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Impact of Water Quality on Diarrheal Infections in Nigerian Urban Slums: A Narrative Review of Exposure Pathways, Evidence and Equitable Wash Interventions

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ABSTRACT

Diarrhoeal infections remain a major public health problem in Nigeria's informal urban settlements, where population growth has outpaced water, sanitation, drainage, and waste services. This review shows that diarrhoea risk is driven mainly by faecal contamination throughout the source-to-mouth chain. Wells, boreholes, piped systems, tanker water, carts, and sachets may become contaminated through nearby latrines, drains, dumpsites, flooding, leaks, poor handling, or weak regulation. Even safe water can be recontaminated during transport, storage, and serving. Nigerian studies report higher diarrhoea rates among households using unimproved sources, although source type does not always reflect actual water quality. Children under five face the greatest health risks, while women and girls bear collection and caregiving burdens. Effective prevention requires reliable water supply, sanitation, drainage, waste control, vendor regulation, microbial monitoring, safe storage, hygiene, breastfeeding, vaccination, treatment, community participation, climate-resilient infrastructure, and evaluation of quality, affordability, equity, reliability, and health outcomes across vulnerable communities.

Keywords: water quality; diarrhoea; urban slums; informal settlements; Nigeria; faecal contamination; WASH; water safety

INTRODUCTION

Urbanisation can improve proximity to services while simultaneously concentrating risk in underserved settlements. In Lagos, Ibadan, Kano, Port Harcourt, Abuja and other rapidly growing cities, informal neighbourhoods may have dense housing, insecure tenure, narrow access routes, open drains, poor solid-waste collection and limited space for safely separated water and sanitation facilities. City-wide statistics can conceal these intra-urban inequalities [1]. Diarrhoea is the passage of three or more loose or liquid stools per day and may result from enteric bacteria, viruses or protozoa. Transmission is commonly described through the "F-diagram": pathogens in faeces reach a new host through fluids, fingers, flies, fields/floors and food. Water quality is therefore central but not isolated [2]. Safe water will have limited effect if hands, utensils and food are heavily contaminated; conversely, improved sanitation and hygiene cannot fully compensate for unsafe drinking water [3].

This review focuses on the causal contribution of water quality in Nigerian urban slums, the pathways that modify exposure, the strength and limitations of available evidence, and interventions capable of producing sustained and equitable reductions in diarrhoeal infection.

Table 1: Water Quality and the Source-to-Mouth Chain

Chain point	Typical hazard	Risk mechanism	Priority control
Source	Latrines, drains, dumpsites, saline or industrial intrusion	Faecal or chemical contamination of wells and boreholes	Sanitary inspection, setback, sealing, source testing
Network	Leaks, illegal connections, low pressure and intermittency	Contaminated groundwater or drain water enters pipes	Continuous pressure, repair, residual chlorine monitoring
Vendor/delivery	Unverified source, dirty tanker or reused container	Contamination during filling, transport or sale	Licensing, traceability, cleaning and spot checks
Household storage	Open vessels, hand dipping, dirty cups	Recontamination and microbial regrowth	Covered narrow-neck vessel, tap/pour serving, cleaning
Consumption/food	Unsafe ice, infant feeds, raw foods and utensils	Ingestion beyond direct drinking water	Safe preparation, handwashing and temperature control

Microbiological Contamination

Acute diarrhoea is most directly associated with faecal contamination of water. Escherichia coli is commonly used as an indicator because it signals recent faecal pollution, although its absence does not guarantee that all pathogens are absent. Water can transmit diarrhoeagenic E. coli, Shigella, Salmonella, Vibrio cholerae, Campylobacter, rotavirus, norovirus, Cryptosporidium and Giardia. Research in Nigeria found diverse diarrhoeagenic E. coli in drinking-water sources and linked the risk to multiple contamination pathways and poor well integrity [4]. Physical and chemical characteristics also influence water safety and household choices. Turbidity may shield microorganisms from disinfection and indicate failures in treatment or distribution, while unpleasant salinity, taste, odour or colour can reduce trust in a source. Nitrate, heavy metals and petroleum-related pollutants are not typical causes of infectious diarrhoea, but they present chronic health risks and may encourage households to use less safe alternatives [5]. Water quality is also closely tied to reliability and quantity. Intermittent supply lowers pressure, extends storage time and forces households to switch between uncertain sources. Scarcity or high costs can reduce handwashing, toilet cleaning and food hygiene. Therefore, safely managed water must be improved, consistently available on premises when needed, and free from faecal and priority chemical contamination [6].

Why Informal Settlements Amplify Exposure

Informal settlements intensify exposure to waterborne and sanitation-related diseases because overcrowding, weak infrastructure, and limited institutional support place pathogens close to people's homes, water sources, and food supplies. High population density produces large amounts of faecal waste in small spaces, while poorly built or overused pit latrines and septic tanks may leak, overflow, or be emptied unsafely. Practices such as open defecation, flying toilets, and waste disposal into drains further contaminate the environment [7]. During heavy rainfall, blocked drainage systems and flooding can connect latrines, rubbish dumps, wells, homes, and food-vending areas, especially in lagoon and waterfront communities. At the same time, unreliable utility services force residents to depend on informal water vendors, including borehole operators, tankers, kiosks, carts, and sachet suppliers. Although these sources are essential, consumers often cannot confirm their safety, treatment, or storage conditions [8]. Poor households may also pay more per litre and respond to rising prices by using less water or choosing cheaper, riskier sources. Insecure tenure and exclusion from formal planning further delay permanent infrastructure, connections, maintenance, and accountability, leaving communities dependent on short-term emergency projects despite their continuing high levels of vulnerability. Community groups may help bridge gaps, but they cannot replace state service responsibilities [9].

Evidence from Nigeria

Evidence from Nigeria indicates a consistent association between unsafe water, inadequate sanitation and diarrhoeal disease, although the strength of causal conclusions varies by study design. National analysis of 22,571 households from the 2018 WASH National Outcome Routine Mapping survey found that using an unimproved drinking-water source increased the adjusted odds of household diarrhoea by 59%, even after accounting for wealth, residence, toilet type, soap or detergent, and refrigerator ownership [10]. However, the study was cross-sectional, relied on self-reported illness, and classified sources by design rather than confirmed microbial safety. Research in informal settlements in Lagos, including Ilaje, Makoko, Ajegunle and Ijora, similarly reports limited water access, poor sanitation, flooding, unhygienic environments and enteric illness. A case-control study among children under five in Ibadan also linked diarrhoea to combined sanitation and hygiene risks, while groundwater studies questioned the assumption that wells are naturally safe [11]. Still, many local studies use convenience samples, questionnaires or one-time water tests, limiting attribution of diarrhoea directly to contaminated water. The 2021 WASHNORM assessment improved monitoring by adding water-quality testing and utility evaluation,

but national and urban averages may conceal severe service gaps in informal settlements, which may be underrepresented in sampling frames and broader official municipal statistics [12].

Health Effects and Vulnerable Groups

Acute diarrhoea causes dehydration and electrolyte loss; repeated infections contribute to undernutrition, growth faltering, impaired development and school absence. Children younger than five are physiologically vulnerable and more likely to ingest contaminated hands or objects. Infants face additional risk when breast-milk substitutes or complementary foods are mixed with unsafe water [13]. Older people, pregnant women and immunocompromised residents may experience more severe disease. The burden is socially distributed. Women and girls commonly collect and manage water and care for sick family members, increasing time poverty and exposure to unsafe routes or sanitation. People with disabilities may be unable to use distant water points or elevated toilets. Renters and recent migrants have less influence over infrastructure. During outbreaks, households relying on informal work may delay care because treatment and lost income are unaffordable [14].

Antimicrobial Resistance and Treatment Pathways

Contaminated water and drains can carry antimicrobial-resistant enteric organisms and resistance genes from households, clinics, animal waste and pharmaceutical residues. This does not mean every diarrhoeal episode requires antibiotics. Most acute watery diarrhoea is managed with oral rehydration solution, continued feeding and zinc for children, with antibiotics reserved for specific indications under clinical guidance [15]. In urban slums, informal providers are frequently used; recent Nigerian research found important gaps in informal providers' diagnosis and treatment knowledge [16]. Poor prescribing can worsen resistance and divert attention from rehydration.

Interventions: From Household Protection to Urban Systems

Effective intervention must move beyond household protection to stronger urban water, sanitation and health systems. Cities should expand legal, metered and affordable piped connections, maintain positive pressure and chlorination, and repair leaks quickly. Boreholes, tankers, kiosks and sachet producers should be registered, inspected and subjected to traceable, risk-based microbial testing [17]. Safe sanitation requires contained toilets, scheduled faecal-sludge emptying, proper treatment and enforcement against dumping into drains and waterways. Drainage systems should be cleared and redesigned, solid-waste disposal controlled, flood routes mapped and water points protected before rainy seasons. At household level, chlorination, filtration, boiling and safe storage in clean, covered containers remain important, alongside handwashing, food hygiene and protection of infant feeds, ice, utensils and surfaces [18]. Health measures should promote breastfeeding, rotavirus vaccination, oral rehydration solution, zinc, recognition of danger signs and prompt outbreak referral. Surveillance should combine water-quality testing, diarrhoea reports and rainfall or flood alerts with rapid corrective action. However, household treatment is mainly an interim safeguard because it transfers costs and responsibility to residents and depends on consistent use. Lasting risk reduction requires safely managed services for all residents and settlement upgrading designed with residents to ensure facilities are affordable, accessible, safe and maintained after funding ends [19].

Evaluating Impact

Impact evaluations should assess multiple dimensions of water and sanitation services. Water quality indicators should include E. coli at the source, during delivery, and in stored household water, alongside turbidity, disinfectant residuals, and relevant priority chemicals. Service quality should be measured through availability, collection time, price per litre, quantity used, outage duration, and repair speed [20]. Sanitation conditions should cover safe waste containment and emptying, drain flooding, waste accumulation, and sanitary inspection scores. Health outcomes should include both caregiver-reported and clinically confirmed diarrhoea, specific pathogen infections, dehydration, hospital admission, and mortality. Behavioural measures should examine correct and consistent water treatment and storage, access to handwashing facilities, vendor compliance, and facility use. Equity and affordability should be analysed across settlements, wealth levels, tenancy status, sex, disability, and age, while tracking costs to households and providers. Evaluations should collect repeated measurements in both dry and rainy seasons and test water at source and point of use [21]. Cluster-randomised or stepped-wedge designs can improve causal inference when infrastructure is introduced gradually. Pathogen testing helps distinguish waterborne outbreaks from wider faecal–oral transmission, while qualitative research explains how price, trust, taste, safety, and source-switching influence adoption and sustained use over time across diverse and especially vulnerable communities.

Policy Recommendations

City authorities should formally include informal settlements in WASH plans, budgets, and utility service areas, regardless of residents' tenure status. They should develop settlement-level water safety plans that address sources, distribution networks, vendors, household storage, sanitation, and flood-related contamination. Testing schedules should be based on risk, with results, corrective measures, and vendor compliance communicated in clear public language. Low-income households need subsidised connections or lifeline water, while prices should be

regulated during outages and disease outbreaks [22]. Investments should combine water supply, sanitation, faecal-sludge management, drainage, and solid-waste services instead of relying on isolated boreholes. High-risk settlements also require pre-rainy-season inspections, drain clearance, chlorination, and outbreak preparedness. Safe household storage and treatment should be supported through reliable products and checks on correct use. Formal and informal providers need training in oral rehydration, zinc, responsible antibiotic use, danger signs, and rapid reporting. Community water committees should have genuine authority, inclusive membership, and transparent maintenance funds. Finally, sustained pathogen-informed research across Nigerian cities is needed to measure exposure, evaluate interventions, and guide effective, equitable urban WASH policy over time and across different seasons [23].

Evidence Gaps and Limitations

Nigeria lacks sufficient longitudinal studies that simultaneously measure microbial water quality, household handling, sanitation exposure and laboratory-confirmed diarrhoeal pathogens in informal settlements. Many studies use the improved/unimproved source binary, single samples or self-reported illness. Urban slums are inconsistently defined and may be missing from official frames. Evidence is geographically concentrated in Lagos and Ibadan, leaving northern and oil-producing cities less studied [24]. Chemical and microbial risks are sometimes conflated, and few evaluations report affordability, gender, disability or maintenance after project closure. These limitations justify stronger surveillance but do not negate the well-established causal role of faecally contaminated water.

CONCLUSION

Poor water quality increases diarrhoeal infection in Nigerian urban slums, but contamination is generated by a wider urban system. Unsafe sources, intermittent distribution, informal vending, household storage, inadequate sanitation, blocked drainage, flooding and poverty form a connected exposure pathway. The policy implication is clear: testing and treating household water alone will not deliver durable protection. Cities must provide reliable and affordable supply, control faecal waste, regulate vendors, manage floods and waste, monitor quality from source to consumption and ensure rapid treatment for illness. Community participation is indispensable, but responsibility for safe urban services must remain institutional. A source-to-mouth, equity-centred approach offers the best prospect of reducing diarrhoea while strengthening resilience to cholera outbreaks and climate-related flooding.

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