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Prevalence and Factors Associated with Diarrhea in Households in Three Rural Health Zones of Haut-Uélé, Democratic Republic of Congo

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Abstract

Context: Waterborne diarrheal diseases remain a major cause of morbidity in rural households in low-income countries, with a particularly high incidence among children under 5 years of age. In the Democratic Republic of Congo, limited access to safe drinking water and inadequate household water management practices expose households to a high risk of diarrhea. **Objective:** To determine the prevalence of diarrhea in households and associated factors in three rural health zones of Haut-Uélé. **Methods:** A cross-sectional analytical study was conducted in January-February 2026 in the health zones of Isiro, Pawa, and Wamba. A sample of 331 households with at least one child under five years of age was selected by systematic sampling after random selection of zones and villages. Data were collected from mothers/caregivers using a structured questionnaire. The association between variables was tested using Fisher's exact test, and factors independently associated with diarrhea were investigated using multivariate logistic regression. The significance level was set at $p < 0.05$. **Results:** Of the 331 households surveyed, 43.2% reported at least one case of diarrhea, across all age groups, in the two weeks preceding the survey (10.5% of the total household population); the prevalence among children under five years of age was 15.4% (86/560 children). Almost all households (95.8%) did not treat drinking water before consumption, and 63.7% stored it for more than 24 hours. In bivariate analysis, a large household size (OR = 2.43; 95% CI: 1.41 - 4.27; p = 0.001) and water storage for more than 24 hours (OR = 3.25; 95% CI: 1.99 -

5.30; p < 0.0001) were significantly associated with an increased risk of diarrhea in the household, while safe water management at home appeared to be a protective factor (OR = 0.54; 95% CI: 0.34 - 0.85; p = 0.011). In multivariate analysis, household size (aOR = 2.33; 95% CI: 1.36 - 4.01; p = 0.002) and storage duration (aOR = 3.09; 95% CI: 1.86 - 5.13; p < 0.0001) remained independently associated with diarrhea. **Conclusion:** Diarrhea in households remains highly prevalent in the rural health zones of Haut-Uélé, where domestic water management practices, particularly the duration and security of storage, are major and modifiable determinants. These findings support the promotion of local, low-cost water treatment approaches, such as solar disinfection (SODIS), as a complementary measure for diarrhea prevention in rural areas.

Keywords

Diarrhea, Domestic Water Management, Drinking Water, Rural Area, Households, SODIS, Democratic Republic of Congo

1. Introduction

Waterborne diseases are caused by consuming drinking water contaminated with human or animal feces carrying pathogenic microorganisms such as viruses, bacteria, and protozoa, which are capable of surviving and multiplying in water, food, and on various surfaces. Among the diseases most frequently associated with this contamination are cholera, dysentery (shigellosis and amebiasis), typhoid fever, cryptosporidiosis, giardiasis, cyclosporiasis, yersiniosis, and salmonellosis, which manifest primarily as diarrheal episodes. Other viral gastroenteritis infections (rotavirus, norovirus, adenovirus, enterovirus, calicivirus, astrovirus, reovirus) can also occur [1]. Diarrhea thus remains one of the leading causes of morbidity and mortality worldwide, particularly among children [1].

Globally, waterborne diarrheal diseases remain particularly prevalent in areas where drinking water treatment is inadequate or nonexistent. Consumption of contaminated water, combined with poor sanitation and hygiene, is responsible for approximately 88% of the four billion cases of diarrhea recorded each year, resulting in 1.8 million deaths, nearly 90% of which occur in children under five years of age [2].

In sub-Saharan Africa, and particularly in the Democratic Republic of Congo (DRC), inequalities in access to drinking water disproportionately affect rural populations, who are largely dependent on natural water sources and surface water, thus exposing them more to the consumption of unsafe water. It is estimated that approximately 37 million people living in rural areas of the DRC are at risk of diseases related to the contamination of streams and rivers [3].

Reducing morbidity and mortality from diarrheal diseases relies on implementing interventions that target the interruption of fecal-oral transmission, including

access to sufficient quantities of safe water, adequate sanitation, the availability of handwashing facilities, and the promotion of personal and food hygiene practices [1] [4]. Among these interventions, household water treatment (HWT) such as solar disinfection (SODIS), boiling, chlorination, filtration, and proper water storage practices are promising alternatives for improving household water security [5].

In the DRC, the rate of drinking water coverage has declined over the past few decades, a consequence of the degradation of existing infrastructure, itself linked to more than twenty years of armed conflict, insufficient investment and sustained population growth [6].

In the province of Haut-Uélé, a study conducted in the Isiro health zone on the physico-chemical and bacteriological quality of water revealed that, out of 23 water points assessed, only 2 (8.7%) provided water that met WHO drinking water standards, free from any indicators of fecal contamination, while 13 water points (56.5%) delivered heavily polluted water, showing 3 to 4 indicators of contamination [7].

In this same province, access to drinking water remains limited: only 24.3% of the population has at least a basic drinking water service [8], while a study conducted in the rural health zone of Isiro estimated the prevalence of diarrhea at 14.57% [9]. Despite the scale of this problem and its health consequences, no large-scale program is currently being implemented to address it [10].

Faced with limited access to conventional disinfection products, harnessing the region's natural solar potential appears to be a relevant alternative for mitigating the consequences of consuming unsafe water [5] [11]. Solar water disinfection (SODIS) is precisely a simple and sustainable water treatment method that uses solar radiation (UV-A and thermal effects) to inactivate pathogenic bacteria and viruses present in water [5]. Although effective and inexpensive, this method remains relatively unknown among the Congolese population in general, and in the Haut-Uélé region in particular [11].

It is in this context that the present study was conducted, with the objective of determining the prevalence of diarrhea in the household and the associated factors.

2. Materials and Methods

2.1. Presentation of the Study Environment

This study was conducted in the rural health areas of the health zones (HZs) of Isiro (rural part), Pawa and Wamba, located in the Haut-Uélé province, in the northeast of the Democratic Republic of Congo. These areas are predominantly rural and characterized by limited access to drinking water, sanitation infrastructure and domestic water treatment services.

2.2. Study Population

The study population consisted of residents of households in the three targeted Health Zones.

2.3. Type and Period of Study

This was an analytical cross-sectional study, conducted among households with at least one child under the age of 5 during the period from January 10 to February 5, 2026.

2.4. Sampling Procedure

2.4.1. Calculating the Sample Size

The sample size was calculated using Schwartz's formula for estimating a proportion:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

where n is the sample size, $Z = 1.96$, p is the expected proportion, $q = 1 - p$ and d the precision.

Two local references were used to set the expected prevalence (p): the national prevalence of diarrhea according to the DHS-DRC III 2023-24 (14%) [12]; and the prevalence of diarrhea measured in the rural health zone of Isiro in 2021, twice as high in children under 5 years of age as in all households (14.57% versus 6.54%), and more marked in rural areas than in urban areas ($p < 0.05$) [9].

Using the local prevalence of Haut-Uélé (14.57%), with a precision $d = 5\%$ and a 95% confidence threshold ($Z = 1.96$), the minimum size required was 191 subjects; adding an anticipated non-response rate of 10% (19 subjects), the minimum sample size was 210 children under 5 years of age.

Considering the proportion of the Haut-Uélé population with access to at least one basic water service, estimated at 24.3% [8], and using the same parameters ($Z = 1.96$; $d = 5\%$; anticipated non-response of 10%), the required sample size was 311 households. This sample was distributed among the three health zones proportionally to their population size, in the form of clusters randomly distributed within the targeted health areas. A total of 331 households were ultimately surveyed.

The weighting by health zone was calculated by relating the population of each zone to the cumulative population of the three zones (621,945 inhabitants), *i.e.* 32% for Isiro (rural part), 36% for Pawa and 32% for Wamba, applied to the total sample to obtain respectively 100, 112 and 100 households (*i.e.* 312 households), distributed in 5 villages per health zone.

2.4.2. Sampling Technique

A four-stage probability sampling method was applied: (1) simple random selection of 3 health zones out of the 13 in the Haut-Uélé province; (2) selection of 5 health areas within each of the selected health zones; (3) simple random selection, without replacement, of one village per selected health area; (4) systematic sampling of households within each selected village, after counting the households in the village (N), calculating the sampling interval (k = N/n), simple random selection of a number between 1 and k to identify the first household to be surveyed,

then progressive application of the sampling interval until the required number of households is reached.

2.5. Operational Definition of Variables

Diarrhea: occurrence of at least 3 liquid or semi-liquid stools during a 24-hour period, over a 2-week recall period preceding the survey (WHO and DRC DHS standard definition), reported by the mother or guardian of the child. Of the 331 households surveyed, 560 children under five years of age were identified (average of 1.7 children per household); the analysis of associated factors focuses on the occurrence of diarrhea in the household, across all ages, taken as the unit of analysis, while the prevalence reported at the child level (86/560 = 15.4%) is presented separately.

Safe water storage: a storage was considered safe when the container used was covered (variable observed directly by the investigator) and the water was extracted by flow rather than by direct immersion from a well container, and both of these criteria were observed at home rather than declared by the respondent.

Dependent variable: occurrence of diarrhea in any household member during the 2 weeks preceding the survey (yes/no). Independent variables: sociodemographic characteristics of the household, water supply and storage practices, knowledge of water contamination sources, and exposure to health awareness campaigns.

2.6. Statistical Analysis

The sample description was carried out using proportions for categorical variables, the mean ± standard deviation for quantitative variables with a symmetrical distribution, and the median and interquartile range for quantitative variables with an asymmetrical distribution.

Bivariate associations were tested using Fisher's exact test, which is more appropriate than Pearson's chi-squared test given the expected small sample sizes in some cells. Factors independently associated with diarrhea were then investigated using multivariate binary logistic regression, including variables showing a bivariate association with a p-value < 0.20 (household size, storage duration, safe water management), as well as the water source, selected a priori for its theoretical relevance. Household water treatment was not included in the multivariate model due to an insufficient sample size in the exposed category (n = 14 households), which would have led to instability in the estimates. The overall model fit was assessed using the likelihood ratio test. Analyses were performed with a significance level set at $p < 0.05$.

2.7. Ethical and Administrative Considerations

The protocol was submitted to the Ethics Committee of the University of Kisangani for approval: UNIKIS/CE/KGB/004/07/2025, with authorizations from the Faculty of Medicine and Pharmacy (FMP) No. FMP/324/2025, the Provincial Health Division (DPS), and the relevant Central Health Zone Offices (BCZS). Par-

ticipation was voluntary and subject to verbally obtained informed consent, due to the low literacy rate in rural areas; a witness or, failing that, a fingerprint was used to authenticate this verbal consent. Anonymity and confidentiality of data were guaranteed at all stages of the study. Children exhibiting signs of danger (severe dehydration, severe acute malnutrition) were referred to the nearest health facility.

3. Results

Water-related morbidity in the households surveyed was characterized by a high prevalence of waterborne diseases, reflecting insufficient access to quality drinking water, precarious hygiene conditions and inadequate sanitation practices among the populations concerned.

Children under five are the most affected group by waterborne morbidity due to their immature immune systems, increased susceptibility to enteric pathogens, and frequent exposure to unsanitary environments. This vulnerability is exacerbated by inadequate hygiene practices and limited access to safe drinking water, contributing to a high incidence of diarrheal diseases and other waterborne infections in this age group.

3.1. Characteristics of the Respondents

Table 1. Household characteristics and water management practices (n = 331).

Variable	Modality	Effective	%
Respondent's gender	Male	125	37.8
	Female	206	62.2
Respondent's age (mean ± SD)	36 ± 13.1 years	—	—
Household size (median, p25 - p75)	7 (5 - 10)	—	—
	Normal (≤5 people)	92	27.8
	Large (≥6 people)	239	72.2
Supply source	Improved spring	223	67.4
	Improved well	12	3.6
	Unimproved well	7	2.1
	Undeveloped source	89	26.9
Water source category	Improved	235	71.0
	Not improved	96	29.0
Secure water storage	Yes	214	64.65
	No	117	35.35
Water treatment before consumption	Yes	14	4.2
	No	317	95.8
Water storage time	≤24 hours	120	36.3
	>24 hours	211	63.7

The sociodemographic characteristics of the surveyed households and their water management practices are presented in Table 1. The majority of respondents were women, with a mean age of 36 ± 13.1 years. Although most households used an improved water source and more than half practiced safe storage, only a small proportion reported treating water before consumption. Nearly two-thirds of households stored water for more than 24 hours, a practice that could promote microbiological recontamination.

3.2. Prevalence of Diarrhea

Table 2. Frequency of diarrhea in surveyed households.

Indicator	N	Effective	%
Households that reported at least one case (all ages), 2 weeks.	331	143	43.2
Number of residents in households that have had at least one case of diarrhea	2,528	266	10.5
Number of children under 5 years of age who experienced at least one episode of diarrhea during the two weeks preceding the survey	560	86	15.4

As shown in Table 2, more than two-fifths of households had reported at least one case of diarrhea during the two weeks prior to the study; the overall prevalence of diarrhea was 10.5% and that among children under 5 years of age was 15.4%.

3.3. Factors Associated with Diarrhea in Households

Table 3. Bivariate analysis of factors associated with diarrhea in households (n = 331).

Variable	Modality	Yes n (%)	No n (%)	GOLD	95% CI	p
Household size	Large (≥6)	117 (49.0)	122 (51.0)	2.43	1.41 - 4.27	0.001
	Normal (≤5)	26 (28.3)	66 (71.7)	—	—	—
Storage duration	>24 h	112 (53.1)	99 (46.9)	3.25	1.99 - 5.30	<0.0001
	≤24 h	31 (25.8)	89 (74.2)	—	—	—
Secure water management	No	62 (53.0)	55 (47.0)	—	—	—
	Yes	81 (37.9)	133 (62.1)	0.54	0.34 - 0.85	0.011
Supply source	Improved	108 (46.0)	127 (54.0)	1.48	0.91 - 2.42	0.144
	Not improved	35 (36.5)	61 (63.5)	—	—	—
Water treatment	Yes	6 (42.9)	8 (57.1)	0.99	0.33 - 2.91	1,000
	No	137 (43.2)	180 (56.8)	—	—	—

Note: Fisher's exact test; OR and 95% CI.

As shown in Table 3, water storage duration greater than 24 hours (OR = 3.25; 95% CI: 1.99 - 5.30; $p < 0.0001$) and large household size (OR = 2.43; 95% CI: 1.41 - 4.27; $p = 0.001$) significantly increased the risk of diarrhea in the household, while safe water management was a protective factor (OR = 0.54; 95% CI: 0.34 - 0.85; $p = 0.011$).

Table 4. Factors independently associated with diarrhea in the household by multivariate logistic regression (n = 331).

Variable	Modality	aOR	95% CI	p
Household size	Tall vs. Normal	2.33	1.36 - 4.01	0.002
Storage duration	> 24 h vs ≤ 24 h	3.09	1.86 - 5.13	<0.0001
Secure water management	Yes vs. No	0.63	0.39 - 1.02	0.060
Supply source	Improved vs. Not Improved	1.20	0.71 - 2.03	0.490

The results of the multivariate logistic regression, presented in Table 4, show that large household size (aOR = 2.33; 95% CI: 1.36 - 4.01; p = 0.002) and a storage duration exceeding 24 hours (aOR = 3.09; 95% CI: 1.86 - 5.13; p < 0.0001) remained independently associated with an increased risk of diarrhea, with the latter variable being the strongest associated determinant in the model. The association of safe water management weakened after adjustment (aOR = 0.63; 95% CI: 0.39 - 1.02; p = 0.060), suggesting that part of its apparent protective effect was mediated by storage duration. The water source was not associated with diarrhea in either bivariate analysis or after adjustment (aOR = 1.20; p = 0.490).

4. Discussion

1) Prevalence of diarrhea:

This study highlights a high prevalence of diarrhea in rural households in Haut-Uélé (43.2% of households reporting at least one case; Table 2), significantly higher than national estimates from demographic surveys in the DRC (14%) [12] and some global estimates reported in low- and middle-income countries [13]. This difference suggests significant intra-national heterogeneity, already documented in several African contexts where isolated rural areas exhibit considerably worse health indicators [13] [14].

The prevalence among children under five years of age (15.4%, or 86 out of 560 children identified; Table 2) is consistent with international trends, confirming their increased vulnerability related to immune immaturity, exploratory behaviors, and high environmental exposure [1] [13]. Randomized trials, notably in Bolivia, have also documented a high incidence in this age group before intervention [15], while recent meta-analyses confirm that this age group bears the majority of the global burden of diarrheal disease [13] [14].

One of the most striking results of our study is the very low proportion of households treating water before consumption (4.2%; Table 1). This level is lower than those observed in several studies conducted in Africa and Asia, where the adoption of home water treatment, although variable, remains more widespread [16] [17]. According to Kraemer and Mosler, the adoption of these practices is strongly dependent on behavioral factors, risk perception, and ease of use [11]. Contrary to the evidence from meta-analyses showing a significant reduction in diarrhea with home water treatment [13] [14], our study found no significant association between water treatment and diarrhea (OR = 0.99; p = 1.000; Table 3).

This discrepancy can be explained by several factors: insufficient statistical power due to the small number of households treating water (n = 14), poor adherence to treatment techniques, variability in the quality of their implementation, or measurement biases, as suggested by some critical reviews focused on adherence to interventions [18].

Water storage for more than 24 hours, observed in 63.7% of households (**Table 1**), appears to be the determinant most strongly associated with diarrhea in our sample, both in bivariate analysis (OR = 3.25; 95% CI: 1.99 - 5.30; $p < 0.0001$) and in multivariate analysis after adjustment (aOR = 3.09; 95% CI: 1.86 - 5.13; $p < 0.0001$; **Tables 3-4**). This finding is consistent with numerous studies showing that recontamination at the point of use is a significant source of exposure [16] [18] [19]. Indeed, studies show that initially potable water can become contaminated during prolonged storage due to improper handling [16]. This observation reinforces the idea that the quality of drinking water depends not only on its source but also on the household practices surrounding its use.

Large household size was also associated with an increased risk of diarrhea in our study, both in bivariate analysis (OR = 2.43; $p = 0.001$) and after adjustment (aOR = 2.33; $p = 0.002$; **Tables 3-4**). This is consistent with observations made in several settings where overcrowding, overburdened sanitation infrastructure, and shared water resources increase the transmission of pathogens [13] [14]. However, some studies did not find this association after multivariate adjustment, suggesting that this effect could be mediated by other socioeconomic factors of the household [14].

Safe water management appeared as a significant protective factor in bivariate analysis (OR = 0.54; $p = 0.011$; **Table 3**), which is consistent with the findings of several meta-analyses highlighting the importance of hygienic water storage and safe handling practices [14]. After adjustment, this association weakened and no longer reached the conventional significance threshold (aOR = 0.63; $p = 0.060$; **Table 4**), suggesting that part of this protective effect is mediated by storage duration, with households practicing safe storage also being those that store water for shorter periods. In contrast to some of the literature that attributes a protective role to improved water sources [14], our study found no significant association between source type and diarrhea, either in bivariate analysis (OR = 1.48; $p = 0.144$) or after adjustment (aOR = 1.20; $p = 0.490$; **Tables 3-4**). This discrepancy suggests that contamination occurs primarily after collection, at the household level, as has already been documented elsewhere [16] [19].

The value of point-of-use interventions, particularly solar disinfection (SODIS), is reinforced by our results. Randomized controlled trials have demonstrated its effectiveness in reducing childhood diarrhea [15] [20] [21], and reviews confirm its potential as a low-cost solution [5] [22]. However, some studies report limited or variable effects related to adherence, climatic conditions, and usage practices [11] [17]. This heterogeneity underscores the importance of integrating behavioral and contextual dimensions into SODIS implementation strategies in rural areas.

Furthermore, water quality data in the Isiro health zone show that less than 10%

of the assessed water points meet drinking water standards [7], which corroborates our findings and confirms the high exposure of rural populations in Haut-Uélé. Studies conducted elsewhere in the DRC and internationally similarly show that microbiological contamination of water sources remains a major problem, even in systems classified as "improved" according to international typology [7] [19].

Finally, the contradictions observed in the literature, particularly regarding the effectiveness of household water treatment or the protective role of improved water sources, reflect the multifactorial nature of diarrheal diseases. As Wolf *et al.* point out, isolated interventions have a limited impact if they are not part of an integrated approach combining water, sanitation, and hygiene (WASH) [14].

2) Limitations of the study:

This study has several limitations that should be highlighted. The collection of diarrhea data based on maternal/guardian recall over two weeks exposes participants to memory and social desirability bias. The cross-sectional design does not allow for establishing a causal link between water management practices and the occurrence of diarrhea. Furthermore, the analysis does not account for the effect of the cluster sampling plan (villages), as the sample size per cluster is insufficient for a stable estimate of within-cluster variance; the reported confidence intervals should therefore be interpreted with reasonable caution [23].

5. Conclusion

Diarrhea in households remains highly prevalent in the rural health zones of Haut-Uélé, where domestic water management practices, particularly the duration and security of water storage, are major and modifiable determinants, while household size appears to be an additional vulnerability factor. These findings support the promotion of local, low-cost water treatment approaches, such as solar disinfection (SODIS), combined with health education focusing on safe water storage, as complementary measures for diarrhea prevention in rural areas.

Author Contributions

Albert Wembakoy Okolongo: conceptualization, methodology, investigation, data curation, formal analysis, and writing of the original draft. Zoé-Arthur Kazadi Malumba: writing, review, and editing. Eugène Basandja Longembe: methodology (epidemiological expertise), validation, and supervision. Joris Losimba Likwela: project administration, coordination, and critical review and editing of the manuscript for important intellectual content. All authors read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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