Environmental and Behavioral Factors Associated with Childhood Diarrhea in the Rural Health Zone of Maluku I, Kinshasa, DR Congo

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Abstract

Background: Diarrhea accounts for nearly one in five child deaths, with approximately 1.5 million annual fatalities, mainly in peri-urban and rural settings with poor living conditions. This study assessed environmental and household Behavioral factors associated with childhood diarrhea in Maluku I.

Methods: A cross-sectional study was conducted in 239 households with children aged 0–59 months. Data were collected using structured questionnaires and analyzed using logistic regression, with associations expressed as odds ratios (ORs) and p-values (<0.05).

Results: The prevalence of childhood diarrhea was 21.3%. Households with clean yards showed an 11-fold lower risk (OR = 0.09; 95% CI: 0.01–0.88; p = 0.039), whereas access to improved water reduced the risk by 7.7-fold (OR = 0.13; 95% CI: 0.11–0.29; p < 0.001). Lack of handwashing at critical times emerged as the strongest risk factor, increasing the likelihood of diarrhea approximately six-fold (OR = 6.13; 95% CI: 2.09–18.00; p < 0.001).

Conclusion: Childhood diarrhea in Maluku I remains highly prevalent and is strongly influenced by modifiable environmental and behavioral factors, highlighting the need for targeted interventions.

Keywords: Childhood diarrhea, environmental factors, behavioral factors, Kinshasa, Maluku I

Introduction

Childhood diarrhea remains a major global health issue, particularly in children under five. It is the second leading cause of mortality, responsible for about 525,000 deaths annually (Organisation Mondiale de la Santé, 2018). Nearly 70% of these deaths occur in ten highly affected countries, including the Democratic Republic of Congo (Organisation Mondiale de la Santé, 2018). Despite global progress, diarrheal diseases still cause avoidable deaths,

mostly in low- and middle-income settings (Liu et al., 2012).

The burden is acute in sub-Saharan Africa. Children experience up to five episodes annually, with approximately 800,000 deaths (Workie et al., 2019). Poor sanitation, unsafe water, lack of handwashing, and risky feeding practices remain central determinants (Demissie et al., 2021; Headey & Palloni, 2019; Bekele et al., 2021). In East Africa, reliance on distant and stored water increases risk, whereas WASH interventions have proven highly effective, reducing diarrheal mortality by 89% in Tanzania between 1980 and 2015 (O'Connell et al., 2017; Modern et al., 2020; Masanja et al., 2019).

In the DRC, only 35% of the population has access to safe water and sanitation (UNICEF, 2018). Diarrhea prevalence fell from 22% in 2001 to 14% in 2023; however, stark disparities persist (UNICEF, 2018; Ministère de la Santé Publique, 2019). In Kinshasa's Maluku I zone, despite PNEVA interventions since 2008 (Programme National École et Village Assainis, 2018), challenges remain, including a lack of piped water, recurrent contamination, poor excreta management, and the absence of systematic handwashing (Hirai et al., 2016; Ministère de l'Environnement et Développement Durable, 2020). Cholera outbreaks in 2011 and 2016 highlighted the fragility of the system.

Given the persistent burden of childhood diarrhea in this rural setting, we sought to address the following research question: Which environmental and behavioral factors drive the occurrence of childhood diarrhea in the rural health zone of Maluku I, Kinshasa, DR Congo? Accordingly, the primary objective of this study was to identify the environmental and behavioral factors that shape the risk of childhood diarrhea in Maluku I to guide more targeted and effective prevention strategies.

Methodology

Study Design

A cross-sectional study was conducted between 9 and 22 September 2024 in households with at least one child aged 0–59 months within Maluku I, Kinshasa, DRC. A cross-sectional design was selected as it permitted the simultaneous estimation of the prevalence of childhood diarrhea and evaluation of associated environmental and behavioral factors. This approach is particularly appropriate for studies such as ours, which are constrained by limited resources and require rapid and cost-effective data collection. Moreover, cross-sectional studies are widely recommended for investigating common, multifactorial public health conditions, including childhood diarrhea.

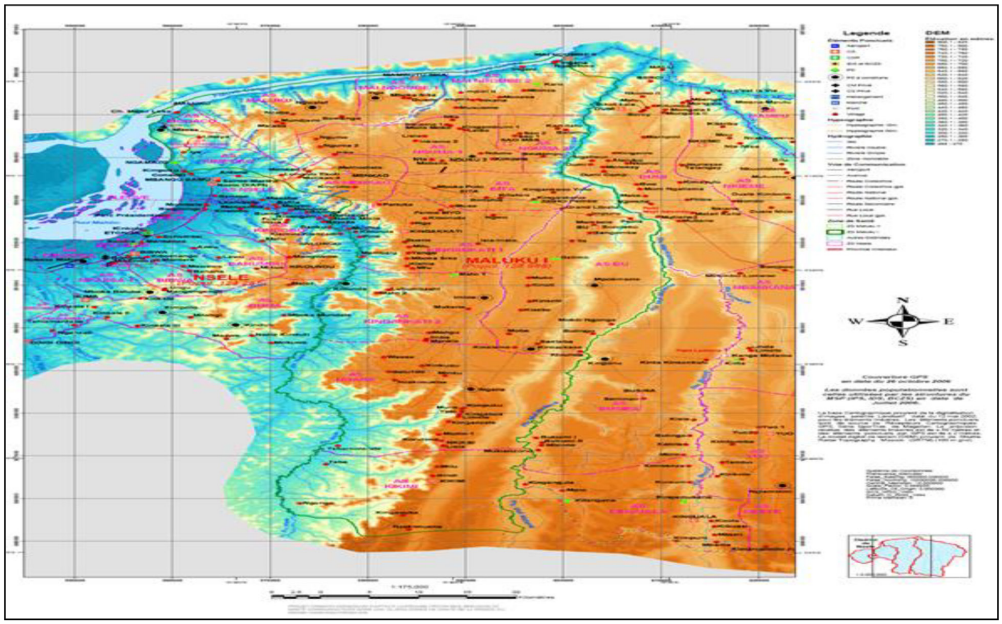
Study Setting

The study was conducted in the Rural Health Zone of Maluku I (see Figure 1), created after the division of the former Kinkole-Maluku zone, which included the N'Sele and Maluku communes and covered nearly 830,000 km², three-quarters of Kinshasa's population.

Maluku I was selected due to its rapid population growth and peri-urban expansion. These dynamics heighten exposure to environmental risks, notably limited access to safe water and sanitation, thereby increasing the prevalence of childhood diarrhea.

Figure 1

Map of the Rural Health Zone of Maluku I and its Surroundings



Source: Central Bureau of Health Zone

Study Population and Sampling

The study population comprised households with at least one child aged 0–59 months residing in the Rural Health Zone of Maluku I. Sample size was estimated using Kish's formula (Kish, 1965), with diarrhea prevalence among under-five children at 17% in Kinshasa (UNICEF, 2018), a 95% confidence level (Z = 1.96), a margin of error of 5% (d = 0.05), yielding n ≈ 217. To address potential non-response, 10% was added, yielding a final sample of 239 households.

Respondents were household heads, mothers, or designated representatives. Four-stage probabilistic sampling was performed. In the first stage, three health areas (Mangengenge, Monaco, and Maluku) were randomly selected. In the second stage, each area was divided into six segments, and one segment was randomly selected. The segmentation of the health areas involved dividing each area into six distinct segments numbered 1–6. This division was based on a map or sketch and considered the estimated number of households in each health area. To achieve this, the first line was

drawn, followed by two additional lines perpendicular to the first, resulting in six required segments. Wherever possible, natural boundaries such as roads, rivers, ravines, or hills were used to delineate the segments. Third stage: within each segment, three streets were randomly chosen. Fourth stage: systematic sampling of households using a pre-defined interval (k =3) until the target of 239 households was reached.

Data Collection Procedure

Data for this study were collected using the following methods: individual interviews via a structured electronic household questionnaire administered to the household head, mother, or child's caregiver (0–59 months), and direct observation of the household environment by investigators using a digital data-collection tool, focusing on housing quality, yard sanitation, and type of latrine used.

Study Variables

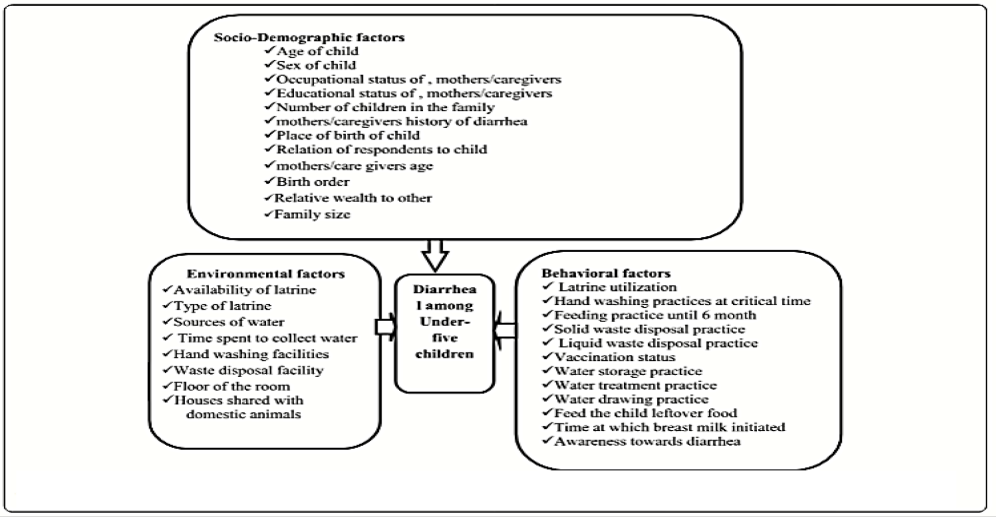
Childhood diarrhea is the dependent variable, defined as the passage of at least 3 loose stools in 24 hours in children aged 0–59 months during the 2 weeks preceding the survey. This short recall period allowed us to control for potential biases. It is a categorical variable with two categories: yes (households reporting diarrhea) and no (households not reporting diarrhea). The respondents did not receive any specific training in recognizing liquid stools. However, prior to administering the questionnaire, the interviewers explained the operational definition of diarrhea used in the study. This preliminary clarification was intended to ensure a uniform understanding of the concept and to enhance the reliability of the response.

The explanatory variables include sociodemographic characteristics: age of the household head, respondent's sex, education level of the household head, occupation of the household head, marital status, religion, health area of residence, and household size. Also, environmental and household living conditions: yard sanitation, yard flooding, type of dwelling, presence of stagnant water, and presence of rodents. Water, sanitation, and hygiene**:** Water source, regular disinfection of water source, treatment of drinking water, method of treatment, storage of drinking water, storage method, duration of water storage, type of latrine, presence of flies in latrines, latrine sharing, number of households using the same latrine, fecal disposal method, practice of burying child feces in the yard, handwashing practices, household waste disposal, and wastewater disposal.

Explanatory variables were selected based on previous studies, including Workie et al. (2019). Figure 2 presents the conceptual model of this study.

Figure 2

Conceptual Framework of Explanatory Factors for Diarrheal Occurrence in Children Under Five



Source: Aboma et al. (2021)

Data Processing and Analysis

A two-step quality assurance process was implemented: daily verification of field-entered data enabled real-time correction of errors, particularly regarding completeness and accuracy, ensuring the consistency of the collected information. Subsequently, the database was meticulously cleaned to ensure the reliability of the results. Data were collected using the KoboCollect application (version 2024.1.3) on mobile devices (Android tablets and smartphones). At the end of the data collection, the database was exported and imported into Stata (version 15.0) for further analysis. After thorough cleaning, statistical analyses included: Quantitative Variables: median and interquartile range for non-normally distributed variables; mean and standard deviation for normally distributed variables. Normality was assessed using the Kolmogorov–Smirnov test

Bivariate analyses, such as Chi-square (χ^2) tests, were used to assess the associations between explanatory variables and childhood diarrhea. The logistic regression model indicated that environmental factors were significantly associated with diarrhea ($p < 0.05$). Factors identified in the conceptual model, based on the literature review, with $p < 0.20$ were included in a logistic regression model to determine the principal factors associated with diarrheal occurrence, while accounting for all variables simultaneously. Odds ratios were calculated, and statistical significance was defined as $p < 0.05$.

However, interactions among key water, sanitation, and hygiene variables

were not tested. The limited sample size, low prevalence in certain categories, and lack of a clear biological rationale would have rendered such analyses unreliable and difficult to interpret, without adding meaningful insight to the model.

Results

Most household heads were women (63.60%) aged 30–44 years (52.30%), with low educational attainment (63.60%) and high unemployment rates (56.07%). The vast majority were married (90.79%), and their religious affiliations were mainly Catholic (39.33%) and Protestant (28.45%). In this study, 51 households (21.3%) reported cases of childhood diarrhea among the 239 surveyed households, as indicated in Figure 3. Table 1 also shows the characteristics of the households.

Figure 3

Prevalence of Childhood Diarrhea in Maluku I Health Zone, Kinshasa

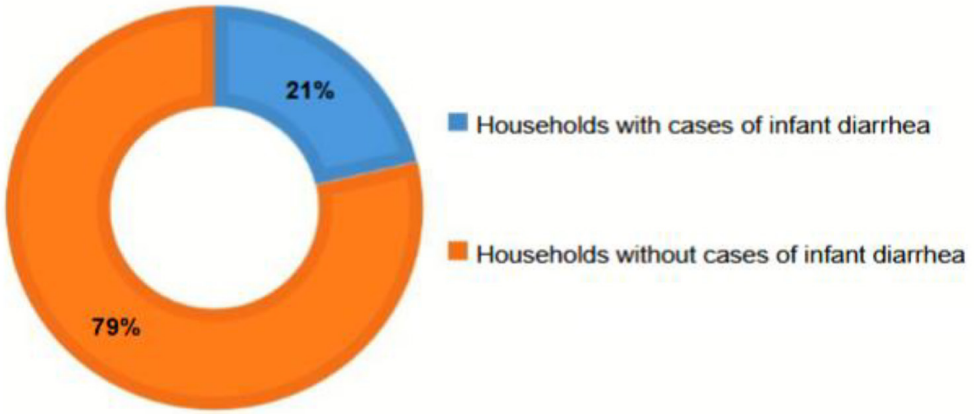


Table 1

Characteristics of Surveyed Households

Variables	Frequency	Percent (%)
Health area of residence (n=239)		
Maluku	77	32.22
Mangengenge	68	28.45
Monaco	94	39.33
Household size (n=239)		
≤4	65	27.20
5–7	143	59.83
≥8	31	12.97
Age of child in months (n=51)		
0–11	12	23.53
12–23	11	21.57
24–35	12	23.53
36–47	12	23.53
48–59	4	7.84
Child's sex (n=51)		
Female	26	50.98
Male	25	49.02

Households were spread across Monaco (39.33%), Maluku (32.22%), and Mangengenge (28.45%), with most families being relatively large, particularly those comprising five to seven members (59.83%), compared with smaller (27.20%) and larger households (12.97%). The sex distribution of the children was nearly equal, with females accounting for 50.98% and males for 49.02%.

Table 2

Environmental Characteristics and Quality of Household Living Conditions

Variables	Frequency (n=239)	Percent (%)
Cleanliness of the household yard		
Unsanitary	135	56.49
Sanitary	104	43.51
Flooding of household yard		
History of flooding	15	6.28
No history of flooding	224	93.72
Type of housing		
Housing made of durable materials	64	26.78
Housing made of non-durable materials	175	73.22
Presence of rodents in the household		
No	22	9.21
Yes	217	90.79

Over half of the households lived in unsanitary outdoor environments (56.49%), with a smaller yet important proportion exposed to flooding (6.28%). Most dwellings were built with non-durable materials (73.22%), and rodent presence was reported in nearly all the households (90.79%).

Table 3

Household Water-related Habits and Practices

Variables	Freq. (n=239)	Percent (%)
Source of water supply		
Improved source	171	71.55
Unimproved source	68	28.45
Regular disinfection of water source		
No	99	41.42
Yes	140	58.58
Drinking water treatment		
Never	154	64.44
Sometimes	73	30.54
Often	9	3.77
Always	3	1.26
Storage of drinking water		
No	61	25.53
Yes	178	74.47
Water storage method (n=178)		
Large external tank	1	0.56
Closed container in refrigerator	8	4.49
Closed container at room temperature	152	85.39
Open container at room temperature	17	9.55
Water storage duration		
0-3 days	207	86.61
4-7 days	30	12.55
>7 days	2	0.84

Most households (71.55%) used improved water sources, while 28.45% still relied on unimproved sources. Although 58.58% of the respondents disinfect water sources, nearly two-thirds (64.44%) do not treat drinking water; among those who do, boiling and chlorination predominate. Water storage was common (74.47%), generally in closed containers (85.39%), although 9.55% used open containers, increasing contamination risk. Most households stored water for up to three days (86.61%).

Table 4

Household Hygiene and Sanitation Behaviors

Variables	Freq. (n=239)	Percent (%)
Type of latrine used		
No latrine (open defecation)	26	10.88
Improved toilet	67	28.03
Unimproved toilet	146	61.08
Presence of flies in latrines		
No	25	10.46
Yes	214	89.54
Shared latrines		
No	141	59.00
Yes	98	41.00
Number of households sharing latrines		
<3	179	74.90
3-5	47	19.67
>5	13	5.44
Mode of excreta disposal		
Construction of a new latrine	161	67.36
Disposal in public drains	13	5.44
Burial within household plot	63	26.36
Septic tank emptied by truck	2	0.84
Practice of burying excreta in courtyard		
No	176	73.64
Yes	63	26.36
Handwashing practices		
Never	42	17.57
Sometimes	170	71.13
Often	18	7.53
Always	9	3.77

Most households rely on unimproved latrines (61.08%), while 28.03% use improved facilities and 10.88% practice open defecation. Fly infestation is widespread (89.54%), and latrine sharing is common (41%). Excreta disposal is mainly through the construction of new latrines (67.36%), although 26.36% of respondents bury waste within plots. Handwashing remains insufficient: 17.57% never wash their hands at critical moments, and very few do so consistently (3.77%).

Bivariate Analysis Results

The analysis showed a strong association between household yard cleanliness and childhood diarrhea ($p < 0.001$). Children living in households with unclean yards are at significantly higher risk of diarrhea. Other factors, such as household size, housing type, flooding, stagnant water, and rodent presence, were not significantly associated with leptospirosis.

The analysis highlights a strong association between water source type and childhood diarrhea ($p < 0.001$). Households using unimproved sources

showed a significantly higher prevalence of diarrhea.

Other practices, including disinfection, treatment, storage, and storage duration, were not significantly associated with the outcome.

Latrine sharing was strongly and significantly associated with childhood diarrhea ($p < 0.001$), particularly when shared by three or more households. Excreta disposal practices, especially burial within household plots or courtyards, were also significant contributors ($p < 0.001$). Handwashing behavior was also associated with an increased risk when never practiced ($p = 0.040$). Other variables, such as latrine type ($p = 0.819$) and the presence of flies ($p = 0.169$), were not significantly associated with diarrhea.

Results of Multivariate Logistic Regression Analysis

Table 5

Multivariate Logistic Regression Analysis

Variables	ORa	95% CI	P-values
Water and hygiene			
water source (improved/unimproved)	0.13	0.11 – 0.29	<0.001*
Disinfection of water source (vs Regular/none)	0.12	0.01 – 1.58	0.106
Water storage method (Safe/unsafe)	0.71	0.05 – 2.81	0.610
Handwashing at critical times (Yes/No)	6.13	2.09 – 18.0	<0.001*
Sanitation and waste			
Latrines shared (Yes/No)	4.06	1.80 – 5.19	0.004*
Burial of septic tank sludge in yard (Yes/No)	6.71	2.92 – 7.12	0.013*
Household waste disposal (Safe/Unsafe)	4.56	1.34 – 15.0	0.042*
Wastewater disposal (Safe/Unsafe)	16.99	4.65 – 18.12	0.002*
Domestic environment			
Cleanliness of the yard (Yes/No)	0.09	0.01 – 0.88	0.039*
Presence of flies in latrines (Yes/No)	1.10	0.25 – 4.85	0.890

* The difference is statistically significant with $p < 0.05$; ORa (Adjusted Odds Ratio)

Discussion

The prevalence of childhood diarrhea in Maluku I was 21.3%, which is at the higher end of the reported rates in Africa. This exceeds findings from Diakité et al. (2019) in Bamako (17%) and Kaneza et al. (2025) in Rwanda (19%), while remaining below Chari et al. (2023) in Zimbabwe (25.1%) and Birhan et al. (2023) in flood-prone Ethiopian areas (29%). Compared with the results of Ugochukwu et al. (2020) in rural Nigeria (10.77%) and Umuhoza Claudine et al. (2021) in Rwanda (12.7%), Maluku I shows an intermediate vulnerability, reflecting the structural sanitation and hygiene challenges characteristic of peri-urban Central African settings. These patterns are consistent with the pooled estimates by Worede et al. (2025) and reinforce the influence of local environmental and

socioeconomic conditions on diarrheal prevalence.

Our findings highlight the critical role of the domestic environment and hygiene behaviors. Households with clean yards had an 11-fold lower risk (OR = 0.09; 95% CI: 0.01–0.88; P = 0.039), confirming the importance of yard hygiene, as shown by Diakité et al. (2019) and Birhan et al. (2023). Access to improved water sources was strongly protective (OR = 0.13; 95% CI: 0.11–0.29; $p < 0.001$), consistent with the findings of Kaneza et al. (2025) and Worede et al. (2025). Conversely, reliance on untreated water increases this risk (Chari et al., 2023).

Sanitation practices are also pivotal. Sharing latrines quadrupled the risk of diarrhea (OR = 4.06; 95% CI: 1.80–5.19; P = 0.004), while burial of septic tank sludge in yards increased the risk by nearly sevenfold (OR = 6.71; 95% CI: 2.92–7.12; p = 0.013), echoing the findings of Mohammed and Zungu (2016) and Birhan et al. (2023). These findings illustrate that peri-urban households in Maluku I face compounded exposure, with contaminated soil and shared facilities intensifying pathogen transmission.

Most strikingly, the absence of handwashing at critical times emerged as the strongest risk factor (OR = 6.13; 95% CI: 2.09–18.00; $p < 0.001$), far exceeding prior estimates (Worede et al., 2025). In peri-urban African contexts with limited hygiene infrastructure, behavioral practices dominate exposure dynamics, confirming Choi (2025) on the primacy of household-level behavior in childhood diarrhea risk.

Sociodemographic vulnerabilities further contextualize these findings. Low maternal education (Umuhoza Claudine et al., 2021; OR = 5.163) and household economic precarity (OR = 1.64) exacerbate risk, while large family size and crowding increase pathogen transmission (Nguyen et al., 2021). These results align with those of Diakité et al. (2019) and underscore the intersection of socioeconomic, environmental, and behavioral factors in shaping the diarrheal burden.

Overall, the study demonstrates that integrated interventions targeting WASH, yard hygiene, sanitation management, and handwashing promotion are essential in Maluku I and, by extension, in similar peri-urban African settings. Addressing structural vulnerabilities while promoting household-level practices can substantially reduce childhood diarrhea, even in areas with constrained infrastructure.

Study Limitations

This study has inherent limitations. As a cross-sectional investigation, it can only identify associations between environmental and behavioral factors and childhood diarrhea and does not permit causal inferences; therefore, interpretations are confined to the observed associations. Moreover, the findings reflect the situation in the Maluku I Rural Health Zone at a single point in time and do not derive from a randomized controlled trial. Certain data, including reported cases of diarrhea, relied on self-reporting and participants'

memory, which may have introduced recall bias. A short recall timeframe was used to reduce the risk of recall bias. The study also did not account for potential seasonal variations in diarrheal incidence. Finally, owing to limited resources, we were unable to assess the quality of water consumed by the surveyed households or link it directly to episodes of diarrheal disease.

Conclusion

This study aimed to identify the key environmental and behavioral factors associated with childhood diarrhea in a peri-urban setting within the Maluku I Rural Health Zone in Kinshasa. The findings highlight the principal contributors to the high prevalence of childhood diarrhea, particularly inadequate sanitation. Practices related to access to potable water, latrine management, and the disposal of excreta and household waste play a significant role in child health in rural areas. These conclusions should prompt an urgent reassessment of public health and sanitation policies, particularly in rural and peri-urban areas.

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Conflict of Interest

None

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