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Effectiveness of Training on the Implementation of Standard Domestic Water Hygiene Practices on Incidences of Diarrhea 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 effectiveness of training on the implementation of standard domestic water hygiene practices in reducing 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 (Madhulipika Giri *et al.,* 2022; 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.

➢ *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.

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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[$(Z\alpha + Z\beta)^2$ 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

Table 1 Behavioral Outcomes before and after Hygiene Training (Intervention vs. Control Zone)

Hygiene Behavior	Zone	Zero time (%)	End time (%)	χ^2	p-value
Use of covered containers	Lac Vert	42.1	83.7	18.24	<.001
	Mugunga	39.6	44.1	0.53	0.47
Regular handwashing at critical times	Lac Vert	38.2	79.6	21.77	<0.001
	Mugunga	40.0	41.5	0.09	0.76
Household water treatment	Lac Vert	28.4	75.0	17.12	0.002
	Mugunga	29.8	34.2	0.45	0.51

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➢ *Behavioral Outcomes*

The hygiene training produced substantial behavioral improvements in the intervention area. Households in Lac Vert reported a statistically significant rise in safe-water behaviors. The proportion using covered containers nearly doubled from 42.1% to 83.7% (χ^2 = 18.24, p < 0.001), while regular handwashing at critical moments increased from 38.2% to 79.6% (χ^2 = 21.77, p < .001). Adoption of water-treatment methods such as boiling and chlorination also improved markedly from 28.4% to 75.0% (χ^2 = 17.12, p = .002).In contrast, the control zone (Mugunga) exhibited only minor, statistically insignificant changes (p > 0.05). These results confirm that behavioral gains were directly attributable to the training.

Table 2 Comparison of Microbiological Water Quality (CFU/100 mL) Pre- and Post-Intervention

Zone	Zero time (Mean ± SD)	End time (Mean ± SD)	% Reduction	t(df)	p-value
Lac Vert (Intervention)	210 (45.2)	12 (8.3)	94.3%	9.12(58)	<0.001
Mugunga (Control)	205 (43.5)	192 (40.1)	6.3%	0.87(54)	0.39

Water-quality analyses further demonstrated the effectiveness of the intervention Table 4.30).In Lac Vert, mean total coliform counts dropped sharply from 210 ± 45.2 CFU/100 mL in zero time to 12 ± 8.3 CFU/100 mL in end time , a 94.3% reduction that was statistically significant (t (58) = 9.12, p < .001). In Mugunga, however, bacterial counts remained largely unchanged (t (54) = 0.87, p = .39). By Phase II, 85% of Lac Vert samples met the WHO guideline of < 10 CFU/100 mL, compared to only 6.7% at baseline, underscoring substantial microbiological improvement.

Table 3 Reported Diarrhea Cases Among Under-Five Children Pre- and Post-Intervention

Zone	Zero time (%)	End time (%)	Change (%)	χ^2	p-value
Lac Vert (Intervention)	46.3	13.2	-33.1	27.44	<.001
Mugunga (Control)	44.1	39.8	-4.3	1.12	0.29

Health impacts mirrored the behavioral and microbiological improvements Table 3.

The proportion of households reporting at least one under-five diarrhea case in the prior two weeks declined from 46.3% to 13.2% in Lac Vert (χ^2 = 27.44, p < 0.001). The reduction of 33 percentage points represents a 71% decline in diarrhea incidence following the hygiene intervention. In Mugunga, the change was negligible (44.1% to 39.8%, p = .29). This pattern reinforces that improved hygiene behaviors were effective in reducing child morbidity.

Table 4 Composite Effectiveness Index for Hygiene Training Intervention

Indicator Category	Lac Vert Improvement (%)	Mugunga Improvement (%)	Mean Difference	t(df)	p-value
Behavioral Indicators	73.4	14.2	59.2	6.82(112)	<0.001
Microbiological Quality	88.9	9.6	79.3	8.04(112)	<0.001
Child Diarrhea Reduction	70.6	10.2	60.4	7.11(112)	<0.001
Overall Effectiveness Index	78.6	11.4	67.2	7.31(112)	<0.001

To capture the overall training impact, a composite index combining behavioral, microbiological, and health indicators was calculated (Table 4.32). The intervention zone achieved an overall improvement of 78.6%, compared to 11.4% in the control zone. The mean difference of 67.2 percentage points was statistically significant (*t* (112) = 7.31, p < 0.001. This integrated measure confirms that the hygiene training intervention had a strong, multidimensional effect on household health and sanitation practices.

IV. DISCUSSION

The fourth objective of this study was to evaluate the effectiveness of hygiene training on the implementation of standard domestic water hygiene practices in reducing incidences of diarrhea in Lac Vert (intervention zone) and Mugunga (control zone). The proportion using covered containers nearly doubled from 42.1% to 83.7% ,regular handwashing at critical moments increased from 38.2% to 79.6% and Adoption of water-treatment methods such as boiling and chlorination also improved markedly from 28.4% to 75.0% . In Lac Vert, mean total coliform counts dropped sharply from 210 ± 45.2 CFU/100 mL in zero time to 12 ± 8.3

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CFU/100 mL in end time , a 94.3% reduction that was statistically significant ($t(58) = 9.12$, $p < .001$). End time, 85% of Lac Vert samples met the WHO guideline of < 10 CFU/100 mL, compared to only 6.7% at baseline, underscoring substantial microbiological improvement. The proportion of households reporting at least one under-five diarrhea case in the prior two weeks declined from 46.3% to 13.2% in Lac Vert . This pattern reinforces that improved hygiene behaviors were effective in reducing child morbidity. To capture the overall training impact, a composite index combining behavioral, microbiological, and health indicators was calculated . The intervention zone achieved an overall improvement of 78.6%. The effectiveness of the hygiene training observed in this study aligns with extensive global and regional evidence emphasizing the value of behavior change interventions in WASH programs. The World Health Organization (2023) and UNICEF (2023) advocate for community-based hygiene education as a key component in achieving sustainable water safety and disease prevention. Studies by Freeman *et al.* (2022) and Atalay *et al*. (2024) have similarly shown that structured hygiene training significantly improves water storage, treatment, and handling practices, leading to measurable declines in diarrhea prevalence. In a meta-analysis conducted by Wolf *et al.* (2018), hygiene education was associated with a 30% reduction in diarrhea risk, while hygiene promotion combined with water treatment achieved reductions of up to 42%. The findings of the present study corroborate these results and further demonstrate that in fragile and low-resource urban settings such as Goma, hygiene training can achieve even greater impacts when the approach is practical, participatory, and reinforced through follow-up visits. This success stands in contrast to large-scale interventions such as the WASH Benefits and SHINE trials in Bangladesh, Kenya, and Zimbabwe (Luby *et al*., 2018; Null *et al*., 2018; Humphrey *et al*., 2019), which reported limited reductions in diarrheal disease despite infrastructure improvements. The difference lies in the depth of engagement: whereas large trials relied on standardized messages delivered to dispersed populations, this study's training was contextually adapted, interactive, and community-driven, allowing households to internalize and sustain behavioral change.

The findings also provide evidence that effective hygiene training must go beyond information dissemination to include motivation, demonstration, and consistent supervision. In Lac Vert, the use of community health volunteers to conduct follow-ups and reinforce messages contributed significantly to behavioral retention and accountability. These results are consistent with observations by Ejemot-Nwadiaro *et al.* (2021), who found that hygiene education programs with household-level reinforcement yielded greater reductions in diarrhea than those relying solely on public campaigns. Furthermore, the marked difference between the intervention and control areas underscores the principle that knowledge alone is insufficient; behavior change must be continuously supported within the social and environmental context of the household. The results also demonstrate the interdependence between water quality improvement and health outcomes. The microbiological analysis discussed earlier revealed that bacterial contamination decreased substantially in Lac Vert after training, corresponding with the decline in diarrheal cases. This relationship highlights the biological plausibility of the observed health improvements, validating that behavior-driven interventions can translate into measurable microbiological and epidemiological outcomes. The integrated impact of improved water treatment, safer storage, and enhanced hand hygiene collectively reduced exposure to fecal pathogens, thereby breaking the transmission chain of diarrheal disease. This finding is supported by earlier work by Fewtrell and Bartram (2021), who established that integrated hygiene interventions addressing multiple contamination pathways are more effective than single-focus interventions. The new knowledge generated by this study lies in its empirical demonstration that community-based hygiene training, when tailored to local conditions and reinforced through household-level supervision, can produce simultaneous improvements in both behavioral and health outcomes within a relatively short period even in fragile, conflict-affected urban settings. Unlike most previous studies in Sub-Saharan Africa that evaluated either behavioral change or microbiological outcomes in isolation, this research established a clear causal link between training, behavior modification, microbial reduction, and decreased diarrheal incidence. The study's integration of behavioral assessment with laboratory verification of water quality represents a methodological advancement in WASH evaluation, providing a holistic framework for understanding how education translates into tangible health benefits. Furthermore, by achieving near-complete compliance and measurable reductions in diarrheal disease without major infrastructural investment, the study contributes new evidence supporting the cost-effectiveness of behavior-centered approaches. This knowledge is particularly valuable for policymakers and practitioners working in humanitarian or post-conflict environments, where resources for infrastructure are limited but the burden of disease remains high. The model developed and validated through this study can therefore serve as a practical blueprint for scaling up low-cost, behavior-driven public health interventions in similar contexts across the Democratic Republic of Congo and other developing regions. The implications of these findings for public health practice and policy are substantial. From a practice perspective, the results underscore the necessity of incorporating hygiene training into routine community health programs, particularly those targeting maternal and child health. Community health workers should be capacitated to deliver regular, participatory training sessions, monitor household practices, and provide ongoing feedback to sustain behavioral gains. Integrating hygiene education into school curricula and community outreach activities can further reinforce early learning and intergenerational transmission of healthy habits. From a policy standpoint, the study supports the inclusion of structured hygiene training and monitoring mechanisms within the Democratic Republic of Congo's National Health Development Plan (PNDS 2021–2025) and municipal WASH frameworks. Coordination between the Ministry of Health, REGIDESO, and humanitarian partners such as UNICEF, Oxfam, and Mercy Corps will be essential to institutionalize these practices. Policies promoting the distribution of affordable hygiene kits including soap, chlorine, and safe

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storage containers can strengthen behavior change sustainability. These findings also have broader relevance for the attainment of Sustainable Development Goals (SDGs), particularly Goal 3 on Good Health and Well-being and Goal 6 on Clean Water and Sanitation. The evidence from Lac Vert illustrates that achieving these global targets requires a dual focus: expanding access to clean water infrastructure and embedding long-term behavioral transformation strategies. By reducing diarrheal incidence through knowledge-based, community-led interventions, the study demonstrates that behavioral empowerment can be as impactful as infrastructural development in safeguarding public health. It also highlights the potential for scaling such low-cost models in other regions of the DRC and beyond, offering a sustainable pathway toward universal water safety and disease prevention.

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 evaluate the effectiveness of training on the implementation of standard domestic water hygiene practices on incidences of diarrhea in Lac Vert and Mugunga.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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