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Association Between Current Household Water Quality Practices and Incidences of Diarrhea Quasi -Experimental Study in Lac vert and Mugunga – DRC

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Abstract: Access to safe drinking water remains a critical public health challenge in low-resource and conflict-affected settings. This study evaluated the effect of household hygiene training on water quality and the reduction of diarrhea incidences among households in Goma Town, Democratic Republic of Congo, this study determined the household water hygiene practices for drinking water in Lac Vert and Mugunga. identify the association between current household water quality practices and incidences of diarrhea in Lac Vert and Mugunga.

A quasi-experimental design was applied in two zones: Lac Vert (intervention) and Mugunga (control). Data were collected in two phases before and after the intervention using structured questionnaires, and microbiological water analysis. A total of 360 households participated, and data were analyzed using descriptive and inferential statistics at a 95% confidence level. Before the intervention, most households in both zones exhibited poor hygiene practices, including unsafe water storage (p =0.033), irregular cleaning of containers (p =0.147), and minimal water treatment (p =0.005). Laboratory analyses revealed high levels of total coliforms and *Escherichia coli* in drinking water (p = 0.001), with Mugunga showing the highest contamination. Following the hygiene training intervention in Lac Vert, significant behavioral improvements were observed households increasingly treated water through boiling and filtration (p = 0.001), used covered containers, and practiced regular handwashing with soap (p =0.001). Correspondingly, the microbiological quality of water improved markedly, with a 99.9% reduction in bacterial load (Log Reduction Value = 3.0). Diarrheal incidence among children under five decreased substantially in Lac Vert during Phase II (p < 0.001), while Mugunga recorded no improvement. The study concludes that structured, participatory household hygiene training is effective in improving domestic water hygiene practices, enhancing microbiological water quality, and reducing diarrheal morbidity. It recommends the institutionalization of hygiene training within community health programs and the National Health Development Plan coupled with routine water quality monitoring and continuous behavioral reinforcement. The findings contribute new evidence from a fragile urban context, affirming that safe water and reduced disease burden depend not only on infrastructure but also on consistent and informed household practices.

Keywords: *Effect, Household, Water, Quality, Incidences, Diarrhea.*

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I. INTRODUCTION

Diarrheal diseases remain a major global public health challenge despite significant progress in water, sanitation, and hygiene (WASH) interventions. The World Health Organization (WHO, 2023) estimates that 1.6 million people die annually due to diarrheal diseases, making it the eighth leading cause of death globally and the fifth leading cause of death among children under five years. Most of these deaths are preventable through improved access to safe drinking water, adequate sanitation, and effective hygiene practices (WHO & UNICEF, 2023). Diarrhea results primarily from ingesting contaminated food or water and remains strongly linked to poor environmental sanitation, unsafe water sources, and inadequate hygiene behaviors. Globally, 2.2 billion people still lack safely managed drinking water services, and 3.5 billion lack safely managed sanitation (UNICEF & WHO, 2023). Microbial contamination of water mainly fecal in origin is the greatest threat to water safety, transmitting pathogens that cause cholera, dysentery, typhoid, polio, and viral gastroenteritis (WHO, 2023). An estimated 4.5 billion diarrheal episodes annually, with over 485,000 deaths directly attributed to unsafe drinking water (GBD, 2019). Climate change, rapid urbanization, and population growth have exacerbated global water stress, with over 2 billion people living in water-scarce countries as of 2022 (UN-Water, 2023). In Sub-Saharan Africa, the burden remains disproportionately high, with nearly half of global diarrheal deaths occurring in the region (UNICEF, 2023). Unsafe water, poor sanitation, and lack of hygiene account for about 70% of diarrheal morbidity and mortality (WHO, 2023). It was said that only 28% of African households have access to safely managed drinking water, while more than 67% lack basic handwashing facilities (AMCOW, 2022). These conditions are compounded by weak governance, rapid urbanization, population displacement, and recurrent cholera outbreaks. The Dakar Declaration (2022), A Blue Deal for Water Security and Sanitation for Peace and Development, affirmed Africa's collective commitment to universal access to water and sanitation as a foundation for human health, stability, and development (AMCOW, 2022).

The Democratic Republic of Congo (DRC) represents one of the most affected nations in Sub-Saharan Africa. According to the Minister of public health hygiene and prevention (MSPHP, 2023), diarrheal diseases remain among the top five causes of morbidity and mortality, accounting for over 11% of under-five deaths. Despite abundant freshwater resources, over 40% of the population relies on unimproved water sources, while nearly half lack access to basic sanitation (UNICEF JMP, 2022). Water contamination is widespread due to open defecation, poor waste management, and inadequate infrastructure maintenance. The Multiple Indicator Cluster Survey (MICS, 2018) reported that 68.4% of the North Kivu population had access to water sources, but only a small fraction met WHO safety standards, with 31.6% relying on unprotected springs. (MICS, 2018)

The situation in Goma Town, particularly in Lac Vert and Mugunga, is aggravated by rapid urbanization, poverty, and prolonged armed conflict, which have displaced thousands of families into overcrowded settlements. In 2022, approximately 34.000 displaced families lived in makeshift shelters lacking basic water and sanitation facilities (OCHA, 2022; Frédéric Joli, 2022).Many households depend on shallow wells and lake water, often shared by humans and animals, or on irregular humanitarian water trucking services (UN-Habitat, 2021) .Even where piped water is available, contamination frequently occurs during collection, storage, and handwashing at home due to the use of uncovered jerry cans, cooking pots, or plastic containers, which are rarely disinfected (Mercy Corps, 2022).

The populations most affected by diarrheal diseases in Goma Town, particularly in Lac Vert and Mugunga, comprise children under five, women, and low-income or displaced households living in overcrowded informal settlements. These communities experience multiple, interrelated vulnerabilities arising from poverty, inadequate water infrastructure, and poor sanitation, which expose them to recurrent waterborne infections. Most households depend on unsafe and untreated water sources, including shallow wells, lakes, and unprotected springs, which are often contaminated by runoff and open defecation (UNICEF & WHO, 2023; OCHA, 2022). Collected water is frequently stored in uncovered or unclean plastic jerry cans and cooking pots, leading to secondary contamination during transportation and storage (Mercy Corps, 2022). Women, as primary caregivers and water handlers, are responsible for collecting, storing, and preparing water, yet they often lack the economic means, soap, or knowledge required to maintain safe hygiene practices (UNICEF, 2022). WHO, (2023); MSPHP, (2023). Declared that Children under five remain the most biologically vulnerable, experiencing high rates of dehydration, malnutrition, and stunting associated with recurrent diarrhea (WHO, 2023; MSPHP, 2023). MSPHP, (2023).

II. METHODOLOGY

➢ *Study Design Approach and Setting*

This study adopted a quasi-experimental design with quantitative analytical methods, conducted in two peri-urban neighborhoods of Goma Town Lac Vert (intervention site) and Mugunga (control site). The design was chosen to assess the effect of household hygiene training on water quality and diarrheal incidence, allowing comparison of pre- and post-intervention outcomes between the two groups under real-world conditions. A quasi-experimental design was appropriate because it enabled evaluation of causal relationships between hygiene training and health outcomes where randomization was not feasible due to ethical and logistical constraints inherent in community-based settings (Sakpal, 2010; Shadish, Cook & Campbell, 2002). The approach facilitated measurement of changes in household hygiene practices, microbiological water quality, and diarrheal incidence following structured hygiene training, while controlling for socio-demographic variables.

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- *Study Population and Sampling*

- *Sample Size Determination*

- ✓ Number of households = Population/6
- ✓ Household survey = Household x Household size/Average household
- ✓ No survey = Household/Household to be surveyed

n = D x [(Zα +Zβ) ^{2} x P1(1-P1) +P2(1-P2) / (P2-P1)^2

P1=P2x OR /1+P2(OR-1)   Q1 = 1-P1, Q2= 1-P2

According to Robert Magnani in Sampling Guide in 2001, in quasi experimental study the power being the probability of rejecting the absence of effect when it exists, it is usually greater than 80%. When Power =80%, Zα=1.96, Zβ=0.84 this is the risk of not detecting a difference which nevertheless exists n = minimum sample size required per survey series or comparison group.
D = design effect (in the following equations this is assumed to be the implicit value of 2 (twice from household surveys and laboratory analyses)

P1 = the estimated level of an indicator measured as a proportion at the time of the first survey and laboratory analysis for the control area.

P2 designates the proportion of the target population having declared adopting the behavior during the second visit 30% Zα = the Z-score corresponding to the degree of confidence one wishes to have in concluding that an observed change in size (P2 - P1) would not have occurred by chance (α level of statistical significance)

Zβ = the Z-score corresponding to the desired degree of confidence.

P1=80%=0.8, P2=30%=0.3, OR=2, D=2

P1=P2x OR /1+P2(OR-1) = 0.3x2/1+0.3(2-1) =0.46; 1-P1= 1-0.46=0.54;

P2(1-P2) =0.30(1-30) =0.30x0.70; (P2-P1)^2 means 0.3-0.46
Q1 = 1-P1 Q2= 1-P2

n = D x[(Zα +Zβ) ^{2} x P1(1-P1) +P2(1-P2) / (P2-P1)^2

P1=P2x OR /1+P2(OR-1) Q1 = 1-P1 Q2= 1-P2

The sample size in the case will be n= [(1.96+0.84) ^{2} X (0.46x0.54) +(0.30x0.70) = 180

(0.30-0.46)^2

n=180

n=180 per site

n=180 per site (Lac Vert=180; Mugunga=180), total 360 per time; we had 360 in zero time and in end time

- *Data Collection Methods*

During data collection, the survey questionnaire and experimentation were used. A structured questionnaire was the principal instrument used for collecting quantitative data on household water hygiene practices, storage behaviors, and reported diarrheal episodes. The questionnaire was designed based on previous WASH (Water, Sanitation, and Hygiene) studies and adapted to the local context to ensure cultural and linguistic appropriateness (WHO, 2023; UNICEF, 2020). It consisted of both closed-ended and open-ended questions to capture factual information and allow for clarification of respondent perspectives where necessary. The questionnaire was administered face-to-face to household heads or primary caregivers by a team of ten trained research assistants under the supervision of the principal investigator. Field administration allowed for the observation of environmental and behavioral aspects that would not have been apparent through self-administered surveys or online formats. To ensure comprehension, the questionnaire originally developed in French was translated into Swahili, the local language widely spoken in Goma, and back-translated to ensure consistency of meaning. Pretesting was conducted among a small sample in a neighboring community to validate clarity, relevance, and reliability of items before full deployment. This approach enhanced data accuracy, minimized interviewer bias, and facilitated effective communication with respondents of varying literacy levels.

- *Data Analysis*

Data were analysed using SPSS Version 20.A total of 360 households participated, Chi-square tests (χ^2) and odds ratios (OR) with 95% confidence intervals (CI) were used to identify the association between current household water quality practices and incidences of diarrhea in Lac Vert and Mugunga.

- *Ethical Considerations*

This study was conducted in accordance with national and international ethical standards governing research involving human participants, guided by the Declaration of Helsinki (2013), the WHO (2022) Ethical Standards for Human Research, and the ethical principles of autonomy, beneficence, non-maleficence, and justice. The research adhered to the ethical guidelines of the Great Lakes University of Kisumu Scientific and Ethical Review Committee (GLUSERC), the National Commission for Science, Technology, and Innovation (NACOSTI), and the local administrative authorities in Goma City.

III. RESULTS

- *Protection of Drinking Water Containers*

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Table 1 Distribution of Respondents According to the Protection of Drinking Water Containers in the Two Zones During the Zero Time

Protection containers	**Intervention zone**		**Control zone**	
	Lac vert		**Lac vert**	
	Zero time	**End time**	**Zero time**	**End time**
Capsule	45 (24.9%)	63(35.5%)	46 (25.7%)	43(23.9%)
Lid	128 (71.0%)	100(55.6%)	123 (68.6%)	136 (75.6%)
Without cover	3 (1.8%)	17(9.4%)	0 (0.0%)	1 (0.6%)
Metal and cap	4 (2.4%)		10 (5.7%)	
	Chi-square = 5.57, p = 0.134		*Chi-square* = 85.46, df = 1, p= 0.001	

The results showed that the use of capsule-sealed containers was higher in the intervention area (Lac Vert) at 63(35.5%) compared to 43(23.9%) in the control area (Mugunga). Conversely, respondents in the control area were more likely to use lids (75.6%) than those in the intervention area 100(55.6%), suggesting slightly better adherence to recommended storage practices in Mugunga. However, a small but notable proportion of respondents in Lac Vert 17(9.4%) reported storing water in uncovered containers, compared to only 1(0.6%) in Mugunga.

➢ *Frequency of Cases of Diarrhea*

Table 2 Distribution of Respondents According to the Existence of Cases of Diarrhea in the Two Zones During the Two Times

Frequency	**Intervention zone**		**Control zone**	
	Lac vert		**Lac vert**	
	zero time	**End time**	**zero time**	**End time**
0-once a mounth	93(51.6 %)	87(48.4 %)	93(51.7 %)	55(48.3 %)
1-3times a mounth	69(38.4 %)	56(31.0 %)	62(34.4 %)	83(90.5 %)
More than 3 times	18(10.0 %)	37(20.6 %)	25(13.9 %)	42(100 %)
Total	180(100 %)	180(100%)	180(100 %)	180(100 %)
	Chi-square=18.67, df=2, p=0.001		Chi-square=56.58, df=2, p)0.001	

The proportion of households reporting diarrhea once a month declined slightly from 96(51.6%) in Zero time to 87(48.4%) in end time, while those experiencing three or more episodes remained relatively low (increasing from 18(10.0%) to 37(20.6%). Conversely, Mugunga recorded a noticeable rise in diarrheal cases during the same period, with respondents reporting one to three monthly episodes increasing from 62(34.4%) to 46.1%, and frequent episodes (more than three times per month) rising from 29(13.9%) to 23.3%.The chi-square test confirmed statistically significant associations between diarrheal frequency and location (χ^2 = 18.67, p = 0.001 for Lac Vert; χ^2 = 56.58, p = 0.001 for Mugunga) demonstrating that the hygiene training intervention in Lac Vert contributed to a relative reduction in diarrheal occurrences compared to the control zone.

IV. DISCUSSION

It was noted that in zero time the capsules were used more in the control area (Mugunga) at 46(25.7%) than in the intervention area (Lac Vert) at 45(24.9%). It is also noted that respondents in the intervention area use lids more at 128(71%) than those in the control area (Mugunga) at 123(68.6%). This table also reveals that 3(1.8%) do not cover their water storage containers at home in the intervention area compared to 0(0.0%) in the control area, which is Mugunga. Metal and caps were used more in the control area at 10(5.7%) (Mugunga) than in the intervention area, which is Lac Vert at 4(2.4%) in zero time. The findings showed that the use of capsule-sealed containers was higher in the intervention area (Lac Vert) at 63(35.5%) compared to 43(23.9%) in the control area (Mugunga). Conversely, respondents in the control area were more likely to use lids (75.6%) than those in the intervention area 100(55.6%), suggesting slightly better adherence to recommended storage practices in Mugunga. However, a small but notable proportion of respondents in Lac Vert 17(9.4%) reported storing water in uncovered containers, compared to only 1(0.6%) in Mugunga. The findings of this investigation are consistent with those of Esperance Olive Hounsounou, who showed that 68.9% of household water storage containers were not covered (Esperance Olive Hounsounou, 2017). The findings of this research are similar to those of Julie Ghislaine Sackou Kouakou *et al.,* who revealed that 65.1% stored water at home and, hygienically, 5.9% of these containers were found to be uncovered (Julie Ghislaine Sackou Kouakou *et al.,* 2010). The findings of this study are matching to those of Misenga Tshimanga Henriette *et al.,* who stated that 6% of the population stored their drinking water in an uncovered bucket (Misenga Tshimanga Henriette *et al.,* 2022). Legesse *et al.* (2021) in Ethiopia and Omari et al. (2021) in Kenya also established strong associations between uncovered containers, absence of handwashing facilities, and higher prevalence of diarrheal disease. The present study confirms these findings in the specific context of Goma, showing that water stored in unclean or uncovered containers and handled with unwashed hands serves as a vector for enteric pathogens leading to recurrent diarrheal infections. The significant decline in diarrhea following improved hygiene behavior in

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Lac Vert further supports the established causal relationship between water handling practices and disease transmission.

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V. CONCLUSION

This study aimed to evaluate the effect of household hygiene training on water quality and its role in reducing incidences of diarrhea among households in Goma Town, focusing on Lac Vert and Mugunga. The research sought to determine household water hygiene practices, assess the microbiological quality of drinking water, identify the association between household practices and diarrheal incidence, and evaluate the effectiveness of training interventions in promoting safe water hygiene behaviors. The sample size was 360 households, for the total population estimated at 63492 in Lac vert and Mugunga. A survey questionnaire be used to collect data from respondents. Collected data be processed with the SPSS software version 20 and analysed using the Chi-square test. At the end of our research, it was noted that:

- The training intervention also encouraged households to reduce practices that exposed water to recontamination, such as dipping cups or hands into storage containers.
- Laboratory analysis showed a significant decline in bacterial contamination, with total coliform and *E. coli* counts decreasing to within acceptable limits in most samples in end time.
- The implementation of structured hygiene training led to a marked reduction in diarrheal disease.

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