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Water, Sanitation and Hygiene Determinants of Diarrheal Disease in Urban Slum Settings: A Cross-Sectional Analysis of 250 Households in West Point, Liberia

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Abstract: ***Background: Diarrhoeal infections remain a serious public health problem in West Africa's urban slums, where Water, Sanitation, and Hygiene (WASH) practices play an important role in disease transmission. This study investigates the socio-demographic factors that determine WASH practices and their impact on diarrhoeal disease in West Point, Liberia's largest slum neighbourhood. Methods: A community-based cross-sectional study was conducted in West Point, Montserrado County, Liberia, between December 2024 and January 2025. Using systematic random selection, 250 households were selected from five geographic zones. WASH practices, socio-demographic variables, and the frequency of diarrhoeal disease were collected using standardised questionnaires based on WHO/UNICEF JMP standards. Statistical analysis included descriptive statistics, chi-square tests, odds ratio calculations, and multivariate logistic regression. Results: According to the survey, 27.2% of households had diarrhoea in the last three months, much higher than the national average of 22%. Households with no formal education had a 2.84-fold increased incidence of diarrhoea (AOR = 2.84). Access to improved water was 52.0%, sanitation was 25.6%, and hygiene was 11.2%, with just 1.6% of families having access to all three components. There were significant regional inequalities, with the South Zone and Coastal Zone having the highest diarrhoea rates. Inadequate formal education, low water availability, and open defecation behaviours all significantly predicted diarrhoea, according to a logistic regression analysis. Conclusions: West Point's WASH practices are poor and are significantly associated with diarrhoea. Insufficient combined WASH access and high loads in certain areas underscore the need for tailored interventions. The findings suggest comprehensive strategies that prioritise improvements in water quality, sanitation infrastructure, and hygiene education, particularly in high-burden areas and among people with low educational backgrounds.***

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Nomenclature:
WASH: Water, Sanitation, and Hygiene
JMP: Joint Monitoring Programme
ODK: Open Data Kit
VIF: Variance Inflation Factor
GAMs: Generalised Additive Models

I. INTRODUCTION

Diarrhoea is the world's second biggest cause of death among children under the age of five, responsible for around 525,000 fatalities per year [1]. The cost falls disproportionately on low- and middle-income nations, with Sub-Saharan Africa having the highest incidence rates [2]. Diarrheal illnesses cause approximately 22% of child mortality in Liberia, suggesting a chronic public health issue despite international efforts to enhance water, sanitation, and hygiene (WASH) [3].

Several decades of epidemiological studies have established a relationship between WASH conditions and diarrhoea. Bacteria, viruses, and protozoa can be transmitted to the intestinal tract through poor water quality, inadequate sanitation facilities, and poor hygiene [4]. According to comprehensive evaluations, interventions that enhance water quality lower the risk of diarrhoea by roughly 42%, sanitation interventions by 28%, and handwashing promotion by 30% [5].

Liberia presents huge problems in delivering appropriate WASH services as a result of the combined effects of long-term civil war (1989-2003) and the 2014-2016 Ebola outbreak, which severely impacted infrastructure development and health systems [6].

Despite post-conflict reconstruction efforts centred on metropolitan areas, informal communities such as West Point continue to lack adequate amenities. West Point, Liberia's largest slum neighbourhood, is located on a peninsula in Monrovia and is home to over 75,000 people who live in overcrowded conditions with limited access to potable water, inadequate sanitation facilities, and poor hygiene standards [7].

Previous research in West Africa has identified strong links between WASH indicators and the prevalence of diarrheal illness. Simnegn Mihrete and Colleagues in Ethiopia observed that children in homes without access to

safe drinking water were 2.3 times more likely to suffer from diarrhoea [8].

According to studies conducted in Bangladesh, families with sufficient sanitation facilities had substantially lower diarrhoea prevalence than those who defecated publicly [9]. Daffe et al. found in Senegal that maternal education was a significant protective factor against children's diarrhoea, with educated mothers more likely to use preventive WASH practices [10].

Despite this evidence, contextualised data from Liberia's urban slums are scarce. The unique socio-demographic traits, environmental factors, and healthcare accessibility patterns of towns such as West Point may influence the associations identified in a variety of settings. Understanding these local characteristics is crucial for creating effective, culturally acceptable therapies that address the specific requirements of Liberia's urban poor [11].

To identify intervention priorities, zone-specific research is required, given the spatial heterogeneity of WASH conditions and diarrhoea prevalence in slum populations [12].

A comprehensive community-based evaluation is used in this project to resolve major information shortages in West Point. The specific objectives were: (1) to evaluate WASH practices and accessibility across five geographic zones, (2) to determine the prevalence of diarrheal disease within households, (3) to identify socio-demographic factors influencing WASH practices and diarrhea risk, (4) to quantify the correlation between specific WASH indicators and the incidence of diarrheal disease using multivariate logistic regression, and (5) to delineate geographic disparities in WASH access. The findings will inform evidence-based policy and programmatic decisions for WASH projects in Liberia's urban slums and other West African settings.

II. MATERIALS AND METHODS

A. Design and Context of the Study

A community-based cross-sectional study was conducted in West Point, Montserrado County, Liberia, between December 2024 and January 2025. West Point is an impoverished urban hamlet on a Monrovian peninsula, with a population of around 75,000 people spread across 1.5 square kilometres. The hamlet has a high population density (about 50,000 people per square kilometre), inadequate sanitation, limited access to potable water, and poor hygiene standards. West Point was chosen as the research location because it reflects the most common WASH issues observed in Liberia's urban slums and is the country's largest slum community [13].

B. Population Analysis and Sampling

i. The Study Population

The study included West Point households with at least one child under age 5. Use the single population proportion formula to calculate sample size: $n = (Z^2 \times p \times q) / d^2$, where Z=1.96 (95% confidence level), p=0.22 (estimated prevalence of diarrhoea based on national data [3]), q=1-p=0.78, and d=0.05.After accounting for missing data, the calculated sample size was reduced from 264 to 250. Administrative divisions divided the community into five geographical zones: north, central, south, coastal, and western. Each zone was chosen at random to have fifty residents. The sample intervals were determined using estimated housing numbers supplied by community health professionals and local leaders. The inclusion criteria were as follows: (1) at least six months of residency in West Point, (2) a household with at least one child under the age of five, and (3) willingness to provide informed permission. Desire to relocate within three months or incapacity to provide trustworthy information were among the exclusion factors.

C. Data Collection

Standardised questionnaires developed from the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation, and Hygiene [14] were used to gather information. The questionnaire was piloted with 30 homes from a non-participating Montserrado County community before being fine-tuned for clarity, cultural relevance, and content accuracy. The questionnaire had six domains: (1) socio-demographic variables (age, gender, education, employment, income, family composition, period of residency); (2) water sources and treatment (primary water source, distance to source, treatment methods, storage practices); (3) sanitation facilities and practices (toilet type, sharing arrangements, maintenance); and (4) hygiene behaviors (handwashing facilities availability, soap presence, critical handwashing Eight trained enumerators with prior expertise in community health research conducted 30 to 40-minute interviews. Enumerators were given three days of training that included research objectives, ethical issues, interview methodologies, and data quality standards. Interviews were held at the participants' homes to ensure their anonymity. The Open Data Kit (ODK) for tablet devices enables data collection and includes built-in validation checks to prevent data entry errors.

D. Variable Definition

i. Outcome Variable

Diarrhoea was defined as the passing of three or more loose or liquid stools in 24 hours by any household member within the three months preceding the survey, which corresponds to typical recall lengths for household surveys [15].

E. Exposure Variables Include

Improved water sources, according to JMP recommendations [16], include piped water, public taps, boreholes, and protected wells. Unimproved water sources include unprotected wells, surface water, and water supplied by a vendor. Better sanitation: flush toilets, ventilated improved pit latrines, and composting toilets [17].

Unimproved sanitation: pit latrines with no slabs, bucket toilets, hanging toilets, and open defecation. Basic hygiene: The availability of a handwashing facility with soap and water throughout the visit [18]. The WASH composite score was derived by combining improved water (1), improved sanitation (1), and basic hygiene (1) on a 0-3 scale.

The knowledge score was calculated from five items assessing comprehension of the causes and prevention of diarrhoea, with a scale of 0 to 5.

The practice score was calculated using six characteristics, each rating

water treatment, storage, sanitation, and hygiene practices from 0 to 6.

Water source risk, sanitation risk, drainage/flooding risk, and waste disposal risk were integrated to produce an environmental risk score ranging from 0 to 8.

F. Statistical Analysis

To ensure the stability of our findings, we performed sensitivity analyses using the Variance Inflation Factor (VIF) and a threshold of 10. We also conducted a residual analysis to identify any outliers or influential data points that may distort the regression results. To account for nonlinear interactions between continuous predictors and the logit of the result, we used Generalised Additive Models (GAMs) or included polynomial terms as needed. Finally, all visualisations, including forest plots of odds ratios and ROC curves, were created using ggplot2 and pROC.

III. RESULTS

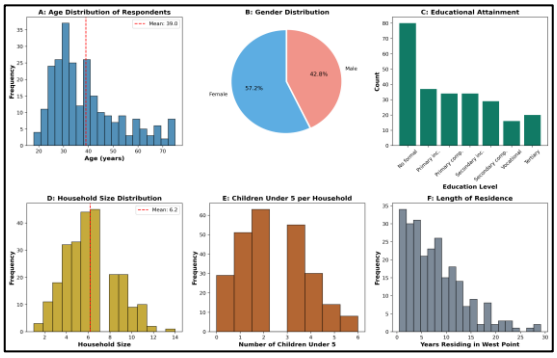
A. Participant Characteristics

The study covered 250 families and yielded a 94.7% response rate. Table I displays socio-demographic variables. The average age of respondents was 39.0 years (SD=13.5), with women accounting for 57.2%. Educational attainment was diverse: 32.0% had no formal education, 28.4% had incomplete basic education, 25.2% had incomplete secondary education, and 8.0% had completed higher education.

The average household size was 6.2 individuals (SD = 2.4), with 2.3 children under the age of five (0–8). The majority of families (48.0%) leased their homes, with 33.2% owning them. The average length of stay at West Point was 7.8 years (SD=5.8), demonstrating a consistent community presence.

Table I: Socio-Demographic Characteristics of Study Participants

Characteristic	Category	N (%)
Age (years)	Mean ± SD	39.0 ± 13.5
	Range	18-75
Gender	Female	143 (57.2)
	Male	107 (42.8)
Education	No formal education	80 (32.0)
	Primary (incomplete/complete)	71 (28.4)
	Secondary (incomplete/complete)	63 (25.2)
	Tertiary	20 (8.0)
Household size	Mean ± SD	6.2 ± 2.4
Children under 5	Mean ± SD	2.3 ± 1.5
Housing tenure	Own	83 (33.2)
	Rent	120 (48.0)
	Family-owned	37 (14.8)
	Occupied without rent	10 (4.0)
Years in West Point	Mean ± SD	7.8 ± 5.8

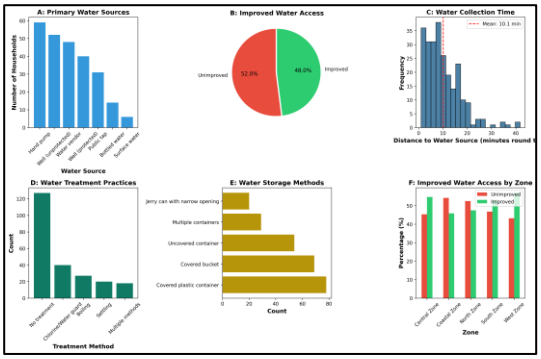


[Fig.1: Demographic Characteristics of 250 Households from West Point, Liberia. (A) Age Distribution of Respondents, with a Mean Age of 35.8 Years. (B) Gender Distribution with 54% Female Representation. (C) Educational Attainment Across Seven Categories. (D) Household Size Distribution with a Mean of 6.2 Persons. (E) Number of Children Under Five per Household. (F) Length of Residence in West Point]

B. Water Sources and Access

Fig.2 illustrates the properties of several water sources. Water was obtained mostly from wells (36.8%), hand pumps (23.6%), water merchants (19.2%), and public taps (12.4%). Water availability grew by 52.0%. The average round-trip travel time to the water source was 10.1 minutes (SD=7.2), which exceeded WHO basic access guidelines.

49.2% of persons treated their drinking water; the majority used chlorination (16.0%) or boiling (10.8%). Both covered (58.8%) and uncovered containers (21.6%) were used to store water.



[Fig.2: Water source Characteristics. (A) Distribution of Primary Water Sources. (B) Improved vs Unimproved Water Access. (C) Water Collection Time Distribution. (D) Water Treatment Methods. (E) Water Storage Practices. (F) Improved Water Access by Zone]

IV. DISCUSSION

The prevalence of diarrhoea at West Point was 27.2%, significantly higher than the national average of 22% [3]. This disparity exemplifies the "urban penalty" that slum inhabitants face, in which high population density and informal housing exacerbate a lack of essential infrastructure.

A. WASH Education and Deprivation

The key finding of this study is that just 1.6% of families have access to the entire "WASH bundle" (improved water, sanitation, and hygiene). This widespread deprivation creates multiple overlapping transmission pathways for pathogens. Research in similar sub-Saharan contexts has demonstrated that while individual WASH components are beneficial, the synergistic effect of the full "WASH bundle" is significantly more effective at reducing childhood enteric infections [19].

Furthermore, the substantial relationship between a lack of formal education and diarrhoea (AOR = 2.84) is consistent with regional studies from Ethiopia and Senegal [8, 10]. Education serves as a substitute for health literacy, enabling individuals to adopt preventive behaviours, such as properly using point-of-use water treatment.
sanitation practices, and proper waste disposal [20].

B. Geographical Differences

Significant geographic variation was seen among the five zones. The South and Coastal zones are the most vulnerable, with the South Zone having a prevalence of 40.0%. This aligns with broader evidence that, in high-density informal settlements, the lack of municipal planning and environmental stressors such as poor drainage are stronger predictors of diarrheal clusters than individual household wealth alone [21].

C. Compared to the Literature

Our finding that unimproved water sources are associated with more than twice the risk of diarrhoea (AOR = 2.31) is consistent with global meta-analyses showing that water quality improvements significantly reduce the risk of diarrhoea [5]. Furthermore, the significant risk associated with shared sanitation is consistent with data showing that, in slum environments, high user-to-latrine ratios usually lead to facility abandonment and increased open defecation [22]. Finally, the environmental issues raised, such as flooding and drainage, are consistent with broader findings that climate-induced urban stressors exacerbate the transmission of enteric diseases in West African coastal slums [23].

The persistent high burden of disease in West Point suggests that the community remains in a state of "protracted crisis" regarding public health infrastructure. Systematic reviews of WASH interventions during and after humanitarian crises highlight that without transitioning from emergency relief to sustainable, community-led infrastructure, disease prevalence remains high even after the immediate threat (such as the Ebola outbreak) has passed [24]. This underscores the need for robust management strategies tailored to conflict-affected or post-disaster urban settings, where traditional health systems are fragile [25].

D. Limitations and Strengths

i. *Strengths:* This study used a community-based method and rigorous random sampling to improve representativeness at West Point. The use of standardized JMP-defined indicators makes comparison with national and international surveys easier. Multivariate analysis enabled the identification of independent predictors while accounting for confounding variables.

ii. *Limitations:* Because the study was cross-sectional, conclusive causal correlations could not be established. Self-reported diarrhoea over three months may be subject to recall bias [14]. Furthermore, the absence of microbiological water quality tests and stool analysis precludes the identification of particular etiological agents. Finally, while West Point shares similarities with other urban slums, its single-site architecture limits its applicability to other contexts.

V. CONCLUSIONS

This study demonstrated that WASH conditions in West Point, Liberia, are severely deficient and are substantially associated with diarrheal illness. The main findings include a diarrhoea prevalence of 27.2%, much higher than the national norm, and just 1.6% of families have access to the full WASH package. Education appeared to be a key factor, with families without formal education having a 2.84-fold higher risk of diarrhoea than those with formal education.

RECOMMENDATIONS

- To lower the illness burden, the Liberian government and non-governmental groups should undertake the following measures:
- Integrated Programming: Rather than vertical, single-component programs, implement integrated WASH interventions that address water quality, sanitation infrastructure, and hygiene promotion.
- Prioritize urgent improvements in the high-burden South and Coastal Zones, where WASH access is limited and diarrhea is prevalent.
- Educational Outreach: To close the "education gap" in disease prevention, design and conduct health education programs, particularly aimed at families with less formal education.

FUTURE DIRECTIONS IN RESEARCH

- Prospective cohort studies should be conducted to determine temporal connections and causal linkages between WASH exposures and diarrheal illness.
- Microbiological Investigations: Use point-of-use water quality testing and molecular stool analysis to discover etiological agents and contamination routes.
- Multi-Site and Intervention Research: Expand research to multiple Liberian slum neighbourhoods, and conduct randomised controlled trials to assess the efficacy of integrated WASH programs.
- Qualitative and Economic Analysis: Investigate socio-cultural drivers of WASH behaviours and evaluate the cost-effectiveness of various intervention techniques.
- Achieving SDG 6 (Clean Water and Sanitation) in Liberia's urban slums would need long-term commitment, cross-sectoral collaboration, and evidence-based, contextually relevant solutions.

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DECLARATION STATEMENT

Some of the cited references are older and are noted explicitly as [25]. However, these works remain significant for the current study, as they are

pioneering in their fields. After aggregating input from all Authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted objectively and without external influence.
- **Ethical Approval and Consent to Participate:** Yes, securing ethical approval and consent from all participating individuals is essential. **The ethical approval and consent are as follows.** Conducted as part of an educational program at the University of Liberia School of Public Health, this study adhered to core ethical principles despite lacking prior IRB approval. We obtained written informed consent, ensured voluntary participation, maintained confidentiality through anonymization, and secured data storage. All procedures followed the standards of the University of Liberia and the Declaration of Helsinki. Though retrospective approval is not possible, we have documented all implemented safeguards.
- **Data Access Statement and Material Availability:** The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Anonymised data may be shared for research purposes, in accordance with institutional data-sharing policies and with appropriate data-use agreements in place to protect participant confidentiality.
- **Author's Contributions:** Each author has individually contributed to the article. Prince L. Fully: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft, Visualization Amos Melish Franklins: Methodology, Formal Analysis, Software, Validation, Writing – Review & Editing, Visualization Neima N. Candy: Supervision, Project Administration, Resources, Writing – Review & Editing, Funding Acquisition Alvan Corker: Methodology, Formal Analysis, Software, Validation, Writing – Review & Editing, Visualization Diamond Fobo: Methodology, Formal Analysis, Software, Validation, Writing – Review & Editing, Visualization

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Amos Melish Franklins, BSc. Public, at the University of Liberia, is a recent graduate student in the Department of Public Health. He is gaining fundamental knowledge in community health, illness prevention, and health promotion techniques as part of his academic studies. As a future public health practitioner, he intends to utilise his expertise to alleviate Liberia's community health concerns. He intends to contribute.

Diamond K. Fobo BSc. A candidate for a senior student in the University of Liberia's Public Health Department. As part of her academic studies, she is studying community health, disease prevention, and health promotion programs. Fobo, a prospective public health professional, is committed to using his skills to address community health issues in Liberia. She aims to contribute to

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