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Low Supply of Clean and Safe Water and Community Households' Health in the Democratic Republic of Congo: A Case of Refugees' Camps in Nyiragongo District

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Abstract

The study was conducted in Nyiragongo District, located in the eastern Democratic Republic of Congo, where the 2021 volcanic eruption severely damaged water infrastructure, leaving many households with limited access to clean and safe water. The situation was further worsened by population influx due to regional conflicts. The study aimed to analyze the impact of existing one-point water sources, water treatment methods, accessibility to safe water, and community knowledge on household health within Nyiragongo refugee camps. Guided by the Aquatic Ape and Community-Based Health Care theories, the research adopted a mixed-method approach combining quantitative (semi-structured questionnaires) and qualitative (focus group discussions) techniques within a descriptive cross-sectional design. Using Yamane's formula (1967), data were analyzed in SPSS version 27 through descriptive and inferential statistics, including Fisher's exact test. Results revealed that 75% of households relied on tanks and rainwater, while 88% reported cholera, and 13% typhoid and diarrhea cases. Despite 88% having knowledge of safe water practices, application was limited due to resource constraints. A significant relationship existed between most variables except water accessibility ($p = 0.543$). The study concluded that inadequate water infrastructure and poor treatment practices endangered community health and recommended increasing water tanks, treatment support, and awareness campaigns.

Keywords: Biological Treatment, Chemical Treatment, Clean and safe water, Community Household, Environmental Degradation, Mechanical Treatment, Physical Treatment

1 Introduction

In many vulnerable communities worldwide, the shortage of clean and safe water remains one of the most pressing yet silent public health challenges. This crisis exposes millions to preventable diseases such as cholera, diarrhea, and typhoid. Globally, access to safe water continues to be a critical challenge, especially in developing nations where waterborne diseases persist. Reports from 2006 indicated that countries including Botswana, China, Fiji, Kuwait, Australia, Liberia, Pakistan, the United States, the Philippines, South Africa, Uganda, Malawi, the United Arab Emirates, and Canada faced significant water shortages, adversely affecting socio-economic development. The United Nations estimated that around four billion people suffer from diarrheal diseases annually, with approximately two million deaths linked to poor water quality and limited supply (United Nations, 2007). Water scarcity is not solely a result of climate change but also inadequate water infrastructure and mismanagement by governments. Rapid population growth further escalates water demand in industrial, agricultural, and domestic sectors.

In the Horn of Africa, countries such as Ethiopia, Djibouti, Eritrea, Somalia, and Kenya have endured recurring droughts that severely reduced water supply. In Djibouti, the depletion of groundwater, the sole water source, has left many residents vulnerable. Similarly, uneven rainfall distribution in Eritrea and Ethiopia's prolonged droughts have intensified water stress. Kenya and Somalia have faced alternating droughts and floods, exacerbating conflicts and rising water prices. UNICEF (2021) reported that 8.5 million people in the Horn of Africa—half of them children such as experience water scarcity, increasing vulnerability to diseases like cholera, typhoid, and hepatitis A.

Despite contributing minimally to global greenhouse gas emissions, Africa remains disproportionately affected by climate change. The Organization for Economic Cooperation and Development (OECD, 2023) noted that over 30 African countries face severe water shortages, with nations such as Mozambique, Zimbabwe, Niger, Malawi, and South Sudan ranked among the most water-stressed. Approximately 387 million Africans lack access to basic drinking water services, while 737 million lack adequate sanitation, resulting in recurrent outbreaks of waterborne diseases. In the Democratic Republic of Congo (DRC), despite vast freshwater resources, access to clean water remains limited. Only 52% of the population has access to safe drinking water, and 29% to basic sanitation (USAID, 2017). In Nyiragongo District, the 2021 volcanic eruption destroyed four major water tanks, compounding the crisis. The influx of 23,581 refugees from Rutshuru in 2022 further strained water resources, with 12% of residents lacking access to water and 79% reporting insufficient quantities (UNIRR, 2022).

1.1 Statement of the Problem

Despite the Democratic Republic of Congo's abundance of water resources, communities in Nyiragongo District continue to face severe challenges in accessing clean and safe water, largely due to the 2021 volcanic eruption that destroyed vital water infrastructure. The situation worsened in 2022 following the arrival of thousands of refugees fleeing conflict from neighboring areas, increasing pressure on limited water sources. This scarcity has led to poor hygiene and a surge in waterborne diseases such as cholera and typhoid. Between January and March 2023, Goma and surrounding districts recorded 6,224 cholera cases (OCHA, 2023). However, no prior study has specifically examined how inadequate clean water supply affects the health of refugees in Nyiragongo, prompting this research to explore the underlying determinants and impacts.

1.2 Research Objectives

i. To analyze the impact of the prevalence of existing one-point water sources on community households' health in Nyiragongo refugees 'camps.
ii. To evaluate the impact of water treatment methods on community households 'health in the Nyiragongo refugees 'camps.
iii. To analyze the impact of accessibility to clean and safe water on community households' health in Nyiragongo refugees 'camps.
iv. To assess the impact of knowledge related to clean and safe water on community households' health in Nyiragongo refugees 'camps.

2 Literature Review

2.1 Empirical Literature

2.1.1 Low Supply of Clean and Safe Water

Access to clean and safe water remains a significant challenge in many developing regions, particularly in rural and vulnerable communities. Limited infrastructure, rapid population growth, and environmental degradation contribute substantially to low water supply and contamination. Studies indicate that inadequate access to clean water negatively affects public health, education, and economic productivity, especially among vulnerable populations such as refugees and low-income households (WHO, 2023). When water supply infrastructure is insufficient or poorly maintained, communities are often forced to rely on unsafe sources, increasing exposure to waterborne diseases such as cholera and diarrhea. Addressing low water supply requires not only infrastructure investment but also sustainable, community-based water management strategies (WHO, 2023). Women and

children are disproportionately affected, as they spend considerable time fetching water from distant and unreliable sources, which reduces their opportunities for education and income-generating activities. Furthermore, insufficient water supply often leads to poor hygiene practices, contributing to the spread of infectious diseases. Integrating water supply programs with community awareness and behavioral-change interventions is therefore essential to ensure sustainable access and use (UNICEF, 2022).

2.1.2 Community Households Health

Community household health is a critical aspect of public health, encompassing the well-being of families within specific environments. Access to fundamental services such as clean water, sanitation, nutrition, and healthcare is essential to disease prevention and the promotion of sustainable health outcomes. Studies have shown that improving household health reduces disease burden while enhancing education, productivity, and community resilience (WHO, 2023).Poverty, inadequate infrastructure, and poor hygiene practices remain significant barriers to optimal household health in low-income areas. Environmental and socio-economic conditions, particularly in vulnerable communities affected by displacement or poverty, strongly influence household health. Inadequate housing, limited access to safe water, and poor waste management systems increase the risk of both communicable and chronic diseases. Research emphasizes that empowering communities through education, participatory health programs, and improved access to basic services can significantly strengthen household health outcomes. Sustainable improvements require integrated approaches that address both immediate health needs and long-term determinants of well-being (UN-Habitat, 2023).

2.1.3 The Impact of the Prevalence of Existing One-Point Water Sources on Community Households' Health

Although water covers seventy percent of the Earth's surface, only one percent is freshwater suitable for domestic, industrial, and agricultural use. Surface water sources—including rivers, streams, lakes, and reservoirs—are the most accessible but are also highly vulnerable to contamination. Water is essential for sanitation and health, yet untreated water may carry microbial and chemical contaminants that pose severe health risks. For example, in 1993, 403,000 people in Milwaukee, Wisconsin, fell ill due to microbial contamination in drinking water (National Academies, 2008). Chemical pollutants from pharmaceuticals, pesticides, herbicides, and industrial activities further threaten water safety. Water sources include rainwater, surface water, and groundwater. Rainwater results from the evaporation of lakes, rivers, and oceans, which then condenses into clouds and returns as precipitation. Groundwater, stored in aquifers, may contain naturally occurring chemicals such as fluoride, arsenic, and iron, which can affect human health if concentrations are excessive (Water Aid, 2017). Human activities, including pesticide use, fertilizers, and improper waste disposal, also contribute to water contamination (US EPA, 1991). Groundwater can be accessed through deep tube wells, hand pumps, springs, dug wells, and shallow tube wells, while surface water is easily collected but highly susceptible to contamination. Artificial recharge is sometimes employed to store surplus water underground for future use (Washington State Department of Health, 2021). Indicators such as the water stress index, criticality ratio, International Water Management Institute index, and water poverty index measure water scarcity. For instance, per capita water use below 1,700 m^3 annually indicates water stress, below 1,000 m^3 indicates water shortage, and below 500 m^3 signals severe scarcity (White, 2012). Globally, countries have adopted diverse measures to address low water supply. In Western Australia, desalination plants and inter-regional water transfers were implemented to meet growing demand (University of Western Australia, 2014). In India, heavy groundwater use, particularly in agriculture, has led to water depletion and contamination, affecting public health (NCERT, 2015). In Kenya and Rwanda, population growth, contaminated water, poor water management, climate change, floods, and droughts have contributed to low water supply, leading to annual child mortality from diarrhea and other waterborne diseases (Kianna, 2014; Lotus, 2019). Studies further show that women and children bear the brunt of water collection duties, often traveling long distances to unsafe sources, which impacts education and household productivity (Marshall, 2011; Brighton, 2014).

2.1.4 The Impact of Water Treatment Methods on Community Households' Health

Many individuals judge water safety solely based on clarity, overlooking invisible biological and chemical contaminants such as bacteria, viruses, protozoa, fluoride, arsenic, and iron. Unsafe water consumption is linked

to approximately 1.9 million deaths annually (WHO, 2013). Water treatment methods can be classified into mechanical, chemical, biological, and physical treatments (US EPA, 2004). Mechanical treatment removes insoluble materials such as plastics and debris. Chemical treatment, used mainly in centralized water treatment facilities, includes coagulation, flocculation, ion exchange, and disinfection (Ferruccio & Paolo, 2024). Coagulation removes fine particles, while flocculation aggregates them for filtration. Ion exchange eliminates ionic contaminants, and disinfection—often used at the household level—kills pathogens using chlorine or boiling. Physical treatment, including sedimentation and filtration, separates solid particles from water (Sarma & Dixit, 2023). Biological treatment employs microorganisms to degrade contaminants and is often applied in plant-based systems, such as desalination plants in Western Australia (Sarma & Dixit, 2023).

2.1.5 The Impact of Accessibility to Clean and Safe Water on Community Households' Health

Globally, 2.2 billion people face a shortage of clean water, and 3.5 million struggle with inadequate sanitation. Water scarcity adversely affects health, education, and economic participation, particularly for women and children, who often spend long hours collecting water (World Affairs Council of Philadelphia, 2023). In rural Tanzania, surveys from 2005 to 2016 show that most households travel up to an hour to collect water, limiting time for education and productivity (Sauti Za Wananchi, 2016). Similar challenges were reported in Meru District, Kenya, where residents traveled 720–8,000 meters to access water (Sambo, 2014). In Ethiopia, water scarcity negatively affected children's growth and school performance (Staneva, Muhammed & Fabrizio, 2021; Mohammed, Zungu & Hoque, 2011). Ghana faces challenges in achieving SDG 6 due to poor water resource management, with many rural households relying on unsafe streams and rivers (Mensah et al., 2023). In India, women often travel 500 meters to collect water, with only 12% practicing chlorination (Venkatesh, Srivastava & Tiwari, 2016). In Kenya, rural populations rely on surface water, often unsafe and distant from homes, contributing to exposure to waterborne diseases (Twaweza, 2024). In Nigeria, many households travel over 500 meters to access water, with limited availability of safe sources (Arikpo, Hosea & Inah, 2019). In Zimbabwe, rural villages reported water provision as low as 9.3 liters per capita per day during dry seasons, with long distances traveled for collection (Manyanhaire, Offat & Kamuzungu, 2009).

2.1.6 The Impact of Knowledge Related to Clean and Safe Water on Community Households' Health

Knowledge about safe water encompasses awareness, perceptions, and practices regarding water use (Gumucio, 2011). Studies across Zaria (Nigeria), rural Bangladesh, Malaysia, India, Pakistan, Nepal, and South Africa reveal that knowledge influences water treatment practices and health outcomes. In Zaria, most households treated water using chlorine, alum, or boiling, indicating high awareness of safe water practices (Handan et al., 2023). In Bangladesh, villages exposed to Brac Wash interventions demonstrated significantly higher knowledge and practices for safe water management than control villages (Fisher et al., 2011). In Malaysia, 40–76% of the rural population showed average knowledge and awareness of water hygiene, with boiling being the common treatment method (Rahim, Sham & Haliza, 2022). In rural India, despite high awareness, 45% did not treat water due to perceived safety (Anjana, 2015). In Pakistan, knowledge among high school teachers was moderate, with half able to define safe water and identify waterborne diseases (Gul, Butt & Muhammad, 2021). In Nepal, 86.5% of urban and 74.5% of rural students had sufficient knowledge of waterborne diseases, though rural awareness lagged (Vaidya, Naresh & Kumar, 2018). In South Africa, students displayed favorable knowledge but inadequate application due to poor sanitation infrastructure (Sibiya & Gumbo, 2013).

2.2 Theoretical Framework

2.2.1 Aquatic Ape Theory

The Aquatic Ape Theory, proposed by Alister Hardy in 1960, posits that certain human traits—such as bipedalism and reduced body hair—developed due to ancestral interactions with aquatic environments, including rivers, lakes, and oceans. The theory suggests that living near water contributed to human evolution and differentiated humans from other primates (Morgan, 2017). Although widely debated and rejected by many anthropologists, the theory highlights the critical role of water in human survival. Its relevance to this study lies in its implication that limited access to water adversely affects human health, increasing vulnerability to water-related diseases such as cholera,

diarrhea, typhoid, and hepatitis A. In modern contexts, particularly in refugee settings like Nyiragongo District, insufficient clean water not only restricts daily needs but also exacerbates disease risks, threatening life and well-being. Understanding this theory underscores the importance of government and community responsiveness to water scarcity, emphasizing water as a fundamental human requirement.

2.2.2 Community-Based Health Care Theory

Developed through the Alma-Ata Declaration (1978) by WHO and UNICEF, the Community-Based Health Care Theory emphasizes that communities should actively participate in managing their health rather than solely relying on external interventions. It advocates empowering households with knowledge, preventive care, and resources—such as chlorine or alum for water treatment—to address health challenges independently (WHO, 2021). This theory is relevant to this study as it highlights the influence of household behaviors on health, encouraging local education on water storage, treatment, hygiene, and sanitation, particularly in resource-limited and vulnerable areas.

2.3 Conceptual Framework

Most studies have shown that the low supply of clean and safe water affects community households' health through factors such as the availability of water sources, the water treatment methods used before consumption, and the accessibility to clean and safe water. However, there was a need to explore how knowledge related to clean and safe water also impacted the health of community households in the refugee camps in Nyiragongo district.

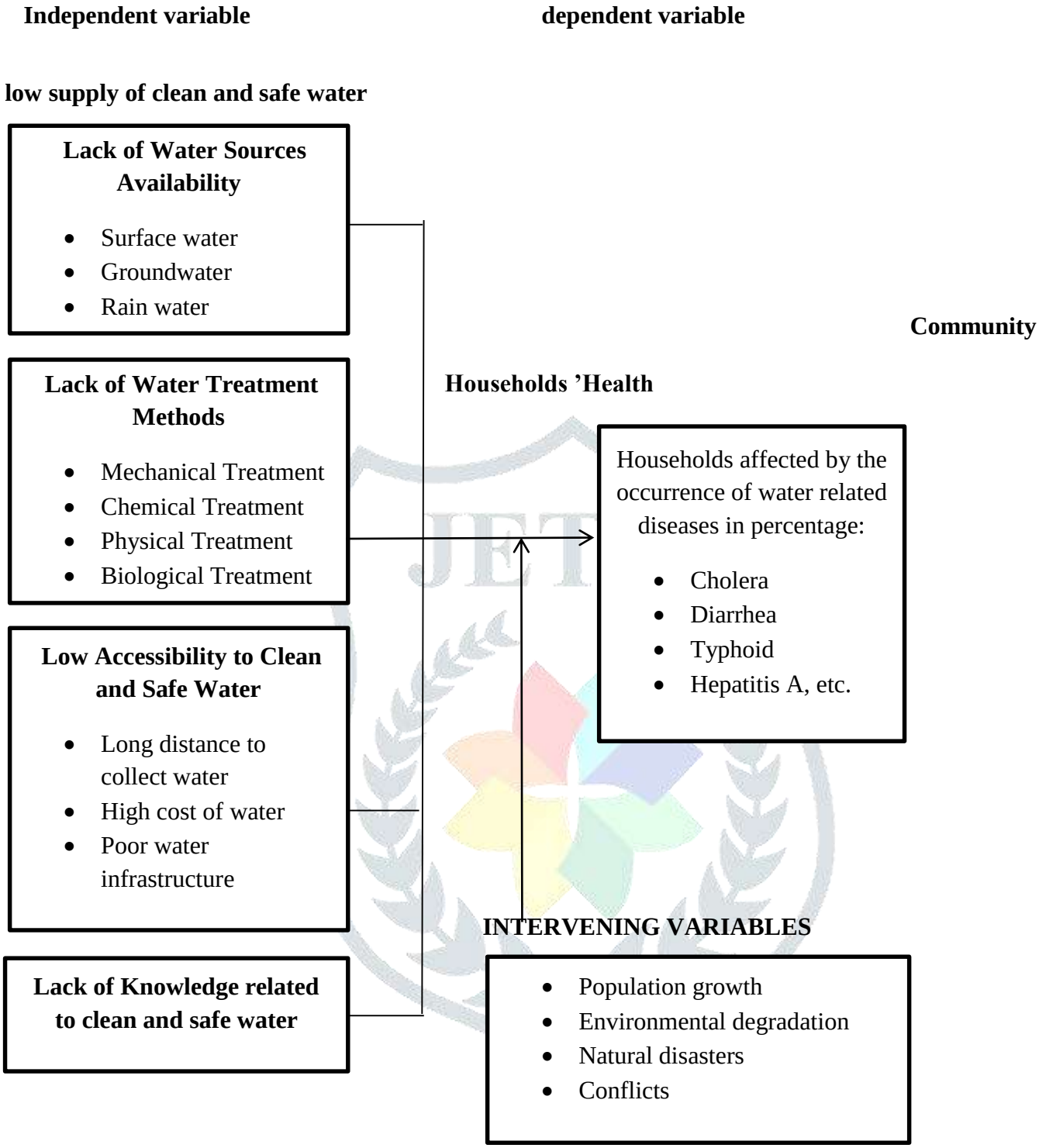

Figure 1 ***Conceptual framework source*** **(Researcher, 2025)**

The conceptual framework illustrates the relationship between variables including independent, dependent and intervening variables of the study. It demonstrates how the lack of availability of water resources, lack of water treatment methods, the low accessibility to clean and safe water and lack of knowledge related to clean and safe water negatively affect community households 'health by the occurrence of waterborne diseases including cholera diarrhea, typhoid, hepatitis A, etc. Furthermore, in case the dependent variable is not significantly influenced by the independent variables outlined, the population growth, the environmental degradation, natural disasters and conflicts, as an intervening variable may still have a direct effect.

2.4 Research Gap Identification

The literature review highlighted how limited and contaminated water sources, poor water treatment, long distances, high costs, and inadequate infrastructure negatively affect health globally. It also revealed that many

people lack sufficient knowledge about clean and safe water, increasing vulnerability to water-related diseases. While numerous studies have examined the impact of low water supply on general populations, there is limited research focusing specifically on refugees, who are among the most vulnerable groups. This gap motivated the present study to investigate key factors influencing access to clean and safe water among refugees in Nyiragongo District, including one-point water sources, treatment methods, accessibility, and community knowledge, with the aim of proposing practical solutions to improve their health outcomes.

3.Research Methodology and Design

3.1 Research Methodology

Research methodology refers to the systematic plan and procedures that guide how a researcher collects, analyzes, and interprets data. It encompasses the tools, techniques, and strategies used to address a research problem in a structured and logical manner, ensuring validity, reliability, and ethical compliance (Creswell & Creswell, 2023). This study explored the impact of low supply of clean and safe water on community households' health in refugee camps in Nyiragongo District, Eastern Democratic Republic of Congo. To achieve the study objectives, both qualitative and quantitative approaches were employed. The semi-structured questionnaire was used to collect quantitative data from refugee household representatives, enabling measurement of the extent of limited water supply and its statistical relationship with household health through descriptive statistics and Fisher's exact test. Open-ended questions were included to allow respondents to provide personal insights privately. Complementing this, focus group discussions captured qualitative data, highlighting lived experiences, challenges, and perceptions regarding limited access to clean water. The combination of these approaches enhanced the study's depth, credibility, and validity by providing both measurable evidence and in-depth understanding.

3.2 Research Design

A research design provides a structured framework for achieving study objectives (Liu, 2015). This study adopted a descriptive and cross-sectional research design. The descriptive design allowed systematic documentation of water supply conditions and household health among refugees at the time of data collection. The cross-sectional design facilitated data collection at a single point in time, assessing the current state of water access and its immediate impact on health without following participants longitudinally. Additionally, a triangulation approach was used to enhance validity by corroborating quantitative and qualitative findings.

3.3 Location of the Study

The study was conducted in Nyiragongo District, North Kivu Province, Eastern Democratic Republic of Congo. Located north of Goma city and near the Rwandan border, the district is characterized by Mount Nyiragongo, an active volcano whose eruptions have historically destroyed water infrastructure. The district was selected due to its high vulnerability to water scarcity, compounded by the influx of refugees, making residents particularly susceptible to water-related health issues.

3.4 Target Population and Sampling

The target population included three groups: 23,581 refugees who migrated to Nyiragongo in 2022, two water supply officers, and two health experts. The primary focus was on refugees, as they were directly affected by the destruction of public water tanks during the 2021 volcanic eruption. A purposive sampling technique was used to select participants with relevant experience regarding water scarcity. The sample size was calculated using Yamane's (1967) formula:
n=N1+N(e), where N=23,581 and e=0.05e = 0.05e=0.05, yielding a sample of 394 refugees. Considering an average household size of seven, 56 households were surveyed across seven camps—Buhumba, Rusayo, Muja, Monigi, Kibumba, Kibati, and Buvira—each represented by eight households. Water and health officers were purposively selected for qualitative insights.

3.5 Data Collection Instruments

Two instruments were used: a semi-structured questionnaire for quantitative data and a focus group discussion guide for qualitative data. The questionnaire included closed- and open-ended questions to capture both measurable responses and personal opinions. Focus group discussions involved groups of four refugees per camp, supplemented by separate discussions with water and health officers, providing deeper insight into challenges, coping mechanisms, and perceptions regarding water access and health outcomes. A pilot study with ten respondents in Monigi camp tested clarity, relevance, and reliability of the instruments. Feedback led to refinement of questions to improve comprehension and eliminate ambiguities. Validity and reliability were further confirmed by two academic research experts prior to main data collection.

3.6 Data Collection Methods and Procedures

The researcher obtained permission from local authorities and formally introduced the study to camp management. Data were collected face-to-face to ensure clarity. Participation was voluntary, and confidentiality was strictly maintained. Questionnaires were administered to household representatives, while focus group discussions captured detailed qualitative insights.

3.7 Data Analysis Techniques

Quantitative data were analyzed using SPSS Version 27. Editing and coding ensured accuracy and facilitated statistical analysis. Descriptive statistics (frequencies, percentages, cross-tabulations) summarized data, while Fisher's exact test was used for inferential analysis due to the small sample size. Qualitative data underwent thematic analysis, identifying patterns and key insights. Triangulation of findings strengthened the validity and comprehensiveness of the study.

3.8 Ethical Considerations

Ethical approval was obtained from Mount Kenya University Ethics Committee, with additional permission from local authorities. Participants provided informed consent after being fully briefed on study objectives, procedures, and voluntary participation. Confidentiality and anonymity were maintained using a coding system, and no personal identifiers were recorded. Data were securely stored in both hard and encrypted soft copies, accessible only to the researcher, in compliance with Rwanda's data protection law (No. 058/2021). The researcher ensured respect, privacy, and autonomy throughout the study, and Turnitin verification confirmed a 14% similarity index.

4.Results

The response rate in the present study was 100%. The researcher ensured that the 56 questionnaires are distributed to the selected 56 refugee households migrated in 2022 in Nyiragongo district. Consequently, the 56 questionnaires distributed were also returned and properly filled, resulting in a 100% response rate. A 100% response rate was considered highly satisfactory and enhanced the reliability of the research findings.

4.1 The Impact of the Prevalence of existing one-point Water Sources on Community Households' Health in Nyiragongo Refugees 'Camps

To address this objective, the researcher first identified the main water sources used for households' consumption in the refugee camps over the past three years. The study then examined whether those same sources were still in use at the time of data collection. Additionally, the researcher assessed the perceived adequacy of the water supply by households, focusing on both the water sufficiency and the quantity of water used per person for daily needs. Lastly, the study analyzed the relationship between the quantity of water used per person on a daily basis and the frequency of waterborne diseases, particularly cholera, reported in the past three years to determine the possible health impacts associated with limited water sources in the refugees 'camps in Nyiragongo district.

Table 1 ***Households' Use of Tanks as Current and Past Main Water Source***

		Past main source			
		Agree	Not sure	Disagree	Total
Current main source	Agree				42 75%
	Not sure				5 9%
	Disagree				9 16%
	Total	42 75%	5 9%	9 16%	56 100%

Source: The Resarcher, 2025

Table 1 presents the comparative analysis of the use of tanks as current and past households 'water source in Nyiragongo refugee 'camps. The rows represent the current main source of water and the columns represent the past main source, presenting both the frequency and the percentage of households who participated. The table demonstrates that 75% of households agreed that in the past three years, they have been collecting water from tanks, 16% disagreed and 9% were not sure. It also illustrates that 75% of households also agreed that they were collecting water from tanks during the time of data collection, with 16% who disagreed and 9% who were not sure. The majority agreed that in the past as well as in the present they were still collecting water from tanks, this shows that there has been no change in terms of water sources in Nyiragongo refugees' camps in the past three years. During the focus group discussion, the majority of respondents confirmed that tanks are refilled by water trucks and this requires financial resources before collecting water, reason why they do not prefer to collect water from tanks when there is rainfall, they also confirmed that they are often assisted by NGOs in water supply. The ones who disagreed confirmed that they rely on rainfall and lake as their main sources of water collection due to lack of funds.

One respondent from Buvira camp said: *''In case there is no rainfall, we usually start to question ourselves about meeting the households' needs, the water collected from tanks is not collected in a big quantity since it requires enough money. When there is rainfall, then we thank God for saving us''.* Another from Muja camp explained: ''*My financial situation does not afford me to collect water from tanks. When the rain does not fall, I just take my jerrycans along with my children and go to fetch water to the kivu lake, although it is very far''.*

The main sources of water in Nyiragongo district were tanks and rainwater, which were used by the majority of the population. This was certainly different from studies reviewed by the researcher in the literature. In western Australia and India, the main sources of water were groundwater and surface water. In most of the study reviewed, the common water sources used were groundwater and surface water rather than rainwater as discovered in Nyiragongo district.

Table 2 ***Perception on Water Sufficiency and Quantity of Water used per Person***

		Water quantity			
		High	Low	Very low	Total
Water sufficiency	Not sure				2
					3%
	Disagree				19
					34%
	Strongly disagree				35
					63%
	Total	2	11	43	56
		3%	20%	77%	100%

Source: The Resarcher, 2025

Table 2 presents the comparative analysis of households' perception on the water sufficiency and the quantity of water used per person on a daily basis. The rows represent the households 'perception on the water sufficiency and the columns represent the quantity of water use per person every day, presenting both the frequency and percentage of households who participated. The table demonstrates that 63% of households' strongly disagreed that the water collected is sufficient for all their household needs, 34% disagreed and 3% stated that they are not sure. Based on the quantity of water used every day, the table illustrates that 77% of households confirmed that the quantity of water used per person in their households is very low, 20% stated that it is low and 3% confirmed that is high. The majority of respondent understood that the water they were collecting everyday was not covering all their needs, to confirm this, they even rated the quantity of water used every day per person as ''very low''. During the focus group discussion, the majority of respondents confirmed that after having collected water, water is prioritized for the Kitchen needs before thinking on any other need, and the majority said that each person uses less than five liters per day.

One participant from Monigi camp stated: *'I have eight children to take care of in terms of washing their clothes, washing them, cooking for them, hygiene and so on, but when it comes to collect water, on a daily basis I may only have 40 liters of water, I have time to use enough water at least when the rain falls''.*

Another from Kibati camp said: *''There is no way to get the quantity of water that will cover all the needs when i realize that i need to buy it in a high price. We just struggle to not miss at least 20 liters a day to help us cook, which is very necessary, and then wait for rainfall to meet the remaining needs''.*

Table 3 ***Water Quantity and Cholera as the most Frequent Disease Three Years ago***

		Occurrence of cholera				
		Strongly agree	Agree	Not sure	Disagree	Total
Water quantity	High					2
						3%
	Low					11
						20%
	Very low					43
						77%
	Total	42	7	2	5	56
		75%	13%	3%	9%	100%

Source: The Resarcher, 2025

Table 3 presents the comparative analysis of households 'perception on the quantity of water used every day per person and cholera as the most frequent disease experienced in the past three years, presenting both the frequency and percentage of households who participated. the table shows that 77% of households confirmed that the quantity of water used per person in their households is very low, 20% stated that it is low and 3% confirmed that is high. Based on the frequency of disease, It illustrates that 75% of households strongly agreed that cholera was the most frequent disease in their households, 13% of households agreed, 3% were not sure and 9% confirmed that cholera was not the most frequent disease experienced in the past three years. The majority of respondents admitted that they have been affected by cholera. Based on the analysis done, this was certainly due to the very low quantity of water that was not enabling them to practice hygiene. During the focus group discussion, the majority of respondents stated that the disease was very serious in their community to the point that some were hospitalized and others lost their lives. Respondents who agreed confirmed that they have also been affected by typhoid and diarrhea.

One respondent from Rusayo camp confirmed: *''During the rainy season, I and my son were affected by cholera and have been assisted by the non-governmental organization called doctors without borders. At the hospital, we've been told that the disease was due to the lack of hygiene and the use of contaminated water''.*

Another from Kibati camp reported: *'Typhoid was about to kill me but I got healed thanks to God. We've been advised to not drink and cook with rainwater due to the dangerous volcanic matters that it contains but this is almost impossible since we do not have an appropriate source of water available to meet our needs. Although there are tanks, we do not fetch much water from tanks due to lack of money''.*

During the literature review, the researcher discovered that in the region of Asia and Pacific, the provision of water was more done in urban areas due to the increase in number of industries and urbanization. This consequently led women and children to be affected by water related diseases including cholera, typhoid and diarrhea, due to the access of low quantity of clean and safe water and the use of contaminated sources as discovered in Nyiragongo district.

Table 4 ***The Fisher's Exact Test of the Association between the Water Quantity and Occurrence of Cholera***

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	24.412[a]	6	.000	.004	
Likelihood Ratio	21.386	6	.002	.000	
Fisher's Exact Test	19.520			.001	
Linear-by-Linear Association	.059[b]	1	.808	.831	.391
N of Valid Cases	56				

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .07.

b. The standardized statistic is -.243.

Source: SPSS 27

Table 4 illustrates the fisher's exact test of the association between the perception on the quantity of water used per person on a daily basis and the occurrence of Cholera. The fisher's exact test demonstrated that there was a significant statistical association between the quantity of water and occurrence of cholera, with a P-value (2-sided) which equaled to 0.001, a value that is less than 0.05. this test led the researcher to confirm that the small

amount of water used per person in the refugee's camps in Nyiragongo district was contributing to water-related diseases, cholera included.

4.2 The Impact of Water Treatment Method on Community Households' Health in Nyiragongo Refugees' Camps

To address this objective, the researcher needed first to analyze the Households 'perception on water treatment, and then assess the relationship between households' water treatment method used and occurrence of waterborne diseases, particularly cholera in Nyiragongo district refugee's camps. This analysis helped to determine whether the lack of proper water treatment contributed significantly to the spread of such diseases.

Table 5 ***Households' Perception on Water Treatment in the Refugees' Camps***

Water treatment perception	**Frequency**	**Percent**
Agree	8	14
Not sure	7	13
Strongly disagree	41	73
Total	56	100%

Source: The Resarcher, 2025

Table 5 presents the frequency and percentage of households 'perception on water treatment in the refugees' camps. It demonstrates that 73% of households strongly disagree that they treat their water, 14% agreed that they treat their water and 13% were not sure. The majority of households admitted that treating water is not their behavior; this also explains why they experienced water-related diseases in the past three years as demonstrated by the table earlier. This suggests that the lack of water treatment also contributed to water-related diseases in the refugees' camps.

Table 6 ***Households' Water Treatment Method and Occurrence of Cholera***

	Chlorination as water treatment method			
	Agree	Not sure	Strongly disagree	Total
Occurrence of cholera rongly agree				42 75%
Agree				7 13%
Not sure				2 3%
Disagree				5 9%
Total	8 14%	7 13%	41 73%	56 100%

Source: The Resarcher, 2025

Table 6 presents the comparative analysis of households 'water treatment method and occurrence of cholera. The rows represent the occurrence of cholera and the columns represent chlorination as the water treatment method used. It demonstrates that 73% of households strongly disagreed that they use chlorination for their water treatment,

14% agreed that they use it as their water treatment and 13% were not sure. Based on the occurrence of cholera, the table illustrates that 75% of households strongly agreed that cholera was the most frequent disease experienced in their households, 13% agreed, 9% disagreed and 3% were not sure. This suggests that the lack of water treatment adversely impacted health of refugees. According to the researcher analysis, households that confirmed that they do not use chlorination to treat their water were those who experienced cholera, those who were practicing chlorination did not experience cholera, and they were very few. During the focus group discussion, the majority of respondents stated that they do not treat their water before consumption due to lack of treatment materials such as chlorine and limited access to firewood for boiling.

One participant from Rusayo camp said:*'' We usually don't treat water. We just use it the way it comes because boiling needs firewood, and we don't have enough. We just struggle to get a little firewood in order to feed our children''.*

Another from Kibumba camp explained:*'' We have heard about chlorination, but we don't have the products. So most of the time, we drink water without treating it''.*

During the literature review, the researcher discovered that in Zaria, the majority of the population was committed in treating their household water through boiling, the use of chlorine and alium. This was absolutely different with what discovered in Nyiragongo district where the majority of refugees were not treating their household water.

Table 7 ***The Fisher's Exact Test of the Association between the Water treatment and Occurrence of Cholera***

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	44.441[a]	6	.000	.000	
Likelihood Ratio	36.536	6	.000	.000	
Fisher's Exact Test	29.178			.000	
Linear-by-Linear Association	.002[b]	1	.965	1.000	.487
N of Valid Cases	56				

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .25.

b. The standardized statistic is -.044.

Source: SPSS 27

Table 7 illustrates the fisher's exact test of the association between the perception on water treatment and the occurrence of Cholera. The fisher's exact test demonstrated that there was a significant statistical association between water treatment and occurrence of cholera, with a P-value (2-sided) which equaled to 0.000, a value that is less than 0.05. this test led the researcher to confirm that the lack of households' water treatment in Nyiragongo refugees' camps was also contributing to water-related diseases, cholera included.

4.3 The Impact of Accessibility to Clean and Safe water on Community Households' Health in Nyiragongo Refugees 'Camps

To address this objective, the researcher first analyzed the households' perception on the ease of access to water sources by gender, in order to confirm whether between male and female who easily accessed water sources. Then, the relationship between this perception and the distance required to reach water sources was examined. Lastly, the researcher analyzed the relationship between the ease of access to water sources and the level of price charged to households for water collection, in order to determine the problem, they encountered in accessing water sources.

Table 8 ***Households' Perception on the Ease of Access to Water Sources by Gender***

		Male	**Female**	Total
Ease of access to water sources	Not sure	7	5	12
	Disagree	21	6	27
	Strongly disagree	22	39	61
	Total	**50**	**50**	**100**

Source: The Resarcher, 2025

Table 8 presents households 'perception on the ease of access to water sources by gender. The rows represent the ease of access to water sources and the columns represent the gender of respondents, presenting the percentage of participants. It demonstrates that 61% of households strongly disagreed that they easily access water sources, 22% were male and 39% were female. The table also shows that 27% of households disagreed that they easily access water sources, 21% were male and 6% were female. It finally demonstrates that 12% of households were not sure on the statement, 7% were male and 5% were female. The majority of respondents admitted that they had difficulty in accessing water sources, with a high percentage of female who strongly disagreed compared to male, which indicates that access to clean and safe water was still a major challenge in the Nyiragongo refugees 'camps with female being the most affected.

Table 9 ***Ease of Access to Water Sources and the Distance Taken to Collect Water***

		Distance taken is short and convenient			
		Agree	Not sure	Strongly disagree	Total
Ease of access to water sources	Not sure				7 12%
	Disagree				15 27%
	Strongly disagree				34 61%
	Total	42 75%	5 9%	9 16%	56 100%

Source: The Resarcher, 2025

Table 9 presents the comparative analysis of households' perception on the ease of access to water sources and the distance taken to collect water. The rows represent the ease of access to water sources and the columns represent the distance taken to collect water, presenting both the frequency and percentage of participants. It demonstrates that 61% of households strongly disagreed that they easily access water sources, with 27% who disagreed and 12% who were not sure. Based on the distance taken to collect water, 75% of households agreed that the distance taken to collect water is short and convenient, 16% of households strongly disagreed that the distance is short and convenient, with 9% of households who were not sure. The majority of respondents stated that the distance they take to collect water is short and convenient although most of them confirmed that the accessibility to water sources was not easy, which suggests that the distance to collect water was not the reason that explained the difficulty in accessing water sources for the majority of households. During the focus group discussion, those who disagreed that the distance is short and convenient were respondents who relied on rainfall and lake as their sources of water collection, and these ones were very few.

One participant from Monigi camp said: *'When it rains, we collect water from the roof and store it. But when there's no rain, we have to walk very far to the lake to fetch water. It takes us over an hour, and we have to carry heavy jerrycans back home''.*

Another from Kibati camp said:*'' The lake is our only option during the dry season, but it is not safe, and we walk at least 2 hours in order to get it. Sometimes the water looks dirty, and we know it can cause diseases. But we have no choice.*

In rural Tanzania, a study was conducted and it was discovered that the long distance to collect water led many households to not fetch enough water for their needs, most of the people were making 30 minutes to an hour in order to collect water. In Mororoni, the population also experienced the same issue, the majority was walking to a distance of 7200 and 8000 meters to collect water, which was around to an hour. This was totally different from the finding of this study, where only 16% of refugees were walking long distances to collect water.

Table 10 ***Ease of Access to Water Sources and Price Charged for Water Collection***

		Price charged for water collection			
		Very high	High	lerate	Total
Ease of access to water sources					7
					12%
	Disagree				15
					27%
	Strongly disagree				34
					61%
	Total	44	7	5	56
		79%	12%	9%	100%

Source: The Resarcher, 2025

Table 10 presents the comparative analysis of households' perception on the ease of access to water sources and the level of price charged for water collection. The rows data represent the ease of access to water sources and the columns represent the level of price charged for water collection, presenting both the frequency and percentage of participants. It demonstrates that 61% of households strongly disagreed that they easily access water sources, with 27% who disagreed and 12% who were not sure. Based on the level of price charged for water collection, 79% confirmed that the price charged for water collection is very high, 12% stated that the price is high and 9% said that it is moderate. During the focus group discussion, the majority of households confirmed that the very high price charged for water collection was the reason of their difficulty in accessing water sources. This suggests that the majority households in Nyiragongo district were affected by the high price of water which was not allowing them to collect much water in order to cover their needs, and this was the reason why cholera and other water related-diseases were frequent among them.

One respondent from Kibumba camp confirmed: *''The water is available in the area, but the price is too high for us, 20 liters of water costs 1500 Congolese francs and this exaggerates during dry season at 2000 Congolese francs. We are a large family, and buying water every day is not affordable. Sometimes, we reduce the amount of water we use just to manage the little we can buy. On some days, we even go without washing or cooking properly''.*

Another from Rusayo camp stated: *'Private water vendors charge a lot, especially during the dry season. If you don't have money, you have to wait for rain. The price is the biggest challenge for us''.*

Table 11 ***The Fisher's Exact Test of the Association between the Accessibility to Clean and Safe Water and Occurrence of Cholera***

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.511[a]	6	.480	.499	
Likelihood Ratio	5.911	6	.433	.584	
Fisher's Exact Test	4.869			.543	
Linear-by-Linear Association	.012[b]	1	.914	.921	.479
N of Valid Cases	56				

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .25.

b. The standardized statistic is -.108.

Source: SPSS 27

Table 11 illustrates the fisher's exact test of the association between the accessibility to clean and safe water and the occurrence of Cholera. The fisher's exact test demonstrated that there was no significant statistical association between accessibility to clean and safe water and occurrence of cholera, with a P-value (2-sided) which equaled to 0.543, a value that is greater than 0.05. Although frequencies and percentages clearly showed that refugees experienced difficulty in accessing water sources, this test led the researcher to confirm that the accessibility to clean and safe water in Nyiragongo refugees' camps was not affecting health of refugees.

4.4 The Impact of Knowledge Related to Clean and Safe Water on Community Households in Nyiragongo Refugees' Camps

To address this objective, the researcher first analyzed the households' perception of having enough knowledge related to clean and safe water, categorized by camp. This helped identify the percentage of households with knowledge in each camp. After that, the researcher examined the relationship between the households' perception of water cleanliness and safety and the water treatment method used. Lastly, the researcher analyzed the households' perception of water-related diseases as indicators of unclean and unsafe water.

Table 12 ***Perception of Having Enough Knowledge on Clean and Safe Water by Camp***

		Knowledge on clean and safe water			
		strongly agree	Agree	Not sure	Total (%)
Camps	Kibumba	7	5	2	14
	Buvira	7	5	2	14
	Kibati	9	4	1	14
	Buhumba	9	3	2	14
	Monigi	9	4	2	14
	Muja	9	4	2	14
	Rusayo	9	4	2	14
	Total (%)	59%	29%	12%	100%
		33	16	7	56

Source: The Resarcher, 2025

Table 12 present the percentage of households' perception regarding their level of knowledge on clean and safe water. The rows represent the different camps in Nyiragongo district, while the columns reflect the respondents' level of agreement. The table shows that 59% of households strongly agreed that they have enough knowledge related to clean and safe water, 29% agreed and 12% were not sure. In Kibumba camp, 7% strongly agree, 5% agreed and 2% were not sure. In Buvira camp, 7% strongly agreed, 5% agreed, and 2% were not sure. In Kibati camp, 9% strongly agreed, 4% agreed and 1% not sure. In Buhumba camp, 9% strongly agreed, 3% agreed, and 2% were not sure. In Monigi camp, 9% strongly agreed, 4 agreed, and 2% were not sure. In Muja camp, 9% strongly agreed, 4% agreed, and 2% were not sure. Finally, in Rusayo camp, 9% strongly agreed, 4% agreed, and 2% were not sure. The majority of respondents indicated that they have enough knowledge on clean and safe water in the refugees' camps. Kibati, Monigi, Muja and Rusayo recorded the highest percentages followed by Buhumba, Kibumba and Buvira.

One respondent from Buvira camp reported:'' *I first learned about clean and safe water during hygiene lessons in school. Later, Non-Governmental Organizations taught us how to treat water and avoid cholera during their visits''.*

Another from Kibati camp said:*'' We were told by a local Non-Governmental Organization how to boil water or use chlorine, but I didn't learn that in school''.*

Table 13 ***Perception on the Water Collected as Clean and Safe and Water Treatment***

		Safety and cleanliness of water			
		Not sure	Disagree	Strongly disagree	Total
Water treatment	Agree				8
					14%
	Not sure				7
					13%
	Strongly disagree				41
					73%
	Total	6	46	4	56
		11%	82%	7%	100%

Source: The Resarcher, 2025

Table 13 presents the comparative analysis of households' perception on the water collected as clean and safe and water treatment. The rows represent the perception on water treatment and the columns represent the perception on the safety and cleanliness of the water collected. The table demonstrates that 82% of households disagreed that the water they collect every day is clean and safe, 7% strongly disagreed and 11% were not sure on the statement. Based on the perception on water treatment, 73% of households strongly disagreed that they treat their water, 14% agreed and 13% were not sure on the statement. The majority of households admitted that the water collected in their households was not clean and safe but they were not practicing any water treatment in order to make it clean, and this was certainly due to the lack of water treatment materials as explained earlier. During the focus group discussion, the majority of respondents confirmed that they don't trust their sources of water.

One participant from Buhumba camp said:*'' The water collected from tank is often brownish in color, especially when it's just been refilled. We can see dirt at the bottom of our containers after a few hours''.*

Another from Buvira camp confirmed: *'' sometimes the tank is not even cleaned before refilling. We fear it's the reason our children often fall sick''.*

In Zaria, the population had enough knowledge on clean and safe water, and this resulted in boiling, putting chlorine and alium in water in order to prevent diseases. In Rural Bangladesh, two groups of the population were examined by an NGO to test their knowledge, but it was found that the group lacking knowledge was the one that was never assisted or sensitized by any Organization. In India, the rural population possessed enough Knowledge but was not practicing that knowledge in treating their household water. The case of rural India was the same case with refugees in Nyiragongo district.

Table 14 ***Water-related Diseases as Indicators of Unclean and Unsafe Water***

Diseases	**Frequency**	**Percent**
Strongly agree	7	12
Agree	39	70
Disagree	10	18
Total	56	100%

Source: The Resarcher, 2025

Table 21 presents the percentage of households' perception on water related diseases as indicators of unclean and unsafe water. It shows that 12% of households strongly agreed that water-related diseases are sign of unclean and unsafe water, 70% agreed and 18% disagreed. During the focus group discussion, the majority of households confirmed that water-related diseases were clear indicators of water contamination.

One participant from Rusayo camp noted:*'' When we start seeing many children suffering from cholera and diarrhea, we immediately now that the water is not safe''.*

Another participant from Kibati added:*'' Even when we boil or store water carefully, if the source itself is not clean, the diseases persist''.*

Table 15 ***The Fisher's Exact Test of the Association between Knowledge related to n Clean and Safe Water and Occurrence of Cholera***

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	55.953[a]	6	.000	.000	
Likelihood Ratio	47.425	6	.000	.000	
Fisher's Exact Test	38.393			.000	
Linear-by-Linear Association	14.945[b]	1	.000	.000	.000
N of Valid Cases	56				

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .25.

b. The standardized statistic is 3.866.

Source: SPSS 27

Table 15 illustrates the fisher's exact test of the association between knowledge related to clean and safe water and the occurrence of Cholera. The fisher's exact test demonstrated that there was a significant statistical association between Knowledge related to clean and safe water and occurrence of cholera, with a P-value (2-sided) which equaled to 0.000, a value that is less than 0.05, this test led the researcher to confirm that the knowledge related to clean and safe water in Nyiragongo refugees' camps was also contributing to waterborne diseases in the refugees' camps in Nyiragongo district.

Table 162 ***Suggestions for Addressing the Low Supply of Clean and Safe Water***

No	Themes	Frequency
1	Increase water tanks	20
2	Improve water distribution	15
3	Drill boreholes	3
4	Water treatment support	12
5	NGOs/Government support	6
6	Total	56

Source: The Resarcher, 2025

Table 16 presents the respondents' suggestions for addressing the low supply of clean and safe water in Nyiragongo refugees' camps; it presents both the themes and the frequency of respondents. The most common suggestion among respondents was to increase water tanks with 20 mentions, followed by improving water distribution with 15 mentions. Several respondents also emphasized the importance of supporting water treatment at the households' level. A few highlighted the importance of drilling boreholes and the role of NGOs and Government in addressing the water supply challenges. These responses show that residents prioritized both infrastructure improvements and institutional support.

5 Discussion of Findings

The findings of this study revealed that the main sources of water used by the community in Nyiragongo district refugee camps were tanks and rainwater. It was reported that the water collected from tanks was expensive and this could not allow the population to collect enough water in order to cover their households needs. In addition, it was also stated that the rainwater may be harmful to the human health due to some volcanic contaminant that it contains, but the community was not caring about the negative consequences of using it as they were in need. Although the community had limited access to clean and safe water, they could even have made some effort to treat the small quantity of water they were fetching in order the prevent the risk of some water-related diseases, since they knew that the water was not clean and safe. Based on the accessibility to water sources, the insufficient number of tanks in the district strongly encouraged water vendors to increase the price of water. The water officers reported that in the past years, before the 2002 volcanic eruption, Nyiragongo district had enough water resources at its disposal. Unfortunaly, the destruction of the latter by the volcanic eruption discouraged the Government to be responsive to

that situation. Health experts reported that cholera affected a big share of Nyiragongo population to the point that all health centers were filled, and this resulted to tents settlement.

6 Conclusion and Recommendations

This study examined the impact of low supply of clean and safe water on community households' health in Nyiragongo District refugee camps. Regarding the first objective, the research concluded that the insufficient number of water tanks forced many households to rely on rainwater, which often contained volcanic and other hazardous materials. For the second objective, the lack of consistent water treatment practices contributed to the prevalence of water-related diseases, as households frequently consumed untreated water from tanks and rainwater. Concerning the third objective, the high cost of water limited the quantity fetched by households, negatively affecting hygiene practices and increasing vulnerability to waterborne illnesses. Finally, for the fourth objective, while the community demonstrated sufficient knowledge about clean and safe water, the effective application of this knowledge in daily practices remained limited.

Based on these findings, several recommendations are proposed. The government and humanitarian agencies should prioritize the installation and equitable distribution of additional water tanks to reduce reliance on rainwater and alleviate high water costs. Awareness campaigns and educational programs should encourage households to treat water before consumption, particularly rainwater and tank water, to minimize waterborne disease risks. Communities must be educated about the hazards of untreated rainwater and guided toward safer alternatives. Authorities should explore subsidies or affordable water supply systems to ensure adequate access to clean water for all households. Additionally, efforts should focus on translating knowledge into practice through community-based follow-ups, peer education, and demonstration projects. While this study provides critical insights into water scarcity and health in refugee settings, several areas warrant further investigation. Future research could evaluate the effectiveness of specific household water treatment methods in preventing disease. Studies may also examine how hygiene and sanitation awareness campaigns translate into actual behavioral changes among refugee households. These investigations will help design targeted interventions to improve water access, hygiene practices, and overall health outcomes in vulnerable communities.

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