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Prevalence of Diarrhea in Children and Water Management Practices in Rural Households in Tshopo Province, DRC: A Cross-Sectional Analysis

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Summary

Introduction: The objective of this study was to determine the prevalence of diarrhea as well as the conditions of water supply and management in households with a view to preparing a diarrhea control intervention.

Methods: An analytical cross-sectional study was carried out on an exhaustive sample of 237 households from two villages in the Tshopo province of the DRC, during the period from July 16 to 23, 2023. Statistics were performed using Pearson Chi-square, Fisher Exact, t-Student and Wilcoxon Mann Whitney tests, according to their conditions of application.

Results: The prevalence of diarrhoea in children aged 0-59 months was 21% (95% CI: 17%-25%). Unimproved sources (93%) were the main source of water supply. The population was aware of poor water quality (73%), believed that it was possible to treat water (90%) and were in favour of treating it (97%). However, only 3% of the population actually treated it. Storing water in unhygienic containers (43%), storing water on the ground (100%) and keeping it for more than 24 hours (51%) were common practices. All variables of sample characteristics, knowledge and observed practices were not statistically different between the two study villages (p>0.05).

Conclusion: The prevalence of diarrhoea is high in both villages surveyed. The population is aware of the poor quality of source water and is willing to treat this water. Intervention is expected on water treatment and safe management to reduce the high incidence of diarrhoea.

Keywords: diarrhea; water treatment; secure management; Tshopo; DRC

Introduction

Infantile diarrhea remains a health challenge despite national programs and international initiatives driven primarily by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) [1, 2]. It is the second leading cause of death in children under 5 years of age worldwide and is responsible for 525,000 child deaths per year, particularly in rural areas of sub-Saharan

Africa [3].

In sub-Saharan Africa, the prevalence of diarrhea in children was 15.3% [4] and in East Africa [5], it was 14.3%.

In Ethiopia, several recent studies have shown fluctuating results of diarrhea prevalence amongchildren under 5 years old. Natnael T et al. (2021) [6] had found this prevalenceat 11% (95% CI: 7.8-14.3%); Alemu TG et al. (2023) [7] and Mohamed AI et al. (2024) [8] had found higher prevalence respectively 57.3% (95% CI 54.5-60.1%) and 51% (95% CI: 46%-56%).

Coverage of improved water points exceeds 90% in several parts of the world while it remains at 61% in sub-Saharan Africa [9].

Several authors recognize the role played by water in the incidence of diarrhea in children. Indeed, communities with poor access to drinking water have higher prevalences of diarrhea [10].

A systematic review conducted in 2005 concluded that diarrheal episodes were reduced by 39% by treating and properly storing water at home [11].

Diarrhea can be prevented and treated with inexpensive means [12] Diarrhea prevention practices such as proper sanitation, safe water supply and hygiene education are effective health interventions that reduce the risk of diarrhea in children under 5 years of age by 27% to 53% [13].

Untreated drinking water exposes children to diarrhea [14]. Ensuring a good water supply and better sanitation constitute a preventive action, the main effect of which is to reduce the number of diarrhoeal episodes and thereby reduce the number of deaths [15, 16], because 11% of deaths in children under five are due to diarrhea [17].

Meta-analyses of point-of-use water quality improvement interventions conducted in 2018 and 2021 showed a reduction in diarrhea of 61% and 50%, respectively, in children, through water filtration interventions [18, 19].

Analysis of factors associated with diarrhea showed a relationship with water storage practices. Koné B et al. cited the place of storage of drinking water ($p = 0.02$) and the storage container ($p = 0.03$) [20]; Ismail AM et al. (2024) noted that storing water in jerrycans increased the risk of diarrhea approximately 5 times (aOR = 4.90, 95% CI: 1.31-8.39) [8] and for Fenta et al. (2020), the risk of diarrhea increased approximately 9 times with water storage in jerrycans (aOR = 8.6, 95%CI: 1.51-48.84) [21].

In the DRC, data related to access to an improved drinking water source vary according to the studies. According to the 2018 Multiple Indicator Cluster Survey (MICS), 59% of the population used drinking water from improved sources, this proportion was very low in rural areas (33%) [22].

During previous studies conducted in the coverage area of the National School and Village Cleanup Program, the following was noted: 1) the water was heavily contaminated throughout the supply chain, especially during storage for 48 hours or more, as evidenced by the presence of coliforms [23]; 2) the prevalence of diarrhea in children under 5 years was high, estimated at 13% (95% CI: 10%-16%) and was associated with lack of water treatment, use of unimproved toilets and storage of water for more than 24 hours [24]; 3) insufficient water treatment by households (22.6%) [23]; 4) the failure of the sustainability mechanism reflected in the loss of certification status of villages and the failure of village committees [25]; 5) insufficient knowledge of the National Sanitized School and Village Program Healthy School and Village Program (NSSVP) by the population.

The National Sanitized School and Village Program Healthy School and Village Program (NSSVP) is a program of the DRC government that aims to contribute to the reduction of diarrheal and vector-borne diseases by improving drinking water supply coverage and promoting the use of hygienic latrines and hand hygiene [26]. In the absence of a sustainability mechanism, these villages had lost the status of healthy village.

In the context where the NSSVP has shown its limits, this study aims to determine the prevalence of diarrhea as well as the conditions of water supply and management in households, in peri-urban areas of the Tshopo province, in the DRC, to prepare a diarrhea prevention intervention.

Materials and Methods

Study site

The study was conducted in two villages in the Bengamisa Health Zone in Tshopo province, among those integrated into the NSSVP. These are the villages of Bayanguma and Bakpeme.

Type and period of study

Our study was cross-sectional with analytical aims, conducted during the period from July 16 to 23, 2023. This type of study was chosen because it provides valuable information on the characteristics, attitudes and behaviors of a population at a given time; it is inexpensive and quick to carry out, although it does not allow conclusions to be drawn on causality.

Sampling

This was a comprehensive study including all residents of the two targeted villages. After enumeration, the sample size consisted of 237 households composed of 1921 persons including 403 children aged 0 to 59 months.

Inclusion criteria

The choice of these two villages was based on the following criteria: being a village integrated into the PNEVA whose status has been lost, having reported several cases of diarrhea from January to May 2023 in the DHIS2 software platform (District Health Information Software) and having a functional community animation cell (CAC). These two villages had presented the high score.

Operational definition of concepts

1. The "sanitized village" status includes the following criteria [27]:
    - Presence of a dynamic village committee working for the sanitation of the village;
    - At least 80% of the population having access to drinking water;
    - At least 80% of households using hygienic latrines;
    - At least 80% of households disposing of their waste hygienically;
    - At least 60% of the population washing their hands before meals and after using latrines;
    - At least 70% of the population understanding the fecal-oral route of disease transmission;
    - *Villages cleaned at least once a week.*
2. *Community animation unit (CAC):* set of community relays in a village.
3. *Functional community animation unit:* CAC made up of trained members who meet monthly, who organize awareness-raising activities in the village and are active in activities organized by the Health Center in their villages.

Data collection techniques

Data collection was carried out from mothers/guardians of children under 5 years old using a form developed using the Kobo collect software configured on a smartphone, coupled with observation of water supply sources, collection containers and storage conditions, using an observation grid.

Data analysis techniques

The collected data were analyzed using STATA 15 software and a no missing data were observed in relation to the different variables of interest.

The description of the sample was carried out using proportions, mean ± SD and median (p75 - p25) and the Shapiro-Wilk test was used to check the normality of the distribution of quantitative variables.

To ensure the similarity of the socio-demographic context of these two villages to be included in the next intervention study, we used the Pearson Chi-square and Fisher Exact tests for categorical variables, and the t-student and Mann Whitney Wilcoxon tests for quantitative variables, depending on whether the distribution was symmetrical with equal variance or not.

Ethical considerations

We had obtained approval from the ethics committee of the University of Kisangani followed by agreements from the health authorities of the province, the Health Zone and village chiefs, for the conduct of this study. Participation in the study was voluntary after signing informed consent. The anonymity of the information was guaranteed from the collection to the dissemination of the results.

Results

Variables	***Terms and conditions***	***Intervention n (%) N=114***	***Control n (%) N=123***	***Total n (%) N=237***	***P value***
Householder Characteristics					
Sex	Male	2 (3)	4 (3)	6 (3)	0.685^{f}
	Female	111 (97)	119 (97)	220 (97)	
Age	Mean ±SD	41.4 ± 14.6	41.5 ± 12.2	41.4 ±13.5	0.05^{st}
Level of study	None	20 (18)	14 (11)	34 (14)	0.05^{f}
	Primary	41 (36)	50 (41)	91 (38)	
	Secondary	48 (42)	59 (48)	107 (45)	
	Superior	5 (4)	0 (0)	5 (2)	
Number of people	Median (P75 – P25)	7 (10 -5)	6 (10 -5)	7 (10 -5)	0.132^{w}
Number of children 0 to 59 months	Median (min - max)	2 (3 – 1)	1 (2 – 1)	1 (2 – 1)	0.018^{w}

f = Fisher's exact test. *st* = t-student test. *w* = Mann Whitney Wilcoxon test.

Table 1: Socio-demographic characteristics of respondents.

Households had similar characteristics between the two sites, except that the median number of children under 5 years of age was significantly higher in the intervention village compared with the control village.

The vast majority of respondents believed that the water consumed in the village was of poor quality and could be treated. Almost all of the subjects agreed to treat this water.

The majority of subjects cited at least one water treatment technique and the use of purifiers was statistically more frequently cited by subjects from the control village.

With no difference between the two study sites, unimproved sources, consisting of river water and natural springs, were cited by almost all respondents as the main source of drinking water; access to these water points was, for the majority of people, within 30 minutes.

We observed, in about two out of five households, the use of unhygienic storage containers, including buckets without lids, basins, barrels and water bottles without taps. The container-dipping technique was statistically different between the two sites, with predominance in the control village.

Settings	***Terms and conditions***	***Intervention n (%) N=114***	***Control n (%) N=123***	***Set n (%) N=237***	***P value***
Assessment of the quality of water consumed	Good	11 (9)	10 (8)	21 (9)	0.079^{chi2}
	Bad	76 (67)	97 (79)	173 (73)	
	Very bad	27 (24)	16 (13)	43 (18)	
Self-estimation of water treatment possibility	Yes	100 (88)	113 (92)	213 (90)	0.29^{chi2}
	No	14 (12)	10 (8)	24 (10)	
Agrees to treat water	Yes	111 (97)	120 (98)	231 (97)	0.62^{f}
	No	3 (3)	3 (2)	6 (3)	
Water treatment techniques	Boiling	9 (8)	5 (4)	14 (6)	0.221^{chi2}
	Purifying	56 (49)	88 (72)	142 (60)	0.001^{chi2}
	SODIS No answers	1 (1) 48 (42)	4 (3) 9 (7)	5 (2) 76 (32)	0.2^{f}

Chi2 = Pearson chi-square test. *f* = Fisher's exact test.

Table 2: Assessment of water quality and knowledge of water treatment.

Settings	***Terms and conditions***	***Intervention n (%) N=114***	***Control n (%) N=123***	***Set n (%) N=237***	***P value***
Main sources	Not improved	105 (92)	116 (94)	221 (93)	0.499^{chi2}
	Improved	9 (8)	7 (6)	16 (7)	
Water access time	≤ 30 minutes	103 (90)	102 (83)	205 (86)	0.095^{chi2}
	> 30 minutes	11 (10)	21 (17)	32 (14)	

Chi2 = Pearson Chi-square.

Table 3: Water supply sources.

With no difference between the two sites, the stored water was mainly used for drinking and cooking, it was almost stored on the ground. About half of the households stored water for more than 24 hours.

The average amount of stored water intended for consumption as drinking water was 33 ± 1.8 liters.

Regardless of the village category, almost all households did not treat water at home. The use of water purifiers was the only technique used by the five households that treated water. The difference in reasons for not treating water was statistically significant for lack of energy source (control village) and ignorance of the importance of water treatment (intervention village).

At least one case of diarrhoea was recorded in about one in two households. The overall prevalence of diarrhoea was similar between the two villages, being about twice as high among children under 5 years of age as among the general population in the households.

Settings	*Terms and conditions*	*Intervention n (%) N=114*	*Control n (%) N=123*	*Total n (%) N=237*	*P value*
Types of containers	Hygienic containers (canister, containers with lid)	68 (60)	68 (55)	136 (57)	0.497^{chi2}
	Unhygienic containers	46 (40)	55 (45)	101 (43)	
Water sampling techniques	Flow	77 (84)	103 (89)	180 (87)	0.285^{chi2}
	Container dive	55 (60)	86 (74)	141 (68)	0.028^{chi2}
Use of stored water	Beverage	88 (96)	111 (96)	199 (96)	1.00^{chi2}
	Kitchen	83 (90)	106 (91)	189 (91)	0.812^{chi2}
	Laundry	27 (29)	43 (37)	70 (34)	0.301^{chi2}
	Dishes	24 (26)	20 (17)	44 (21)	0.128^{chi2}
Storage location	On the ground	89 (97)	116 (100)	205 (99)	0.085^{chi2}
Storage duration	24 hours	42 (46)	60 (52)	102 (49)	0.384^{chi2}
	> 24 hours	50 (54)	56 (48)	106 (51)	
Total quantity stored	Mean ± SD	76 ± 5.3	83 ± 7.6	80 ± 4.8	0.47^{st}
Quantity stored drinking water	Mean ± SD	37 ± 3.2	30.4 ± 1.97	33 ± 1.8	0.07^{st}

chi2 = Chi-square test. *st* = Student t-test.

Table 4: Water storage and management conditions in households.

Settings	*Terms and conditions*	*Intervention n (%) N=114*	*Control n (%) N=123*	*Set n (%) N=237*	*P value*
Treats water	Yes	5 (4)	3 (2)	8 (3)	*0.48^{f}*
	No	109 (96)	120 (98)	229 (97)	
		N=109	N=120	N=229	
Reason for not treating water	Lack of purifier	96 (88)	101 (84)	197 (86)	*0.001^{chi2}*
	Energy source	0 (0)	12 (10)	12 (5)	
	Ignorance	13 (12)	7 (6)	20 (9)	

f = Fisher's exact test. *chi2* = Pearson chi-square test.

Table 5: Home water treatment.

Settings	*Intervention N=114*	*Control N=123*	*Together N=237*	
Number of people in households	984	937	1921	
Number of children aged 0 to 59 months	221	182	403	
Number of cases of diarrhea in the 2 weeks preceding the survey	108	112	220	
Number of cases of childhood diarrhea in the 2 weeks preceding the survey	55	31	86	
	Intervention % (95% CI)	*Control % (95% CI)*	*Together % (95% CI)*	*p value*
Overall prevalence in the 2 weeks preceding the survey	11% (9% - 13%)	12% (10% - 14%)	11% (9% - 13%)	0.86^{chi2}

Prevalence among children in the 2 weeks preceding the survey	25% (19% - 31%)	17% (12% - 23%)	21% (17% - 25%)	0.16^{chi2}
Number of households with at least one case of diarrhea in the 2 weeks preceding the survey	50 (43.9%) (35% - 53%)	69 (56%) (47% - 65%)	119 (50%) (44% - 56%)	0.06^{chi2}

Chi2 = Pearson chi-square test.

Table 6: Frequency of diarrhea in households.

Discussion

Water supply sources

The results of this study showed, without difference between the two study sites, that unimproved sources, consisting of river water and natural springs, were the main source of water supply (Table 3). For the majority of respondents, the quality of this water was "poor" contrasting with their positive attitude in favor of water treatment (Table 2).

Population coverage with access to basic water services is on average low in developing countries and varies from one region to another.

In sub-Saharan Africa, in 2023, the percentage of children living in households that had access to basic water services was 58.15% (95% CI = 57.51-58.8) [19]. In Central Africa, this average coverage was 47.4% (95% CI = 45.1-49.6) but the DRC had the lowest coverage (33.9% 95% CI = 29.7-38.6) in the region while Cameroon had the highest coverage (62.21%, 95% CI = 58.77-65.5) [19]. In West Africa this coverage was 64.9% (95% CI = 63.9-65.5) [28].

In Eastern Africa, just over half of children had access to basic water services (52%, 95% CI = 51.1-52.9), with a minimum of 36.3% (95% CI: 33.4-39.3) in Madagascar and a maximum of 78.5% (95% CI: 74.0-82.5) in Comoros [19]. In Southern Africa, Lesotho, Namibia and South Africa had 71.84% (95% CI: 67.92-75.45), 76.56% (95% CI: 74.08-78.86), and 89.47% (95% CI: 87.08-91.46) of children living in households, respectively, compared to a sub-regional average of 79.4% [28].

Furthermore, in sub-Saharan Africa, 9.3% (95% CI = 8.95-91.46) of children living in households used surface water for drinking [19]. The use of surface water for drinking was frequently reported in other African countries. By subregion, Angola in Central Africa (18.5%, 95% CI = 16.2-21.1), Sierra Leone in West Africa (20.5%, 95% CI = 17.8-23.4), Madagascar in East Africa (26.5%, 95% CI = 23.4-29.7) and Namibia in Southern Africa (5.2%, 95% CI = 3.8-7.2) were the main countries where children living in households used surface water for drinking [28].

A study conducted in Cameroon found that 32.3% of households had no access to improved water services, 55.5% had basic access, 9.0% had intermediate access and only 3.0% had optimal access. The proportion of the population using unimproved water sources is much lower than that observed in our study [29].

Surface water or water from an unimproved source is more likely to be contaminated with pathogens and contribute to diarrhoeal morbidity and mortality in children under 5 years of age [30]. In addition, studies had also found a significant relationship between the level of access to water and mortality of children under five [31, 32].

Certainly, the current recourse of the population of our study to unimproved water sources, following the failure of the sustainability mechanism of the National Sanitized School and Village Program (NSSVP), exposes them to diarrheal diseases. This situation is perceived by the population itself as a need and interventions aimed at improving water quality are expected. The water supply situation is poor in the area of our study. Nevertheless, in the presence of poor quality water, certain interventions had proven effective in reducing the risk of diarrheal diseases, in particular water filtration and safe management (use of containers with lids and hygienic water collection) which had reduced the prevalence of diarrhea by 61% [19].

Water storage

Unhygienic storage and handling of water, i.e. use of uncovered containers, inadequate hygienic cleaning of storage containers, water collection by diving containers and storing water for more than 24 hours were common practices among the majority of our respondents (Table 4). In Ethiopia, jerrycan/can with lid was the most used storage container (92.5%) with the most frequent cleaning frequency being once a week (64.3%), which is a less hygienic practice [33].

The risk of water contamination is high if the storage equipment is not covered, which increases the risk of diarrhoea. A significant association was observed between diarrhoea in children under five years of age and the habit of not covering the drinking water storage equipment. Children living in households where water was stored without a cover were 2.35 times more likely to contract diarrhoea than their counterparts [33].

In Mauritania, water storage for an average of 48 hours was associated with household water contamination and diarrhea [20]. In Cameroon, deterioration of water quality was observed during transportation and home storage, regardless of the storage equipment used [34].

In the Tshopo Province of the DRC, during a study conducted in the area of the National School and Sanitized Village Program, investigators found that 76% of households stored water for 48 hours or more and this storage duration was associated with water contamination [23].

According to the observations of Miriac et al in Benin, unhygienic water handling was considered as bad human practices, it contributed to the degradation of water quality and was the cause of waterborne diseases [35]. Since water storage at home is a step with a high risk of water contamination, safe water management at home must involve the use of water storage containers with lids, water collection using a tap, daily cleaning of hands and containers and reduction of the water storage period to 24 hours.

Water treatment

Water treatment is very poorly carried out due to lack of water purifier and almost all were favorable to start treating water (Table 5).

Water treatment is a practice that reduces the prevalence of diarrhea by 39% [11] but it is very little practiced in a context of high exposure to water contamination. In Cameroon [36], in Mauritania [37] and in India [38], 15% of households treat water; on the other hand, in South Kivu [39] and in Senegal, households did not treat water [40].

Water treatment with chemicals is the best known and most widely used method. Among households in Mauritania that treated their water, 86% used bleach and no household used solar disinfection [37]. During the recent study conducted in the DRC (2018), 94% of households did not treat water and no household used solar disinfection [22].

Treated water must be managed safely to avoid the risk of recontamination. In a study conducted in Zambia [41], water chlorination and safe management reduced diarrhea by 48%, making safe water management a mandatory complementary intervention to maintain the effectiveness of water chlorination.

Prevalence of diarrhea

Our study found that in about 50% of households, at least one case of diarrhea was recorded in the two weeks preceding our survey; the overall prevalence of diarrhea was 11% and about twice as high among children aged 0 to 59 months (Table 6).

Several authors recognize the role played by unsafe water in the incidence of diarrhea in children. Indeed, Azage et al (2016) observed in Ethiopia that communities with poor access to drinking water had higher prevalence of diarrhea [10], which corroborates the high frequency of diarrhea observed in our study.

Recent publications have shown that diarrhea continues to be a major public health problem especially in low-income countries with high prevalences in children aged 0-59 months, comparable to those found in our study or even higher.

In Ethiopia, another study found the prevalence of diarrhea to be 25.5% in children under 5 years old, which was linked to the quality of water source, types of latrines and quality of waste management [42].

In India, this prevalence was 21.6% [43]; in the North East of Ethiopia, it was respectively 23.1% (CI95%: 19.4%-26.5%) in 2019 [44] and 17.6% in 2021 [45] and, in Northwestern Ethiopia, at 20.8% (CI95%: 16.8-37.8) [46] In Ivory Coast, on the other hand, the prevalence of diarrhea in children under 5 years old was higher (33.3%) [47].

The province of Tshopo, being in the similar socio-economic context of these different countries, must promote alternative interventions with proven effectiveness for reducing the risk of diarrheal diseases, including water filtration and safe management which had reduced the prevalence of diarrhea by 61% [19].

The use of covered containers with taps, 24-hour storage time, hygienic handling and water treatment can help communities reduce household diarrhea cases, in the context of large quantities of water that is generally of poor quality.

This is in line with the WHO report which showed that effective and consistent application of household water treatment and safe storage can reduce diarrhoeal diseases by 28% to 45%, depending on the type of water supply [33].

Conclusion

This study showed the significant magnitude of diarrhea in both villages and the need for intervention. The population is aware of the poor quality of source water, they consider themselves capable of treating water at home and are willing to do so. However, the practice of water treatment is not in place in both villages. Future research will consist of an intervention study of water treatment and safe management through the use of standardized containers and community awareness to assess the effects on reducing diarrhea.

Perspectives

Therefore, the proposed intervention in this community in terms of "continuous treatment and hygienic management of water" for the control of diarrheal diseases is justified, accepted and feasible. Thus, the water chlorination method will be used because it is better known and adapted to the local context and the resources available in rural areas. Also, the two villages selected for the future study are comparable on almost all the variables of interest retained: attitude and perception of the quality of the water consumed judged to be "bad"; acceptance of water treatment; use of unimproved sources for the supply of water intended for consumption; less hygienic conditions of storage and handling of water at home; overall prevalence of diarrhea and that among children aged under 5 years high. These villages can be included in a study, one as an intervention village and the other as a control village.

The proposed intervention will consist of the distribution of plastic buckets with lids and taps. To all intervention village households for hygienic storage and collection of water, the supply of water purifiers chlorine-based for six months, systematic water treatment, promotion of hand and container hygiene and reduction of the storage time of treated water to 24 hours.

Limit of the study

The cross-sectional design of the study, the reliance on self-reported data and the lack of control over potential confounding variables constitute limitations for our study. Despite the complexity of factors that may influence the prevalence of diarrhea, a multivariate analysis to control for confounding factors and provide information on independent predictors was not performed and will be part of subsequent secondary analyses.

Conflicts of interest

None.

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