to Adepoju et al. (2021), who pointed out that control measures against waterborne diseases in semi-urban Nigeria are constrained not by the lack of knowledge but by institutional deficiencies in WASH governance.

The research proves that water-related diseases are very common among semi-urban populations within Southwest Nigeria and that diarrhoea and typhoid represent key morbidity causes. Unsafe water quality, especially E. coli infestation and improper chlorination, is the key driver. Logistic regression also proves that lack of protection on watersources and lack of toilets and lack of hygiene are key predictors. Hesitant control is not only infrastructural but also institutional and shows systematic deficiencies within the provision and governance system of WASH. This is consistent with studies for the region (Mensah et al., 2021; Olowe et al., 2022) and recommends urgent integrated and community-led control interventions that combine infrastructure investments, health messages, and stricter regulation.

CONCLUSION AND RECOMMENDATIONS

This research estimated the burden and control of waterborne diseases among selected semi-urban populations of Southwest Nigeria and uncovered a significant public health burden. Over half the households reported experiencing at least one episode of diarrhea, typhoid, or associated illness over the last three months, and medical records validated these results. Laboratory examination of household water supplies provided evidence of widespread

microbiological contamination, especially with E. coli, and non-optimal residual chlorine levels, and highlighted the unsafe status of drinking water supplies within these populations. Regression analysis established dependence on unprotected water supplies, lack of household toilets, and poor hand-washing habits to be the most significant predictors of the occurrence of waterborne disease. Despite sustained interventions, key barriers remain and include weak infrastructure, weak enforcement of sanitation policies, inefficient waste management systems, and lack of public health awareness.

The results indicate that decreasing the burden of waterborne diseases among semi-urban Nigeria requires an integrated and multi-level intervention. Firstly, investments to ensure safe water supplies are imperative and should be directed to the increase the coverage of protected boreholes, covered piped water supplies and regular chlorination. Secondly, members-led sanitation and enforcement of sanitation policies should be intensified to abolish the aberrant habit of defecation outside and sanitize waste disposal systems.

Thirdly, information and sensitization through mass medical education efforts should be increased to ensure habitual hand washing and safe household drinking water behaviors and through the collaboration between the school system and the civic organizations. Fourthly, the institutional capacity to monitor drinking water quality and crisis manage through improved monitoring and inter-agency coordination needs to be improved. Finally, economic barriers to the accessibility to safe drinking must be remedied through the protections to low-cost consumption technologies and subsidized rates to the households at the base.

Competing Interest

The authors have declared that no conflicting interest exist in this study.

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