AWARENESS, PERCEPTIONS AND ADOPTION FACTORS OF POINT-OF-USE WATER TREATMENT IN HIGH-DENSITY AREAS OF MZUZU CITY

MSc THESIS (WATER RESOURCES MANAGEMENT AND DEVELOPMENT)

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MZUZU UNIVERSITY

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Awareness, Perceptions and Adoption Factors of Point-of-Use Water Treatment in High-Density Areas of Mzuzu City

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BSc (Environmental Management)

A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF WATER AND SANITATION IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE (MSc)

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DECLARATION

I hereby declare that this thesis titled, "Awareness, Perceptions and Adoption Factors of Point-of-Use Water Treatment in High Density Areas of Mzuzu City" has been written by me and is a record of my research work. All citations, references, and borrowed ideas have been duly acknowledged. It is being submitted in fulfilment of the requirements for the award of the degree of Master of Science (MSc) in Water Resources Management and Development of Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University.

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CERTIFICATE OF APPROVAL

I, the undersigned, certify that this thesis is a result of the author's work and that to the best of my knowledge, it has not been submitted for any other academic qualification within Mzuzu University or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on

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ABSTRACT

This study assessed awareness, perceptions and adoption factors of point-of-use water treatment in high density areas of Mzuzu City, Malawi, Africa, focusing on Mzilawayingwe, Chiputula, Zolozolo West, Luwinga, and Lupaso wards. The study aimed to comprehend the factors impeding POU water treatment adoption in high-density areas.

A mixed methods approach was utilized, combining quantitative and qualitative data obtained through household surveys, focus group discussions (FGDs), and key informant interviews (KIIs). The researcher administered a survey to 322 households, organized 5 Focus Group Discussions (FGDs) [one in each ward], and held 5 Key Informant Interviews (KIIs).

The findings revealed high awareness and positive receptiveness to POU water treatment in high-density areas. Socio-economic factors such as location, education, income, and assets significantly influenced awareness. Preferences for treatment methods were shaped by community dynamics, household assets, and health centre proximity. Adoption factors included self-efficacy, cues for action, and action efficacy, addressing barriers such as the perception of tap water cleanliness among higher income levels. The study concluded that POU water treatment had the potential to enhance the quality of life in high-density areas if barriers were addressed and benefits were communicated effectively. The complex interplay of socio-economic factors, community dynamics, and individual beliefs highlighted the need for targeted interventions. The recommendations called for further research in diverse urban settings, inclusive advocacy strategies by public health practitioners, and the development of affordable, and effective POU water treatment products.

Key words

Point-of-use water treatment, awareness, perceptions, factors.

DEDICATION

I dedicate this thesis to my beloved parents, Mr. and Mrs O.G. Mkandawire, whose unwavering support and encouragement have been the driving force behind my journey to realize my dreams. Throughout the highs and lows, you stood by me with boundless love, understanding, and guidance. Your sacrifices and dedication have shaped not only my academic achievements but also the person I am today. This work is a tribute to your enduring belief in my potential, and your relentless commitment to my success. Thank you for being my pillars of strength, for instilling in me the values of resilience and determination, and for being the source of inspiration that fuelled my pursuit of knowledge.

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ACRONYMS

AAH	Action Against Hunger
BA	Barrier Analysis
BCC	Behaviour Change Communication
CCAP	Church of Central Africa Presbyterian
DBC	Design for Behaviour Change
DEHO	District Environmental Health Officer
DWDO	District Water Development Officer
GoM	Government of Malawi
MZUNIREC	Mzuzu University Research Ethics Committee
NCST	National Commission for Science and Technology
NRWB	Northern Region Water Board
NSO	National Statistical Office
POU	Point of Use
PIN	People in Need
SBCC	Social Behaviour Change Communication
TOPS	Technical and Operational Support Program
UNICEF	United Nations for Children and Education Fund

WHO	World Health Organisation

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CHAPTER 1: INTRODUCTION

1.1 Background of the study

The quality of water consumed by people is not just essential for the well-being of individuals but also pivotal for fostering the development of nations worldwide. Poor water quality and access have a direct impact on public health (Chimphamba & Phiri 2014).

While coverage of safely managed water sources has seen an improvement since 2015 from 69% to 73%, no region is on track to achieve universal access by 2030 (WHO & UNICEF 2023). In 2022, 2.2 billion people still lacked safely managed drinking water (WHO & UNICEF 2023). Previous research has shown that globally, approximately 1.8 billion people rely on drinking water sources that are contaminated by excreta (Asefa et al. 2021; Gebremichael et al. 2021). Notably, Africa faces the highest contamination rate (53%), followed by Southeast Asia (35%) (Asefa et al. 2021).

Many communities across Africa, still obtain their water for domestic use from unprotected sources (Jensen & Khalis 2020; Kaonga et al. 2013). For instance, access to clean water in Sub-Saharan Africa is at 30% with a marginal increase of about 0.4% in recurring years (WHO & UNICEF 2023). However, this comes with significant disparities where rural people face the worst with at least 4 in 5 people having no access to improved water sources (WHO & UNICEF 2023).

Malawi, like many African countries, faces significant challenges in providing clean water to its citizens with only 67% of households having access to improved drinking water sources, but this distribution is uneven across districts and between urban and rural areas (WHO & UNICEF 2023).

Furthermore, Mzuzu City, an urban area in Malawi is no exception with 32% of its population having no access to improved water sources (Government of Malawi 2020; Msilimba & Wanda 2013; Mzuzu City Council 2014). The disparities are evident in urban setups as well, where high-density areas suffer the most. In the case of Mzuzu City, 93% of its population in high-density areas has no access to improved water sources (Msilimba & Wanda 2013).

On the other hand, Diarrhoea, the second leading cause of child morbidity and mortality worldwide, is responsible for more than 90% of deaths in children under 5 years of age in low and middle-income countries (Asefa et al. 2021; Merid et al. 2023). Globally, 1.7 billion cases of diarrhoea occur each year, killing more than 525,000 children under the age of five annually (Merid et al. 2023). The high burden of diarrhoea is mainly attributed to limited access to improved water and sanitation (Merid et al. 2023).

Given the significant impact of diarrhoea on child morbidity and mortality, particularly in low and middle-income countries where access to improved water and sanitation is limited, effective interventions are essential to address this public health challenge. One such intervention that holds promise in reducing the burden of diarrhoea is point-of-use water treatment (WHO 2014; Wolf et al. 2018a).

Point-of-use water treatment involves treating water at the household level to make it safe for consumption. This approach acknowledges that even when access to improved water sources is limited, households can take steps to improve the quality of the water they consume (Lantagne & Yates 2018; Wolf et al. 2018a). By implementing point-of-use water treatment methods such as boiling, chlorination, filtration, or solar disinfection, households can effectively remove or inactivate harmful pathogens present in their drinking water (WHO 2016, 2013; Wolf et al. 2018a).

Point-of-use water treatment coupled with safe storage has been proven to be an effective method of assuring safe water by reducing the risk of contracting waterborne diseases like diarrhoea by 61% (Wolf et al. 2018b). However, despite this growing evidence, point-of-use water treatment behaviour is not widely practiced in developing countries (WHO & UNICEF 2019). According to WHO (2014), only 33% of people have been reported to practice point-of-use water treatment in developing countries. This poses a threat on the health of the already susceptible population to waterborne diseases (Holm et al. 2016; WHO 2014).

This evidence has not prompted people to practice point-of-use water treatment. The practice is only short-lived where there are advocacy and implementation efforts by governments and other implementing partners such that only boiling among point-of-use water treatment practices has managed to achieve scale (Ojomo et al. 2015).

A better understanding of the factors holding people back from practicing point-of-use water treatment from the people's perspectives could illuminate where water practitioners are lacking (Reichelt 2011). This phenomenon is the genesis of this study that aims to assess awareness, perceptions, and factors keeping people away from practicing point-of-use water treatment in high-density areas of Mzuzu City.

1.2 Problem Statement

At least 32% of the total population in Mzuzu City has no access to protected water sources (GoM 2020). The problem is more pronounced in high-density areas where the majority of people (93%) use water from unsafe water sources (Msilimba & Wanda 2013; Mzuzu City Council 2019; Wanda et al. 2012a). Moreover, water from unsafe sources is not treated at point-of-use (Holm et al. 2016; Msilimba & Wanda 2013). Residents in high-density areas have been trained in the use of various point-of-use water treatment methods (boiling, chlorination, and filtration) but few (33%) use these methods (Holm et al. 2016; Msilimba & Wanda 2013).

However, if people continue consuming untreated water, they will be susceptible to waterborne diseases which have proven to be fatal, claiming at least 842,000 lives annually across the globe (Masanyiwa et al. 2019; Moropeng & Momba 2020). This study, therefore, seeks to assess awareness, perceptions and identify factors keeping people away from practicing point-of-use water treatment in high-density areas of Mzilawayingwe, Chiputula, Zolozolo west, Luwinga and Lupaso wards in Mzuzu City.

1.3 Study Objectives

1.31 Main Objective

To assess awareness, perceptions, and explore enablers and barriers of point-of-use water treatment adoption in high-density areas of Mzilawayingwe, Chiputula, Zolozolo West, Luwinga, and Lupaso wards in Mzuzu City.

1.3.2 Specific Objectives

a) To assess awareness of point-of-use water treatment in high-density areas of Mzuzu City.

b) To analyse the perceptions of people on point-of-use water treatment methods in high density areas of Mzuzu City.

c) To assess factors affecting adoption of point-of-use water treatment in high-density areas of Mzuzu City.

1.3.3 Research questions.

d) What is the level of awareness of point-of-use water treatment practices among residents in high-density areas of Mzuzu City?

e) What perceptions do people have about point-of-use water treatment methods in high density areas of Mzuzu City?

f) What factors affect adoption of point-of-use water treatment in high density areas of Mzuzu City?

1.4 Justification of the study

Sustainable development goals place a strong emphasis on water quality. However, there is a gap in information regarding the capacity of people living in high-density areas to ensure safe water availability where groundwater and surface water sources still rank highest (Holm et al. 2016). This includes the capacity to practice positive behaviours like point-of-use water treatment. This study focusses on assessing awareness, perceptions and identifying factors influencing people to practice point-of-use water treatment in high-density areas.

It is, therefore, necessary to conduct this study because it will help us better support the need to promote and sustain positive behaviours in our societies like point-of-use water treatment which has proven to be effective in reducing the risk of contracting waterborne diseases like diarrhoea by 61% (Wolf et al. 2018b). This in return will anchor both National Water and Sanitation policies of Malawi which stresses how bad hygiene practices in our societies compromise access to basic water and sanitation services. This is consistent with Sustainable Development Goal Number 6 which ensures availability and sustainable management of water and sanitation for all. The realisation of this goal is highly compromised with bad hygiene practices in our societies. As revealed by WHO & UNICEF (2023), no SDG region is on track to achieve universal access by 2030. Without this study, Malawi will not have meaningful headway towards this goal.

Furthermore, the study will bridge the gap in knowledge on the status of point-of-use water treatment, and how we could improve to ensure that people perceive the need to practice point-of-use water treatment amidst water supply and coverage challenges facing high-density areas of Mzuzu City.

Again, this study will collect primary data in the context of urban setup thereby providing a basis for further research in similar contexts. This will enrich the academia with more ideas and approaches and provide solutions to the practical world regarding the adoption of POU water treatment and universal access to clean water.

1.5 Ethical consideration

Ethical clearance for the study was sought from the Mzuzu University Research Ethics Committee (MZUNIREC). MZUNIREC issued a letter of approval. This, together with a reference letter from the department was taken to the Chief Executive Officer of Mzuzu City Council for clearance to conduct the study in the city. Mzuzu City Council also produced a letter of approval for the study to be conducted in the city and copied the same letter to the Officer in Charge of the Malawi Police Service for Mzuzu City.

Furthermore, written consent was solicited from block leaders before data collection in all study areas. An informed consent form devised for the study was administered verbally before any survey, with consent noted in the survey tool. No participant's names were collected in the study to ensure confidentiality and protect participants in case of any anomaly that could have risen due to their involvement in this study.

1.6 Research dissemination strategy

Findings from the research will be disseminated through research conferences and publication in journals. Locally, the data will also be accessible from Mzuzu University Library and Centre of Excellence in Water and Sanitation for further research or other educational purposes regarding point-of-use water treatment.

1.7 Study Limitations

The study was conducted amidst the Covid-19 pandemic, and this affected the process of data collection. However, this was foreseen, and it was highly regarded in the data collection plan. Covid-19 personal preventive equipment (PPEs) was budgeted for and was provided to the research team (Facemasks and Hand-sanitizers). Covid-19 preventive measures were always observed during the data collection exercise. Online interviews were conducted where possible with key informants, and where necessary, the questionnaire was left with the key informant and collected at a later stage after completion.

2 LITERATURE REVIEW

2.3 Overview of access to water and coverage

The quality of water consumed by households corresponds to their public health that makes it an important aspect for domestic water supplies. This implies that poor water quality and access has a direct impact on public health (Chimphamba & Phiri 2014; Pradhan et al. 2018).

In 2019, the WHO/UNICEF Joint Monitoring Programme (JMP) revealed that access to clean and safe water is a worldwide problem. In 2015, 844 million people lacked even a basic drinking water service. Statistics show that 263 million people spent over 30 minutes per round trip to collect water from an improved source (constituting a limited drinking water service), and 159 million people collected drinking water directly from surface water sources, 58% of which lived in sub-Saharan Africa (WHO & UNICEF 2019).

Africa has higher levels of poverty signifying that access to clean and safe water is often limited. Previous research has shown that many African communities obtain their domestic water supplies from unprotected sources (Kaonga et al. 2013).

Moreover, equality in coverage remains a challenge. Vast inequalities exist between rural and urban areas and between the rich and poor. However, noticeable improvements have been evident as coverage of safely managed services increased in all SDG regions with estimates available (WHO & UNICEF 2023), rising from 25% to 35% in Least Developed Countries. Rural coverage of safely managed services increased from 39% to 53% (WHO & UNICEF 2019). The gap between urban and rural areas decreased from 47 to 32 percentage points (WHO & UNICEF 2019).

Malawi is one of the countries in the Sub-Saharan Region that has made progress in the provision of safe and potable water by about 67% (WHO & UNICEF 2019). Despite this remarkable achievement, the country still faces challenges related to water supply and quality in some urban and peri-urban areas.

These challenges are attributed to the fact that most peri-urban and rural areas are not connected to piped water supplied by utility providers (Water Boards) due to limitation in capacity. Several water quality assessment studies have been conducted in some districts and urban setups of Malawi where several shallow wells were reported to be highly contaminated with faecal bacteria and other pollutants (Chidya et al. 2016; Kaonga et al. 2013; Mapoma et al. 2014; Pritchard et al. 2008). Unfortunately, water from such contaminated sources is consumed directly without treatment (Government of Malawi NSO 2018).

To curb these challenges, the government of Malawi, Non-Governmental Organisations (NGO) and international agencies embarked on borehole initiatives that offer clean and safe water. However, lack of regular monitoring resulted in inefficiency in operation and inadequate water supply to meet its population forcing poor people to use unprotected and unsafe water sources (Mkwate et al. 2017; Pritchard et al. 2008).

Mzuzu City is one of the most rapidly growing urban areas with a population density of 1,516 persons per square kilometre, which is faced with a public water supply and coverage challenges in Malawi (Mzuzu City Council 2019). It is estimated that 32% of the total population of Mzuzu has no access to protected water sources (Government of Malawi 2020). The problem is bigger in high density areas where majority of people (93%) use water from unsafe water sources (Msilimba & Wanda 2013; Mzuzu City Council 2019; Wanda et al. 2013).

Northern Region Water Board ($NRWB$) is the main water supplier in Mzuzu City. The $NRWB$ was established as a corporate organization under the Waterworks Act Number 17 of 1995 to supply potable water and water borne sanitation services to Mzuzu City and other urban and peri urban communities in Northern Malawi (Wanda et al. 2012b). It has the mandate of planning and asset management of water service infrastructure in the Region. In addition, the board is responsible for setting tariffs, ensuring cost effective and efficient operations, and promoting water demand management measures in Northern Malawi (Wanda et al. 2012b).

Inequitable distribution of water points coupled with poor coverage and access is prevalent. Access to portable water favours those in planned settlements leaving a significant percentage of those living in unplanned settlements with little or no access to portable and safe water. Apparently, even in some planned settlements such as Mchengautuwa, where a good water pipe network exists, water supply is still a major issue for residents (Mzuzu City Council 2014; Wanda et al., 2012b). Residents have in the past predominantly accessed water via $NRWB$ during late night hours due to low pressure of water supply and small sized storage tanks (Wanda et al. 2012b).

The water from unsafe sources is not treated at point-of-use (Holm et al. 2016; Msilimba & Wanda 2013). Residents in high density areas have been trained on the use of various point-of-use water treatment methods but few (33%) make use of the methods (Holm et al. 2016; Msilimba & Wanda 2013). This corresponds with findings of the WHO & UNICEF (2019) that observed that point-of-use water treatment remains under-utilised in most countries across Africa.

2.4 Point-of-use water treatment

In its manual on Introduction to Household Water Treatment and Safe Storage, the Centre for Affordable Water and Sanitation Technology (CAWST) of Canada introduces POU water treatment as follows: “Household-level approaches to drinking water treatment and safe storage are also commonly referred to as managing the water at the point of use (POU)” (WHO 2012). When water is collected in homes, it is treated and stored to ensure that it is safe for drinking (WHO 2012). POU water treatment offers an affordable option for poor communities to have access to safe drinking water, which is crucial in preventing waterborne diseases (WHO & UNICEF 2019). Effective application of POU water treatment has been shown to significantly reduce levels of contamination in water obtained from highly contaminated sources. This is effective in protecting households from diarrheal diseases (Lantagne & Yates 2018). The success of POU water treatment is achieved through the effective use(Boisson et al. 2013), proper storage and observing good hygiene in handling the water (Ho et al. 2013). Apart from normal household use, POU water treatment is also routinely used during disasters and other various emergencies when normal water supply is disrupted (Lantagne & Yates 2018). "Having access to safe water is an important and immediate priority in nearly every emergency" (WHO & UNICEF 2019).

2.5 Point-of-use water treatment methods and technologies.

According to WHO (2013), the process of treating water at point of use can be summarized as follows: sedimentation, filtering, disinfection, and safe storage.

According to the two sources, during **sedimentation**, and letting stand and settle, the goal is to reduce turbidity by letting physically large particles settle at the bottom of the container. Turbidity is caused by material suspended in water which can act as hosts to harmful microbes. Use of coagulation and flocculation can speed up the sedimentation process (WHO 2013).

Filtration is meant to separate physical particles from the water. This can be done with a membrane, sand, cloth, ceramic, or other specialized filters as discussed in the UN Climate Technology Center and Network [CTC-N] (n.d.)(CAWST 2011; WHO 2013).

Disinfection is employed to destroy pathogens. Common techniques include boiling, use of chemicals such as chlorine, solar disinfection, and UV disinfection (CAWST 2011; WHO 2013).

The following is a review of some common POU water treatment techniques:

Boiling is highly effective in removing pathogens and is practiced around the world as a POU water treatment technique (CAWST 2011). The water is boiled at 100 degrees Celsius for 1 minute before it is transferred into a clean container for storage. The boiled water may have a poor test. To resolve this, the water can be aerated by vigorous shacking (CAWST 2011).

Cloth filtration: In a study done in Ghana and Ethiopia, Stevenson (2008) described cloth filtration as a process of straining water through a cloth tied tightly over the mouth of a clean container. He points out that cloth filtration was shown to be effective in treating water against cholera in Bangladesh and Guinea worm in Ghana and Sudan.

"Huq showed that 99% of cholera parasites (those bound to planktonic copepods) were removed by quadruple-folded sari cloth in Bangladesh" (Stevenson 2008). This technique may only be effective in targeting diseases with large carrier hosts and hence using it in combination with other treatments is more appropriate (Stevenson 2008).

Sand/bio-sand filtration: A container is filled with layers of sand and gravel. Fine sand is placed on top of the layers followed by coarse sand and gravel at the bottom (CAWST 2011). A thin layer of water (5-6cm high) is poured at the top of the sand and filters through the sand layers to an outlet pipe which is raised to the level where the sand layer begins (Lantagne & Yates 2018). On the surface of the fine sand, a bioactive layer forms, and is responsible for consuming some of the pathogens (CAWST 2011; Lantagne & Yates 2018). To protect the bioactive layer from being disturbed when water is poured into the container, a thin, porous material can be put over the surface of the sand (Lantagne & Yates 2018). According to Kaizer, bio sand filtration is highly effective in removing bacteria and protozoa (Lantagne & Yates 2018). This process has proven effective in reducing diarrheal diseases by 47% (Lantagne & Yates 2018).

Membrane filtration makes use of a membrane with pores through which water is forced either by gravity or pressure, while blocking contaminants (CAWST 2011).

Membrane filters come in various types and sizes and not all of them are effective in filtering viruses. Microfiltration is the least effective type of membrane filtration, followed by ultrafiltration with the most effective one being nanofiltration which has the smallest pore sizes and removes most microbiological contaminants (CAWST 2011; WHO 2019). Some examples of commercially available membrane filters include Sawyer, Lifestraw, Nerox filters (CAWST 2011).

Ceramic filter is common both in developing and developed countries and involves the use of a ceramic component made from clay and shaped as a pot, candle or disc that acts as a filter (Lantagne & Yates 2018; WHO 2019). The common set up involves installing the filter at the bottom of a bucket that holds the untreated water, sometimes the filter itself can come in form of a bowl or container that holds the untreated water (Lantagne & Yates 2018). The receptacle holding untreated water is placed on top of a clean empty vessel that has a tap installed near the bottom level acting as an outlet for treated water (Lantagne & Yates 2018). Water from the top container slowly sips through the ceramic filter into the lower container by gravity and is effectively cleared of most microbes except some smaller microorganisms such as viruses (WHO 2019). The filters are usually impregnated or coated with colloidal or nanoparticles of silver or copper, this enhances microbial removal and prevents the growth of bacteria within the filter (Lantagne & Yates 2018; WHO 2019).

Flocculation is the process of removing suspended particles in the water by application of coagulants and flocculants such as iron or aluminium salts (WHO 2019). The process works by aggregating suspended particles and larger microorganisms to form flocs which can either be settled by sedimentation or filtered by a filtration component (WHO 2019). Many POU water treatment products that employ flocculation such as PuR Purification of Water made by Procter and Gamble includes a chemical disinfectant that destroys any remaining microbial contaminants (WHO 2019).

Ultraviolet (UV) irradiation/disinfection: UV disinfection works by exposing the water to UV light which destroys the DNA of microorganisms. This effectively deactivates most of the microbes in the water including bacteria and viruses (CAWST 2011; WHO 2019). The UV system consists of a UV bulb that emits UV light and a container that holds the water that is exposed to the UV light. The treated water in then released into a clean storage container (CAWST 2011; WHO 2019). Usually, pre-treatment activities such as filtration and sedimentation are involved to prepare the water for effective treatment with UV light (CAWST 2011).

Solar disinfection is generally effective in tropical or subtropical regions where sunlight intensity is particularly favourable (WHO 2019). The combination of UV radiation and heat of the visible light work to destroy the structure of pathogens in the water (WHO 2019). A simple technique involves putting water into a transparent plastic bottle, placing it on a metal surface that reflects light, and exposing it to light for 24 hours if it is sunny or 48 hours if it is cloudy (CAWST 2011; WHO 2019, 2013). The water should be free from turbidity, and the bottle should be placed on its side to increase exposure to the sunlight (CAWST 2011; WHO 2013).

Chemical disinfection: Chemical disinfectants destroy microorganisms by oxidizing effect to destroy the biological structure of microbes using chemical compounds that include bromide, iodine, peroxide, and chlorine compounds (WHO & UNICEF 2019). Chlorine is highly effective, and is the most used chemical disinfectant, available in powder, liquid, or tabled forms (WHO 2013). PuR (P&G Purifier of Water) and Waterguard are some of the examples of available chlorine-based disinfectants (CAWST 2011). It is important to apply an appropriate dosage when treating water with chemical disinfectants and ensure that the water is free from turbidity (CAWST 2011; WHO 2013)

According to Rowe (2012), the most common POU water treatment solutions in Malawi are Waterguard, P&G Purifier of Water and the chlorine stock solution. These are followed by filters such as LifeStraw Family Filter, the Tulip Siphon Filter, and the Tulip Filter. A national survey by Stockman et al. (2007) in Malawi found awareness of Waterguard among mothers to be relatively high.

2.6 Why point-of use water treatment?

According to WHO (2019), access to clean and safe water in poor or remote places is difficult either because a centralized reliable supply system is non-existent or inefficient. Even where treated water is supplied from the municipal network, it can get contaminated during distribution thereby making it unsafe at point of use (Ansah et al. 2016).

According to WHO & UNICEF (2019), "approximately 485 000 diarrhoeal deaths in low and middle-income countries each year are attributable to unsafe drinking-water".

These conditions underscore why POU water treatment is important because it is a suitable option for ensuring that households have access to safe drinking water (CTC-N, n.d.). POU water treatment can be very effective in helping households protect themselves against waterborne diseases. Research has shown that cases of diarrheal diseases are reduced "by as much as 61%" when households that are at risk of waterborne diseases properly and consistently treat and store their water at home (WHO & UNICEF 2019).

POU water treatment can be set up more quickly and affordably whenever water needs to be treated. This contrasts with the number of resources and time that would be needed to set up an industrial water purification system (WHO 2013).

POU water treatment becomes even more important in times of emergencies, disasters, or disease outbreaks when conventional water supply systems are disturbed. POU water treatment techniques can be implemented quickly to ensure that water is safe for drinking for the affected communities (Lantagne & Yates 2018).

2.7 Point-of-use water treatment awareness

Studies conducted across Africa show that a significant percentage of people are aware of point-of-use water treatment. For instance, in Tanzania, a higher level of awareness was evident in a study on the perceptions of people on household water treatment and storage methods where over 80% of the people said they were treating water to kill germs while the remaining percentage (20%) mentioned that they were treating water to improve its taste and remove bad smell (Masanyiwa et al. 2019). This is consistent with other studies conducted across Africa (Moropeng & Momba 2020; Wolf et al. 2018b), and it shows that a lot of people in our communities are aware of point-of-use water treatment and its prowess to cure water from pathogens which cause waterborne diseases.

Although studies show that more people are aware of water treatment methods and its benefits, implementation is poor as only 33% of the people are said to practice point-of-use water treatment in developing countries posing a threat on the health of an already susceptible population to waterborne diseases (Holm et al. 2016; WHO 2014). This has been the case even in many point-of-use water treatment programs which reported strong initial uptake that decreases over time (Ojomo et al. 2015). This is happening although most developing countries lack basic access to safe and clean water supply (WHO & UNICEF 2019). For instance, in Malawi, groundwater and surface water sources are still primary sources of drinking water in rural communities as well as high density settlement areas in urban settings (Holm et al. 2016).

2.8 Perceptions of people on point-of-use water treatment methods

Perceptions are divided when it comes to point-of-use water treatment methods across Africa. Nevertheless, boiling ranks highest with regards to ease of operation and returns its efficacy (Merton 2018). Costs of purchase and taste are significant issues raised against filters and chlorination respectively in most studies across Africa, and the reason behind stunted numbers in practice (Holm et al. 2016; Moropeng & Momba 2020).

Bitew et al. (2017) conducted a study in Ethiopia on "Knowledge, Attitude, and Practice of Mothers/Caregivers on Household Water Treatment Methods in Northwest Ethiopia". Findings showed that people in urban areas generally did not view POU water treatment as necessary possibly because the communities had access to piped water supply which they believed to be safe for drinking. This happened even though "the supply was inadequate and irregular". Bitew et al. (2017) further found that even the communities that obtained their water from unprotected sources that were "prone to contamination" rarely practiced POU water treatment. Findings such as those of (Bitew et al. 2017) that many people see no need to use POU water treatment because they perceive their water to be safe for drinking are shared by many other studies on the subject, such as Mudau et al. (2017) and Sonya (2019).

A study by Kgabi et al. (2014) on "Utilisation of Water Purification “Tablets” at Household Level in Namibia and Tanzania" showed that some people disliked the use of Waterguard (a chlorine-based water treatment product) as a POU water treatment technique because of the smell and taste it created in the water. Instead, they preferred the use of boiling as a POU water treatment technique.

2.9 Factors affecting adoption of point-of-use water treatment

Lack of a manufacturing company of point-of-use water treatment in Malawi is one of the contributing factors to low adoption of POU water treatment with regards to costs of purchase and availability (Holm et al. 2016). Cultural norms, level of education, availability of extension services, and lack of health promotion programs are among the other factors stressed across different studies influencing people to revert to their old ways even when point-of-use water treatment technologies are given to people (Moropeng & Momba 2020; Ojomo et al. 2015). Ochaney (2019), in a study on "Factors Affecting Water Treatment at Point-Of-Use A Comparative Analysis about Access to Water" done in Tanzania, showed that adoption of POU water treatment was low because of various factors. These included people perceiving the water to be "safe for consumption" or they found it hard to access or implement POU water treatment technologies or techniques. Mudau et al. (2017) conducted a study in Limpopo, South Africa on "Cholera and Household Water Treatment Why Communities Do Not Treat Water After a Cholera Outbreak" and found that even after a cholera outbreak had occurred a few months earlier, most households did not consider POU water treatment as a priority as they felt it was unnecessary.

Similarly, Moropeng & Momba (2020) in their study on "Assessing the Sustainability and Acceptance Rate of Cost-Effective Household Water Treatment Systems in Rural Communities of Makwane Village, South Africa" found that although most people in the area knew of POU water treatment, only a very small number practiced it. They observed that some of the contributing factors were low level of education, low-income levels that determine accessibility to POU water treatment products or techniques, the perception that the water used was already clean and safe, difficulty in handling POU water treatment solutions or having issues with the product. Another finding was that POU water treatment products made water smell or test bad or that the treatment process worked too slowly (Moropeng & Momba 2020).

Kumwenda et al. (2014) conducted a study on use of Waterguard (a water treatment solution) in households in Chikwawa District in Malawi. The researchers found out that mothers of under 5-year-old children were more likely to use Waterguard to protect their children against diarrheal diseases. They concluded that factors affecting Waterguard use among the households were "previous Waterguard use, availability of Waterguard in the house, perception about vulnerability to diarrhoea and cholera, perception about water source and cost" (Kumwenda 2014).

3 METHODOLOGY

3.3 Study Area

Malawi is situated in Southeast Africa and lies within the western branch of the East African Rift Valley System (Mzuzu City Council 2019). Mzuzu City (Figure 1), which covers 48 square kilometres, is found on the northern end of the Viphya Plateau at altitude between 1300 m and 1350 m above sea level in Mzimba District in Northern Malawi (Mzuzu City Council 2019). The study area has a subtropical climate with a distinct rainy season during November to May, and average monthly rainfall ranges from 0.3 mm in August to 222 mm in January (Government of Malawi 2018). The city is the largest urban centre in Northern Malawi, and the third largest urban Centre in Malawi after Blantyre and Lilongwe. Most of the City is lying in a gently sloping land with ridges and gullies to the East and South (Mzuzu City Council 2019). Mzuzu City is one of the fastest growing urban areas in Malawi with a population of 221,272 (Government of Malawi 2018). The Inter-censual growth rate of 5% was the highest in Malawi among the cities (Government of Malawi 2018).

The study mainly focused on high density settlement areas of Mzilawayingwe, Chiputula, Zolozolo west, Luwinga and Lupaso wards which have total populations of 4,076, 6,888, 11,631, 15,657 and 5,390 respectively (Government of Malawi 2018).

These wards were purposively selected basing on evidence from previous studies conducted in Mzuzu which showed that at least 70% of communal water points in these areas are disconnected. This is prominent in Area 1B (Luwinga ward) and Lupaso (Lupaso ward) where there is proliferation of unprotected shallow wells, and the water has been deemed not safe for direct human consumption. Moreover, only 33 % of people have been reported to treat water at point-of-use, and there is a significant increase of diarrhoea cases especially among children under the age of five (Mzimba North HMIS 2020; Mzuzu City Council 2018; Wanda, et al. 2012; Holm, et al. 2016).

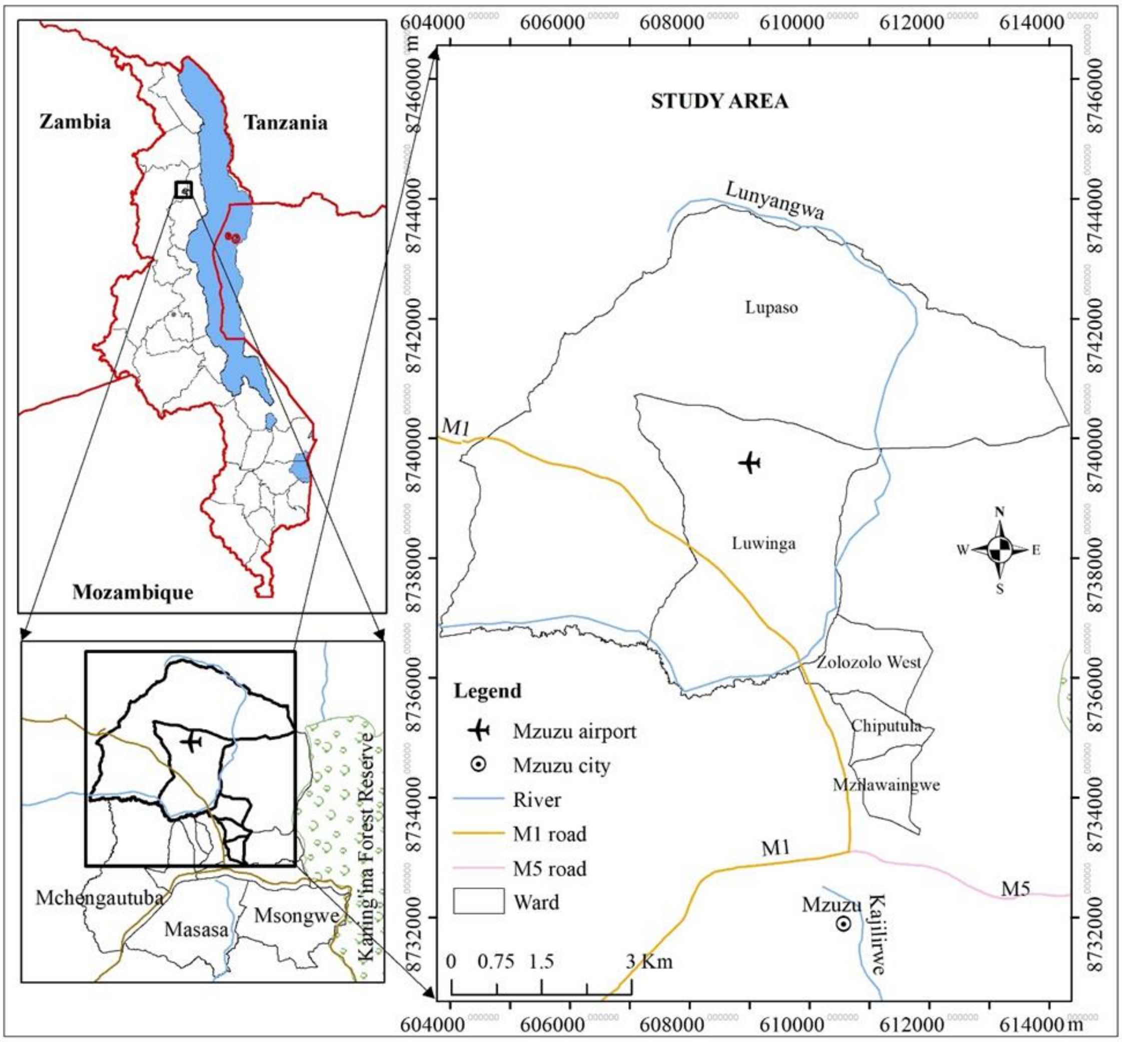

Figure 1: Map of Mzuzu City showing Mzilawayingwe, Chiputula, Zolozolo west, Luwinga and Lupaso wards (source: ArcGIS)

3.4 Research design

This study adopted a mixed methods research design. Mixed methods research is an approach to inquiry that involves collection of both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks (Creswell 2014). The study adopted this form of inquiry on the assumption that the combination of qualitative and quantitative approaches will provide a more complete understanding of a research problem than either approach alone. In this regard, a convergence model variant of triangulation came into effect, thus, to directly compare quantitative statistical results with qualitative findings or to validate or expand quantitative results with qualitative data (Creswell 2006).

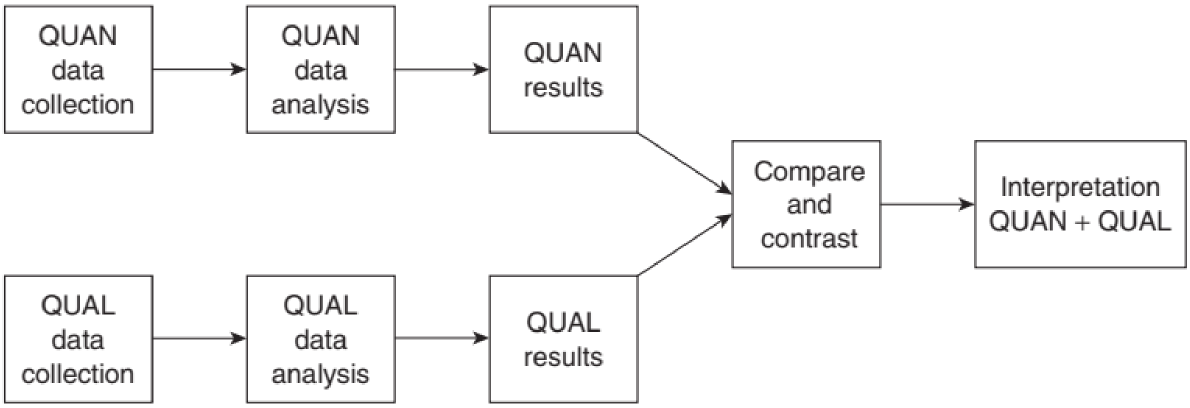

Figure 2: Shows Triangulation design; Convergence model. source, (Creswell 2014)

3.5 Sampling framework

In this study, three sampling techniques were used with respect to the data collection techniques that were selected to acquire the desired information, thus, people's awareness, perceptions and factors affecting adoption of point-of-use water treatment.

The target population included people living in high density areas of Mzuzu City where water supply issues have been established including poor pipe networks, more public water supply outlets disconnected and proliferation of unprotected shallow wells. These issues drive people into drawing water from unprotected sources which are not safe for direct human consumption. Therefore, a simple random sampling was used to identify households to be surveyed. Thus, every case of the population had an equal chance of inclusion in the sample (Taherdoost 2016). The sample size of 322 was generated by (Taherdoost 2016) formula in Microsoft Excel.

$$n = \frac{p\,(100-p)z^2}{E^2}$$

where,

n is the required sample size

P is the percentage occurrence of a state or condition

E is the percentage maximum error required

Z is the value corresponding to level of confidence required

The sample size generated was distributed into the study areas (wards) proportionate to its population. This was computed in Microsoft excel using the underlying formula.

Sample size distribution = Total Sample Size x Population of Subgroups

Entire Population

Study Area (Wards)	Population	Sample Size
Mzilawayingwe	4076	30
Chiputula	6888	51
Zolozolo West	11631	86
Luwinga	15657	116
Lupaso	5390	40

Total Sample Size	322
Total Population	43642

Figure 3: Shows sample size distribution proportionate to population of study area.

Furthermore, the study got more information from residents of high-density settlement areas through focus group discussions where people from the same neighbourhood expressed and shared their views regarding point of use water treatment. These focus group discussions consisted of six to eight participants following (Krueger 2002) recommendation. These participants were purposively sampled, and a selection criterion included people in the pre-determined study area, willing to participate, do not use piped water as primary source, store water in their homes and do not practice point of use water treatment.

The study also caught up with key technocrats in the field of Water, Sanitation and Hygiene (WASH) around Mzuzu through key informant interviews. The key informants were purposively sampled with regards to their contribution to point-of-use water treatment in Mzuzu City. Some of the officials and institutions interviewed include the Water and Sanitation Coordinator from Mzimba North District Health Department, the Water and Sanitation Officer from Mzuzu City Council, and the Centre Manager from Mzuzu CCAP Smart Centre.

3.6 Data Collection

Objective 1: *To assess if people living in high density areas of Mzuzu are aware of point of use water treatment.*

A household structured survey questionnaire was developed and administered in high density settlement areas of Mzilawayingwe, Chiputula, Zolozolo West, Luwinga and Lupaso wards. The selection of participants for the household survey was based on a non-specific targeting approach to capture diverse perspectives on water sources and treatment practices. This included households drawing water from various sources, such as unprotected wells, rivers, dambos, and standpipes. Given the presence of households accessing water from standpipes, the survey accounted for this by addressing perceptions and practices related to the quality and treatment of piped water. This inclusion allowed for a comprehensive assessment of water treatment behaviours across different water sources. The questionnaire was programmed in Kobo toolbox and administered in Android-powered mobile gadgets with Kobo-collect application.

Data was collected on people's awareness on point-of-use water treatment in high density areas of Mzuzu City. Some of the valuables included sources of drinking water, knowledge of at least one proven POU water treatment method, pathways of POU water treatment messages and/or trainings, access to POU water treatment products and personal conviction of POU water treatment.

Objective 2: *To analyse the perceptions of people on point-of-use water treatment methods in high density areas of Mzuzu City*

A household structured survey questionnaire was developed and administered in high density settlement areas of Mzilawayingwe, Chiputula, Zolozolo West, Luwinga and Lupaso wards. The questionnaire was programmed in Kobo toolbox and administered in android powered mobile gadgets with Kobo-collect application. Data was collected on perceptions people have on point-of-use water treatment methods including what they like and don't, ease of use, ease of access and affordability of the POU water treatment products.

Objective 3: *To assess factors affecting adoption of point-of-use water treatment in high density areas of Mzuzu City*

A household structured survey questionnaire was developed and administered in high density settlement areas of Mzilawayingwe, Chiputula, Zolozolo West, Luwinga and Lupaso wards. The questionnaire was programmed in Kobo toolbox and administered in android powered mobile gadgets with Kobo-collect application. Data was collected on factors affecting adoption of point-of-use water treatment in high density areas of Mzuzu City including perceived self-efficacy, perceived positive consequences, perceived negative consequences, perceived social norms, perceived access, perceived divine will, perceived action efficacy, perceived severity, perceived susceptibility/perceived risk and perceived cues for action, policy, and culture.

Key informant interviews were conducted with key technocrats in the field of Water, Sanitation and Hygiene (WASH) around Mzuzu. The officials and institutions interviewed include the Water and Sanitation Coordinator from Mzimba North District Health Department, the Water and Sanitation Officer from Mzuzu City Council, and the Centre Manager from Mzuzu CCAP Smart Centre. Data was collected on resource availability, standards, certification, regulation, market strategies and user guidance on point-of-use water treatment technologies.

Focus group discussions were conducted consisting of six to eight participants following (Krueger 2002) recommendation in all study areas. Data was collected on perceived self-efficacy, perceived positive consequences, perceived negative consequences, perceived social norms, perceived access, perceived divine will, perceived action efficacy, perceived severity, perceived susceptibility/perceived risk, and perceived cues for action.

3.7 Data Analysis

Objective 1: *To assess if people living in high density areas of Mzuzu are aware of point of use water treatment.*

Data from Kobo toolbox was downloaded and cleaned in Microsoft excel before being imported into SPSS version 25 for analysis. This objective generated categorical data, therefore analysis from this objective was done in two disciplines. The first one was to summarise the data collected from the study areas. Descriptive statistics were computed for frequencies of responses in each category and this process was core in ensuring that the data was indeed thoroughly clean.

The second discipline included comparing the data sets for statistical differences. This was mostly applied on demographic data. For instance, awareness of POU water treatment against education. These comparisons of proportions were conducted using a Chi-square test. Differences were evaluated for statistical significance at alpha > 0.05.

The third discipline surveyed for a relationship between level of awareness and the socio-economic factors. For instance, if level of awareness is linked to education of a respondent. And if the level of a respondent's education can predict his/her level of awareness. A multinomial logistic regression befitted this discipline well. The multinomial logistic regression was found fitting because the categorical dependent variables on this objective had more than just two outcomes and not ordered as would prefer an ordinal/binary logistic regression.

Objective 2: *To analyse the perceptions of people on point-of-use water treatment methods in high density areas of Mzuzu City*

On this objective, emphasis was on comparing perceptions of people on different point-of-use water treatment methods. The analysis of this data surveyed for significant difference in respondents' perception basing on their experience with a particular point-of-use water treatment method. A Chi square test was used to execute this task.

Objective 3: *To assess factors affecting adoption of point-of-use water treatment in high density areas of Mzuzu City*

On this objective, data was analysed in three disciplines. The first discipline determined significant differences among the factors identified. A Chi- square test again came in handy with the differences evaluated for statistical significance at alpha > 0.05.

In the second discipline, the binary logistic regression model was used to investigate factors that influence people to practice point-of-use water treatment in high density settlement areas to which the practice of point-of-use water treatment was taken as the dependent variable. The dependent variable was dichotomised with a value of 1 if a respondent did practice point-of-use water treatment (Doer) and 0 if the respondent did not practice point-of-use water treatment (non-Doer). Predictor independent variables was regressed against the binary dependent variable of the behavioural status of respondent.

The binary logistic regression model as specified in equations, 1 to 5, according to Taruvinga and Mushunje (2010), was used to determine factors influencing people to practice point-of-use water treatment.

$$\phi_i = E\left(\gamma_i = \frac{1}{\chi_i}\right) = \frac{1}{1 + \ell^{-\left(\beta_i + \sum_{i=1}^{k=n} \beta_{ij} \chi_{ij}\right)}}$$ ………….. (1)

Where,

ϕ_i , is the probability of the respondent (*i*) being a Doer.

γ_i , is the observed behavioural status of the respondent.

$i, \ \chi_{ij}$, are the factors determining behavioural status of respondent.

İ and β_j , stands for parameters to be estimated

By denoting $\beta + \sum_{j=1}^{k=n} \beta_{ij}$ *as Z*, equation (1) can be written to give the probability of Behavioural status of the respondent (*i)* as:

$$\phi_i = E\left(\gamma_i = \frac{1}{\chi_i}\right) = \frac{1}{1 + \ell^{-Z_i}} \quad \text{………………………………………….. (2)}$$

From equation (2) the probability of a respondent being a Doer is given by $(1-\phi_i)$ which gives equation (3) as follows.

$$(1 - \phi_i) = \frac{1}{1 + \ell^{Z_i}} \quad \text{……………………………………………………… (3)}$$

According to Taruvinga and Mushunje (2010), the odds ratio would therefore be, [(i.e, $\phi_i/(1-\phi_i)$]as given by equation (4);

$$\left(\frac{\phi_i}{1 - \phi_i}\right) = \frac{1 + \ell^{Z_i}}{1 + \ell^{-Z_i}} = \ell^{Z_i} \quad \text{………………………………………………. (4)}$$

The natural logarithm of equation (4) gives rise to equation (5);

$$Ln\left(\frac{\phi_i}{1 - \phi_i}\right) = \beta + \sum_{j=1}^{k=n} \beta_{ij} + \varepsilon_i \quad \text{……………………………………………….. (5)}$$

The third discipline involved analysis of qualitative data obtained from focus group discussions and key informant interviews. Data from focus group discussions and key informant interviews was coded and analysed using thematic analysis.

4 RESULTS

4.3 Awareness of point of use water treatment

4.1.1 Knowledge of proven Point-of-Use water treatment methods

The results showed that all study participants were aware of at least one proven Point-of-Use (POU) water treatment method (Figure 4). Boiling (98%) and water guard/chlorine (93%) are POU water treatment methods that were widely known. The least known methods were letting stand and settle (31%), covering in a clean bucket (2%) and solar disinfection (1%).

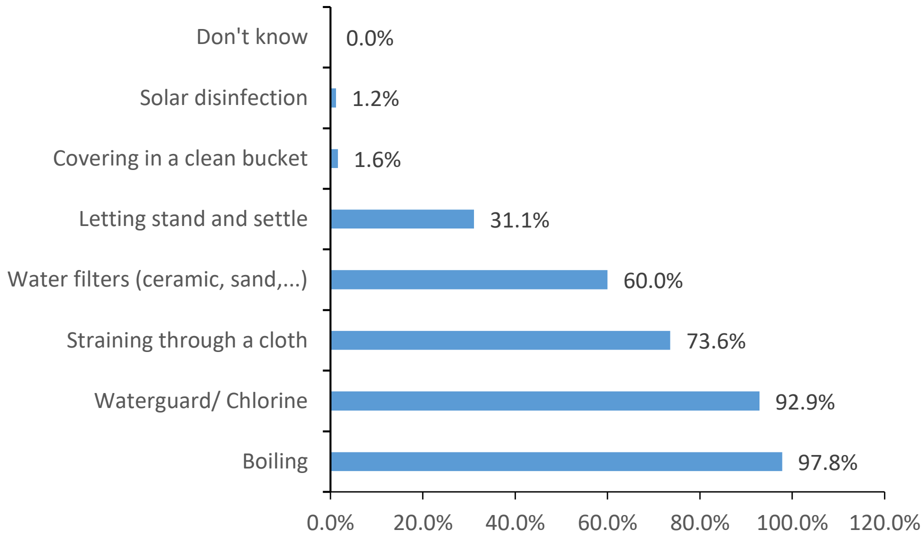

Figure 4: Knowledge distribution of POU water treatment methods.

4.1.1.1 Knowledge of proven Point-of-Use water treatment methods by community

The results revealed a varying level of awareness and utilization of POU water treatment methods across the surveyed communities. Overall, the communities demonstrated a high level of awareness regarding boiling water as a means of treatment, with percentages ranging from 93% to 100%. Zolozolo West had the highest awareness and utilization rates for boiling water at 100%.

Furthermore, use of waterguard/chlorine was known and practiced by a majority of respondents, except in Chiputula, where awareness was relatively low (78%). Straining water through a cloth was another commonly known method, with awareness ranging from 47% to 83%, suggesting moderate utilization in most areas.

Letting water stand and settle, awareness ranged from 8% to 44%, indicating varied adoption rates across the community. Similarly, covering water in a clean bucket was practiced less except in Chiputula (8%). Interestingly, solar disinfection and water filters (ceramic, sand, etc.) were not well-known methods in any of the communities.

Chi-square statistics were used to examine association between categorical variables (awareness of POU water treatment and community). The results revealed a significant association at 5% significance level between awareness of POU water treatment and a respondent's community (X^2= 147.49, df= 28, $p < 0.01$) (Table 1).

Table 1: Awareness of POU water treatment by community

	Area 1b (%)	Chiputula (%)	Lupaso (%)	Mzilawayingwe (%)	Zolozolo-west (%)	X^2	df	*P*-value
Boiling	99.1	98.0	92.5	93.3	100	147.49	28	.000
Adding waterguard/chlorine	98.3	78.4	100	90.0	91.9			
Straining through a cloth	66.1	70.6	82.5	46.7	90.7			
Using water filter (ceramic, sand...)	0.0	3.9	0.0	0.0	0.0			
Letting it stand and settle	40.9	9.8	7.5	23.3	44.2			
Covering in a clean bucket	0.0	7.8	0.0	0.0	1.2			
Solar disinfection	0.0	7.8	0.0	0.0	0.0			
Don't know	0.0	0.0	0.0	0.0	0.0			

4.1.1.2 Knowledge of proven Point-of-Use water treatment methods by gender

Table 2 provides a summary of respondents' knowledge of POU water treatment by gender. Each row represents a specific water treatment method while the columns represent gender. The percentages in the table indicate the level of awareness for each POU water treatment method by gender. The results showed that the study was dominated by female respondents (98%). Only (2%) of the respondents were men. However, a chi-square test revealed that there was no association between gender of the responded and his/her knowledge of POU water treatment methods as there were no significant differences at 5% confidence level (X^2= 2.586, df= 7, p= 0.921).

Table 2: Awareness of POU water treatment methods by gender

	Female (%)	Male (%)	X^2	df	P-value
Boiling	97.8	100	2.586	7	.921
Adding waterguard/chlorine	92.7	100			
Straining through a cloth	74.1	50.0			
Using water filter (ceramic, sand...)	0.6	0.0			
Letting it stand and settle	31.0	33.3			
Covering in a clean bucket	1.6	0.0			
Solar disinfection	1.3	0.0			
Don't know	0.0	0.0			

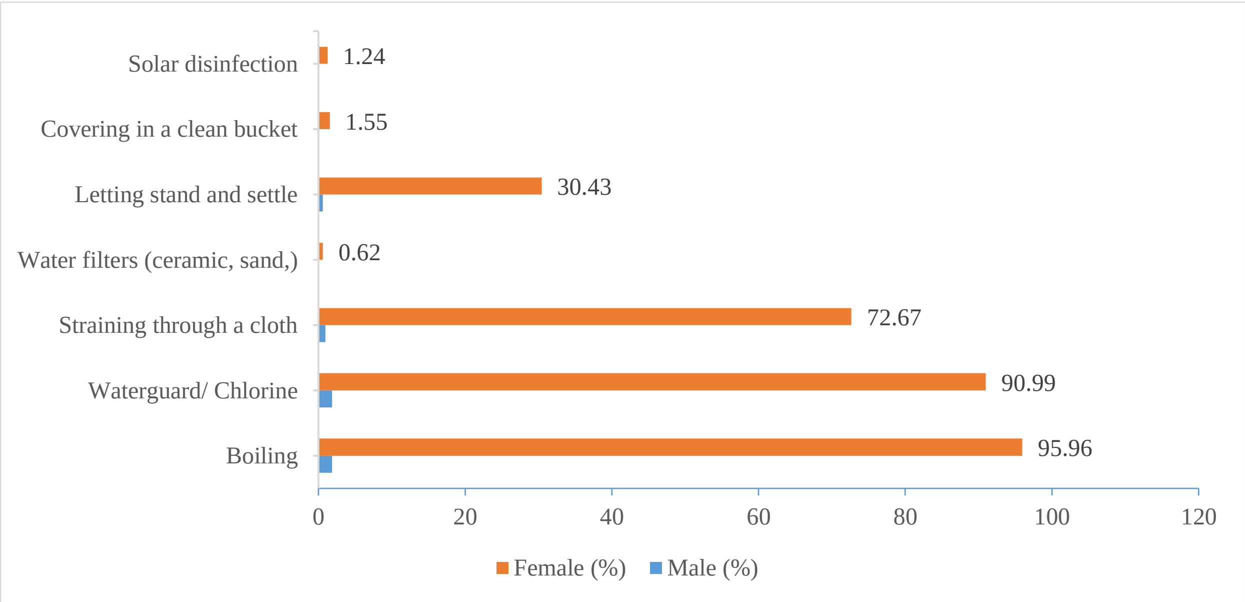

Figure 5: Awareness of POU water treatment methods by gender.

4.1.1.3 Knowledge of proven Point-of-Use water treatment methods by age

Table 3 displays results on the awareness of point-of-use (POU) water treatment methods among different age groups. Each row represents a specific water treatment method, while the columns represent different age groups: 15-24, 25-34, 35-44, and 45 and above. The percentages in the table indicate the level of awareness for each POU water treatment method within each age group.

The awareness of boiling as a water treatment method was relatively high across all age groups, ranging from 97% to 98%. However, respondents who fell in (25-34) age group had the highest percentage of awareness on Boiling (52%) Adding waterguard/chlorine (50%), straining through a cloth (40%) and letting it stand and settle (15%) (Figure 6). Chi-square statistics were used to examine association between categorical variables (awareness of POU water treatment and age). The results revealed an insignificant association at 5% significance level between awareness of POU water treatment and a respondent's age (X^2 = 31.52, df = 21, p = .065).

Table 3: Awareness of POU water treatment methods by age

	15- 24 (%)	**25- 34 (%)**	**35- 44 (%)**	**45- Above (%)**	**X^2**	**df**	**P-value**
Boiling	97.5	98.2	97.6	96.7	31.52	21	.065
Adding Waterguard/chlorine	87.7	94.7	95.1	93.3			
Straining through a cloth	66.7	75.9	75.6	76.7			
Using water filter (ceramic, sand...)	1.2	0.0	0.0	3.3			
Letting it stand and settle	33.3	28.2	29.3	43.3			
Covering in a clean bucket	2.5	0.6	0.0	6.7			
Solar disinfection	1.2	0.6	0.0	6.7			
Don't know	0.0	0.0	0.0	0.0			

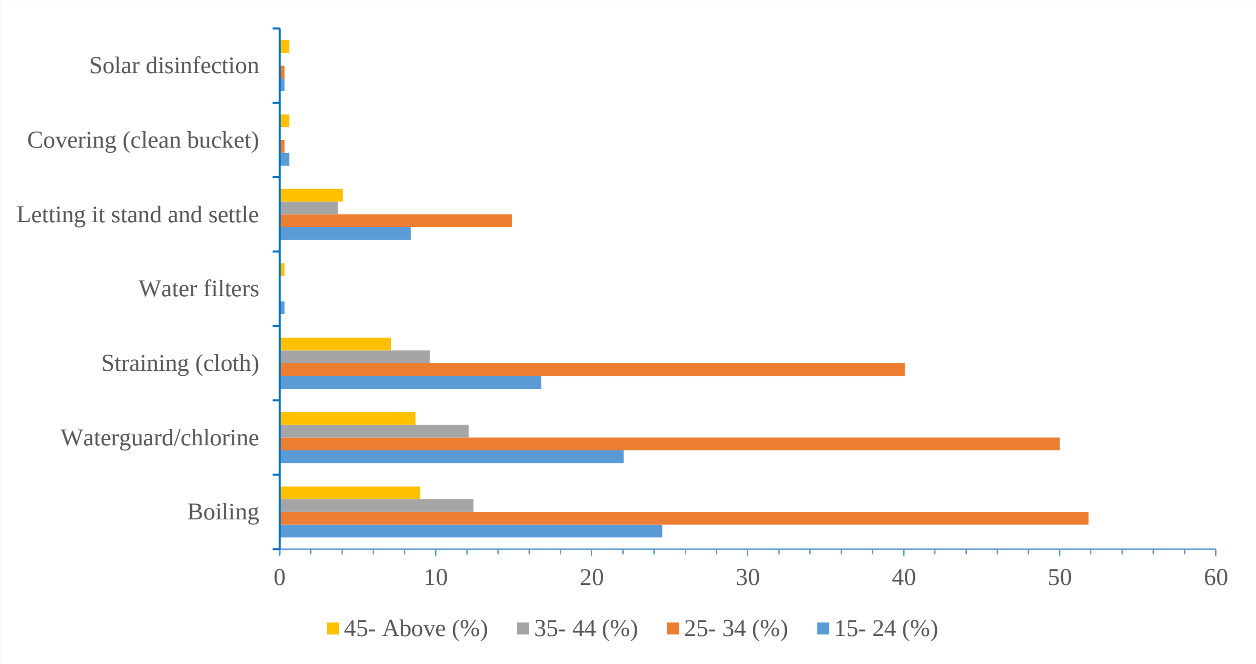

Figure 6: Awareness of POU water treatment by age

4.1.1.4 Knowledge of proven Point-of-Use water treatment methods by level of education

The results revealed that awareness of boiling and use of waterguard/chlorine was relatively high across all education levels with percentages ranging from (97%- 100%) for boiling and (89%- 100%) for waterguard/ chlorine. Use of water filters (10%) was the least known method and only known by those who had a tertiary education. Furthermore, the results revealed that those who had attained secondary education demonstrated the highest percentage of awareness in all but (use of water filters) POU water treatment methods (boiling 58%, waterguard/chlorine 56%, straining through a cloth 42%, letting stand and settle 17%, covering in a clean bucket 1% and solar disinfection 1%) (Figure 8). Chi-square test at 5% confidence level revealed a significant association between awareness of POU water treatment and level of education ($X^2 = 41.83$, df = 14, $p < .001$) (Table 5).

Table 4: level of education and awareness of POU water treatment methods of respondents

	Primary (%)	Secondary (%)	Tertiary (%)	X^2	df	*P*-value
Boiling	97.3	97.9	100	41.83	14	.000
Adding waterguard/chlorine	89.1	94.2	100			
Straining through a cloth	78.2	70.2	81.0			
Using water filter (ceramic, sand...)	0.0	0.0	9.5			
Letting it stand and settle	32.7	29.3	38.1			
Covering in a clean bucket	0.9	1.6	4.8			
Solar disinfection	0.9	1.0	4.8			
Don't know	0.0	0.0	0.0			

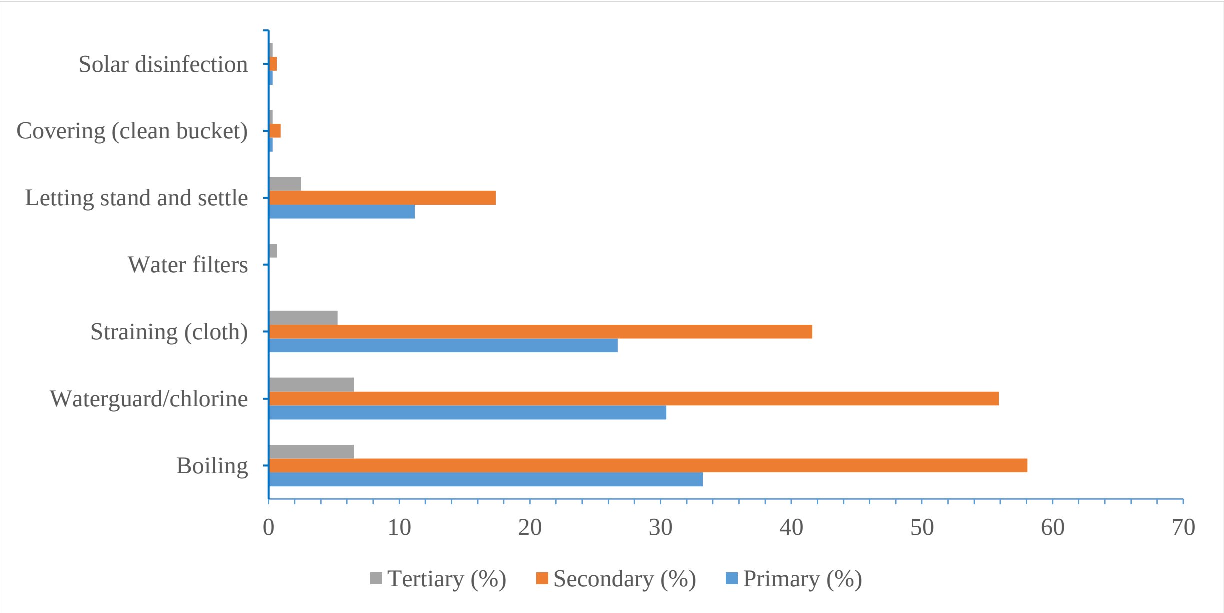

Figure 7: Level of education and awareness of POU water treatment methods of respondents.

4.1.1.5 Knowledge of proven Point-of-Use water treatment methods by religion

Table 6 presents data on the awareness of different point-of-use (POU) water treatment methods among respondents categorized by their religious affiliation.

The study was dominated by Christians (91%) with only (9%) being Muslims (Figure 9). This was also reflected in higher percentage of awareness across all POU water treatment methods i.e. Boiling (89%), waterguard/chlorine (84%), straining through a cloth (67%), water filters (1%), letting it stand and settle (29%), covering in a clean bucket (2%) and solar disinfection (1%). To determine if awareness of POU water treatment methods was associated with a respondent’s religious affiliation, a chi-square test was used at 5% confidence level. And the results revealed an insignificant association between awareness of POU water treatment methods and religion (X^2 = 11.38, df = 7, p= .123).

Table 5: Respondent's religion and their awareness of POU water treatment methods

	Christian (%)	**Islam (%)**	**Traditional (%)**	**X^2**	**df**	***P*-value**
Boiling	98.6	90.0	0.0	11.38	7	.123
Adding waterguard/chlorine	93.2	90.0	0.0			
Straining through a cloth	73.6	73.3	0.0			
Using water filter	0.7	0.0	0.0			
Letting it stand and settle	31.5	26.7	0.0			
Covering in a clean bucket	1.7	0.0	0.0			
Solar disinfection	1.4	0.0	0.0			
Don't know	0.0	0.0	0.0			

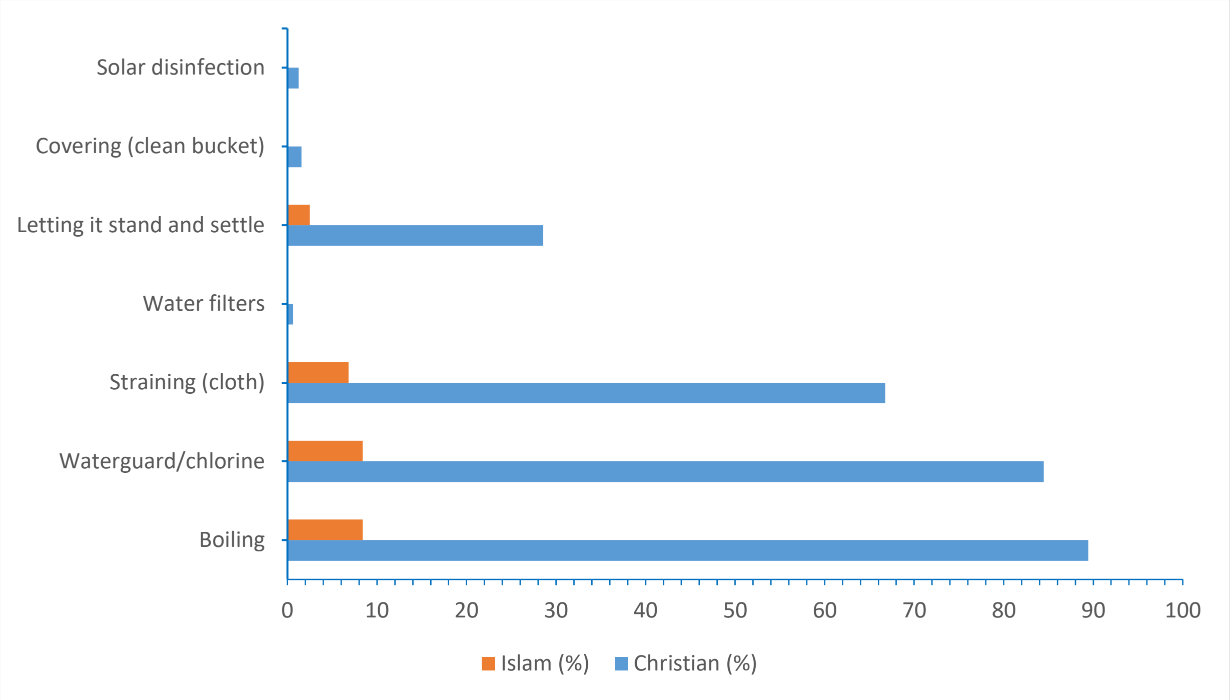

Figure 8: Respondent's religious affiliation and their awareness of POU water treatment methods.

4.1.1.6 Knowledge of proven Point-of-Use water treatment methods by household main source of income

Table 7 and Figure 10, illustrate respondents' main sources of income and their knowledge of POU water treatment methods. The results show that most (57%) of the respondents were entrepreneurs. And they demonstrated the highest percentage of awareness across all but (filters) POU water treatment methods (boiling, 54%; waterguard/chlorine, 52%; straining through a cloth, 40%; letting it stand and settle, 14%; covering in a clean bucket, 1%; and solar disinfection, 1%). Furthermore, only those with formal employment were aware of water filters (1%). However, chi-square test at 5% significance level revealed an insignificant association between awareness of POU water treatment and household main sources of income ($X^2 = 31.31$, df = 21, p= .069).

Table 6: Respondents sources of income and their knowledge of POU water treatment methods

	Cash remittance (%)	Casual labour (%)	Entrepreneurship (%)	Formal employment (%)	X^2	df	*P*-value
Boiling	100	100	96.2	100	31.31	21	.069
Adding waterguard	85.7	88.6	91.2	98.9			
Straining through a cloth	71.4	75.0	70.3	79.8			
Using water filter	0.0	0.0	0.0	2.2			
Letting it stand and settle	57.1	34.1	25.3	39.3			
Covering in a clean bucket	0.0	0.0	2.2	1.1			
Solar disinfection	0.0	0.0	1.6	1.1			
Don't know	0.0	0.0	0.0	0.0			

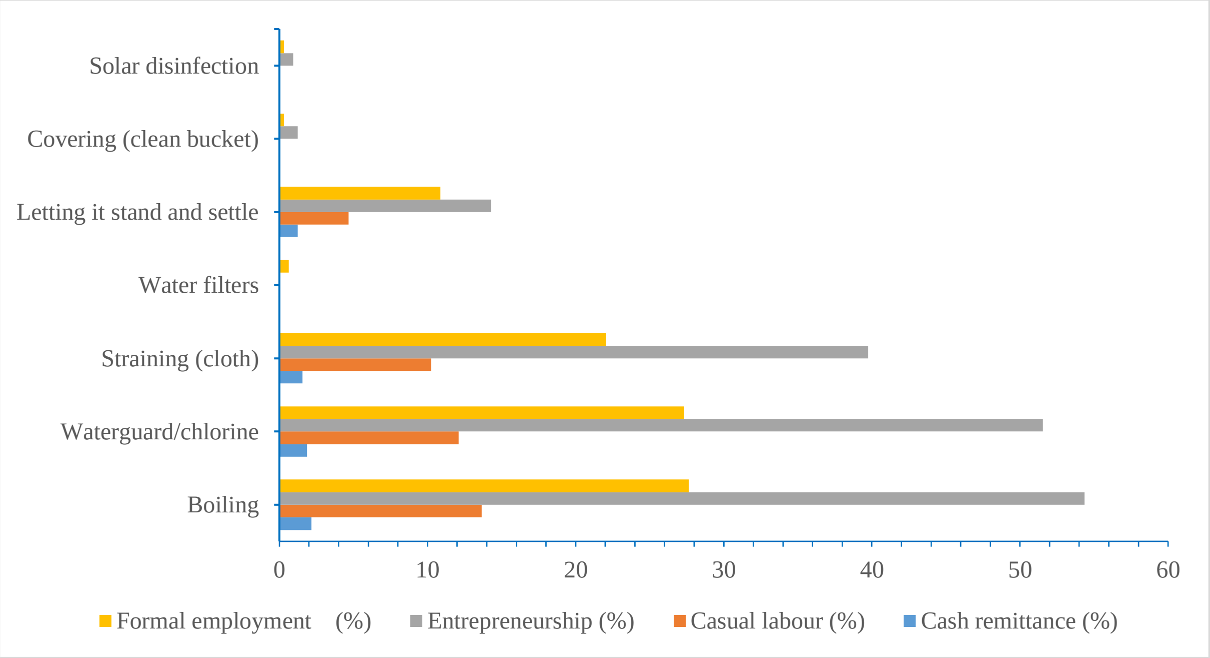

Figure 9: Respondents sources of income and their knowledge of POU water treatment methods.

4.1.1.7 Knowledge of proven POU water treatment methods by household income per month

Figure 11, show results of the relationship between respondents' awareness of POU water treatment and their monthly income. The results showed that respondents (40%) who made a monthly income ranging from K21,000 - K40, 000 had the highest level of knowledge of boiling (40%), use of chlorine (37%), straining through a cloth (30%), letting stand and settle (12%), covering in a clean bucket (1%) and solar disinfection (1%). Furthermore, only those who had a monthly income above K80, 000 were aware of water filters (1%). A chi-square test at 5% level of significance revealed a significant association between awareness of POU water treatment and respondents' monthly income (X^2 = 48.72, df = 28, p= .009).

Table 7: Awareness of POU water treatment methods by respondent's monthly income

	below K20,000	**K21,000 - K40,000**	**K41,000 - K 60,000**	**K61,000 - K80,000**	**Above K80,000**	**X^2**	**Df**	***P*-value**
Boiling	95.7	99.2	92.5	100	100	48.72	28	.009
Adding waterguard	85.5	91.5	97.5	100	98.2			
Straining through a cloth	66.7	75.2	65.0	85.7	78.6			
Using waterfilter	0.0	0.0	0.0	0.0	3.6			
Letting it stand and settle	30.4	29.5	22.5	35.7	39.3			
Covering in a clean bucket	0.0	1.6	2.5	0.0	3.6			
Solar disinfection	0.0	1.6	0.0	0.0	3.6			

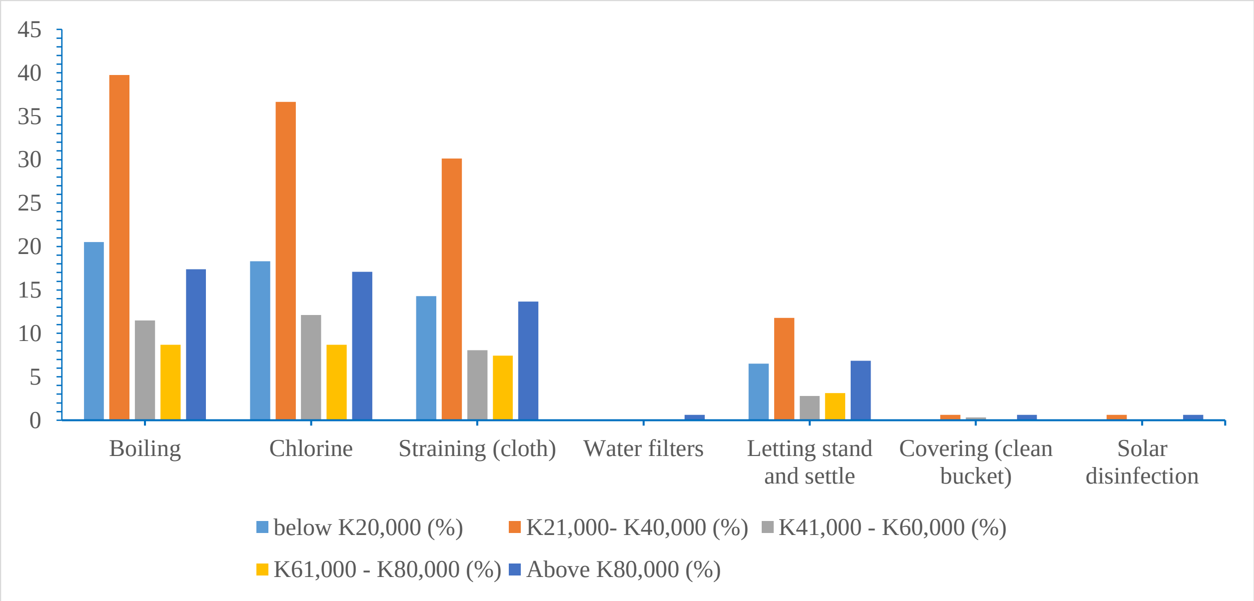

Figure 10: Awareness of POU water treatment methods by respondent's monthly income.

4.1.1.8 Knowledge of proven Point-of-Use water treatment methods by household assets

Table 9 illustrates a relationship between respondents' awareness of POU water treatment and the assets they had. Overall, the data from the table indicates that awareness of POU water treatment methods varies significantly across different household assets. While some assets, particularly cell phones (95% -100%) and beds (92%- 100%), demonstrate relatively high awareness across multiple water treatment methods, other assets show limited to no awareness. To determine if awareness of POU water treatment methods was associated with the respondents' assets, a chi-square test was conducted at 5% level of significance. The results revealed a significant association between awareness of POU water treatment and respondents' assets (X^2 = 177.52, df = 105, p< .001).

Table 8: Respondent's awareness of POU water treatment by household assets

	Boiling (%)	Waterguard (%)	Straining with cloth (%)	water filter (%)	Letting settle (%)	Covering in bucket (%)	Solar disinfection (%)	X^2	Df	*P*-value
Radio	27.9	30.1	27.0	100	26.0	60.0	50.0	177.52	105	.000
Television	52.7	55.2	53.2	100	52.0	100	100			
Cell phone	95.6	95.7	94.9	100	96.0	100	100			
Newspaper	5.7	6.4	6.3	0.0	7.0	0.0	0.0			
Bicycle	19.7	19.7	20.7	0.0	18.0	0.0	0.0			
Computer	3.2	3.3	4.2	50.0	6.0	0.0	0.0			
Refrigerator	28.9	30.4	29.5	100	34.0	40.0	25.0			
Internet	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Washing machine	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Water geyser	1.9	2.0	1.7	0.0	2.0	0.0	0.0			
Bed	93.7	93.6	92.4	100	93.0	100	100			
Sofa	56.5	59.2	56.5	100	60.0	100	100			
Dining table	70.8	72.2	71.7	100	71.0	80.0	75.0			
Press iron	16.5	17.4	18.6	100	24.0	40.0	25.0			
Fan	9.8	11.0	11.8	100	12.0	20.0	25.0			
Motorcycle	1.9	2.0	2.1	0.0	1.0	0.0	0.0			
Sewing machine	0.3	0.3	0.0	0.0	0.0	0.0	0.0			

Sources of information

Table 10 and Figure 12 below, present results of respondents' awareness of POU water treatment methods and the pathways of POU water treatment methods. The results revealed that media (40% -100%) and religious centres (60% - 100%) were the most formidable pathways of information on POU water treatment methods. A chi-square test at 5% level of significance revealed a significant association between awareness of POU water treatment and respondents' monthly income (X^2 = 367.88, df = 84, p< .001).

Table 9: Respondents awareness of POU water treatment by pathways of information

	Boiling (%)	**Adding waterguard (%)**	**Straining (cloth) (%)**	**Using water filter (%)**	**Letting it stand and settle (%)**	**Covering in a clean bucket (%)**	**Solar disinfection (%)**	**X^2**	**Df**	***P*-value**
Household visits	45.1	46.2	53.2	100	62.0	60.0	75.0	367.88	84	.000
Group training	1.0	1.0	0.8	0.0	0.0	0.0	0.0			
Media (radio, tv, newspapers)	89.5	89.6	92.8	100	91.0	40.0	50.0			
Mobile messaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
From child through school	11.1	11.7	11.8	0.0	8.0	20.0	25.0			
Religious centre	72.7	72.6	79.3	100	80.0	60.0	75.0			
Hospital	16.2	16.4	16.5	0.0	17.0	20.0	0.0			
School	15.6	16.4	18.6	50.0	18.0	20.0	0.0			
Parents	10.5	9.0	9.3	50.0	9.0	20.0	25.0			
Friends	1.3	2.0	1.7	0.0	1.0	0.0	0.0			
Healthy meetings	1.0	1.0	1.3	50.0	1.0	20.0	25.0			
Spouse	0.3	0.3	0.4	0.0	0.0	0.0	0.0			
Mobile van campaign	1.3	1.3	1.3	0.0	1.0	0.0	0.0			

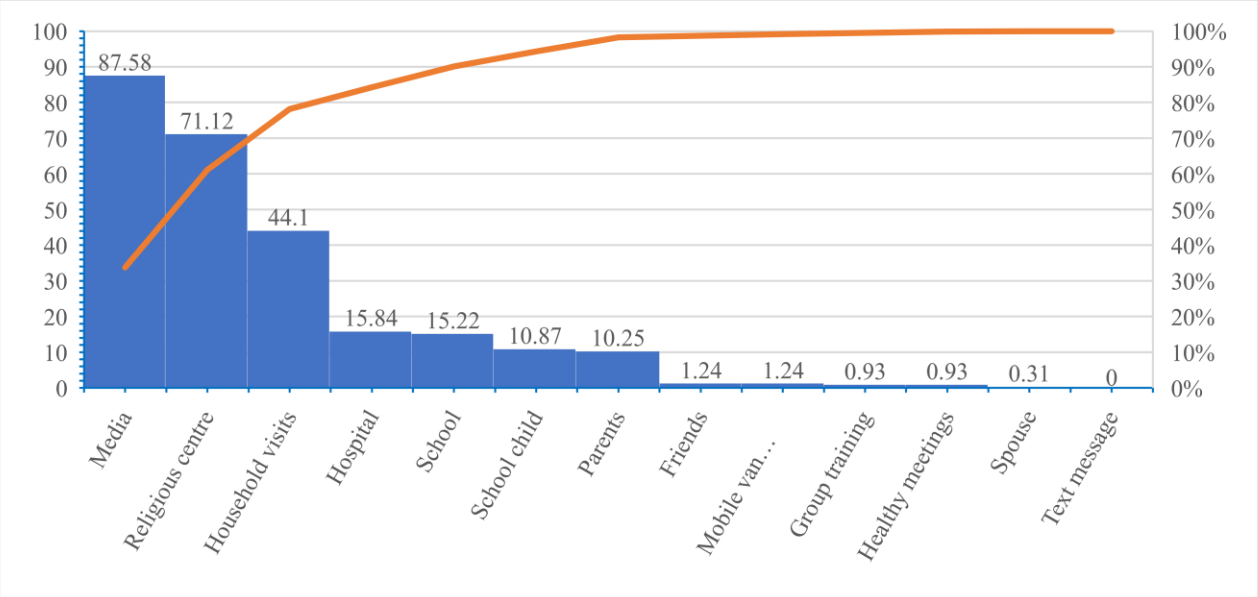

Figure 11: Respondents awareness of POU water treatment by pathways of information.

Knowledge of proven Point-of-Use water treatment methods by main source of drinking water

Table 11 presents respondents' main sources of drinking water and awareness of POU water treatment methods. Each row represents a specific main source of drinking water, while the columns represent different methods of POU water treatment. The percentages in the table indicate the level of awareness for each POU water treatment method across all sources of drinking water.

The results revealed that respondents who collected their drinking water from community standpipes demonstrated relatively high percentages of awareness of POU water treatment across all POU water treatment methods than the rest (44% - 75%).

A chi-square test of significance at 5% level of significance revealed a significant association between awareness of POU water treatment methods and respondents' main source of drinking water (X^2 = 58.54, df = 35, p= .008).

Table 10: Respondents awareness of POU water treatment by HH sources of water

	Boiling (%)	Adding waterguard(%)	Straining (cloth) (%)	Using water filter (%)	Letting it stand and settle (%)	Covering in a clean bucket (%)	Solar disinfection (%)	X2	df	P-value
Borehole	1.6	2.0	1.3	0.0	0.0	0.0	0.0	58.54	35	.008
Community standpipe	47.6	44.5	43.9	0.0	46.0	60.0	75.0			
Piped into dwelling	9.2	10.0	10.5	50.0	17.0	20.0	25.0			
Piped into yard/ plot	40.3	42.1	42.6	50.0	35.0	20.0	0.0			
Protected well	0.6	0.7	0.8	0.0	2.0	0.0	0.0			
Unprotected well	0.6	0.7	0.8	0.0	0.0	0.0	0.0			

Assessment of knowledge and awareness of POU water treatment products and their health benefits

The study revealed that majority of people (100%) knew where they can get materials for them to treat water in their homes. Furthermore, majority of the respondents (100%) agreed to the notion that POU water treatment reduces the risk of contracting water borne diseases, demonstrating a high level of awareness of the health benefits of POU water treatment.

Table 11: Knowledge of access to POU water treatment products/materials and healthy benefits

Survey questions	Frequency (*n=322*)	Percentage
Do you know where you can buy new POU water treatment products/parts replace broken parts?	321	99.7%
Do you think consuming untreated water puts a person at risk of contracting water borne diseases?	321	99.7%
Do you think POU water treatment can reduce the risk of contracting water borne diseases?	322	100%

4.4 Perceptions on point-of-use water treatment methods

Status of the responded regarding POU water treatment.

The study revealed that majority (71%) of the people treated their water before consumption with (29%) of people reported not to treat their water before consumption (figure 13).

A logistic regression was performed to ascertain the effects of age, community, marital status, education, household main source of income, household income per month, household main source of drinking water, awareness of POU water treatment, sources of information and household assets on the likelihood that participants practice POU water treatment. The logistic regression model was statistically significant, $\chi^2(10) = 24.573$, $p < .006$. The model explained 11% (Nagelkerke R^2) of the variance in practice of POU water treatment and correctly classified 73% of cases.

The results revealed that an increase in unit on community was associated with an increased likelihood of practicing POU water treatment while increasing household assets was associated with reduced likelihood of practicing POU water treatment (Table 13).

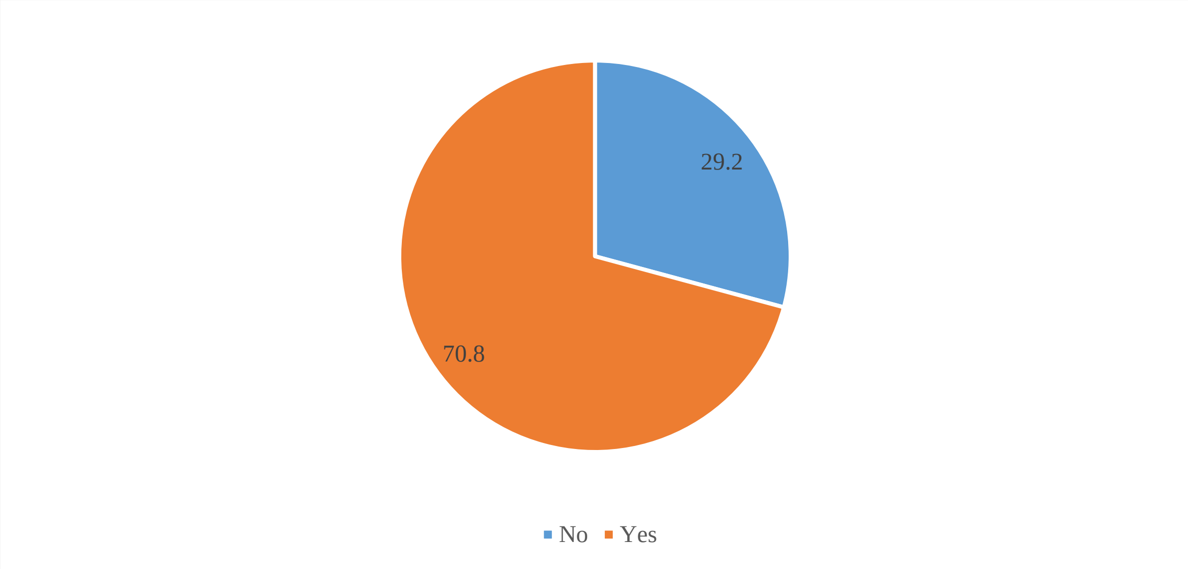

Figure 12: Practice of POU water treatment among respondents.

Table 12: Factors and odds ratio for the practice of POU water treatment among respondents

	B	**S.E.**	**df**	**Sig.**	**Exp(B)**
Age	.088	.160	1	.582	1.092
Community	.241	.085	1	.005	1.273
Marital status	.239	.205	1	.244	1.270
Education	.207	.282	1	.462	1.230
Household main source of income	.416	.237	1	.079	1.516
Household income per month	.000	.000	1	.703	1.000
Household main source of drinking water	-.322	.141	1	.022	.725
Awareness of POU water treatment	.162	.157	1	.301	1.176
Sources of Information	-.100	.128	1	.432	.904
Household assets	-.203	.086	1	.019	.816
Constant	.234	.697	1	.737	1.264

The most convenient POU water treatment method/technology used.

The results from the study showed that the majority of people (62%) had boiling as their most convenient method of POU water treatment. Only (9%) of the people found waterguard/chlorine as their most convenient method (Figure 14).

A multinomial logistic regression was performed to ascertain the effects of age, community, marital status, education, household main source of income, household income per month, household main source of drinking water, awareness of POU water treatment, sources of information and household assets on the likelihood of participants choosing one POU water treatment as a convenient method over the other or not at all. The dependent variable (Respondent most convenient POU water treatment method) had three categories thus, none, adding waterguard/chlorine and boiling. None was set to be the reference (baseline) category while adding waterguard/chlorine and boiling were the comparison groups. The model was statistically significant, $\chi^2(18) = 34.803$, $p < .010$. The model explained 12% (Nagelkerke R^2) of the variance in respondents' most convenient POU water treatment method and correctly classified 64% of cases.

On adding waterguard/chlorine category, the "community" predictor was positive and significant (*B*= .396, S. E= .146, *p*< .007). Thus, an increase in one unit of community was associated with an increased likelihood of a respondent choosing adding waterguard/chlorine as the most convenient POU water treatment method relative to the baseline category (None).

On boiling category, the "community" predictor was positive and significant (*B*= .211, S. E= .086, *p*<.014). Thus, an increase in one unit of community was associated with an increased likelihood of a respondent choosing boiling as the most convenient POU water treatment method relative to the baseline category (None). However, the "household assets" predictor was negative and significant (*B*= -.272, S. E= .086, p<.002), thus an increase in one unit of household assets was associated with a decreased likelihood of a respondent choosing boiling as the most convenient POU water treatment method relative to the baseline category (None).

Table 14 below, provides detailed results of the relationship between the dependent variable categories and the predictors.

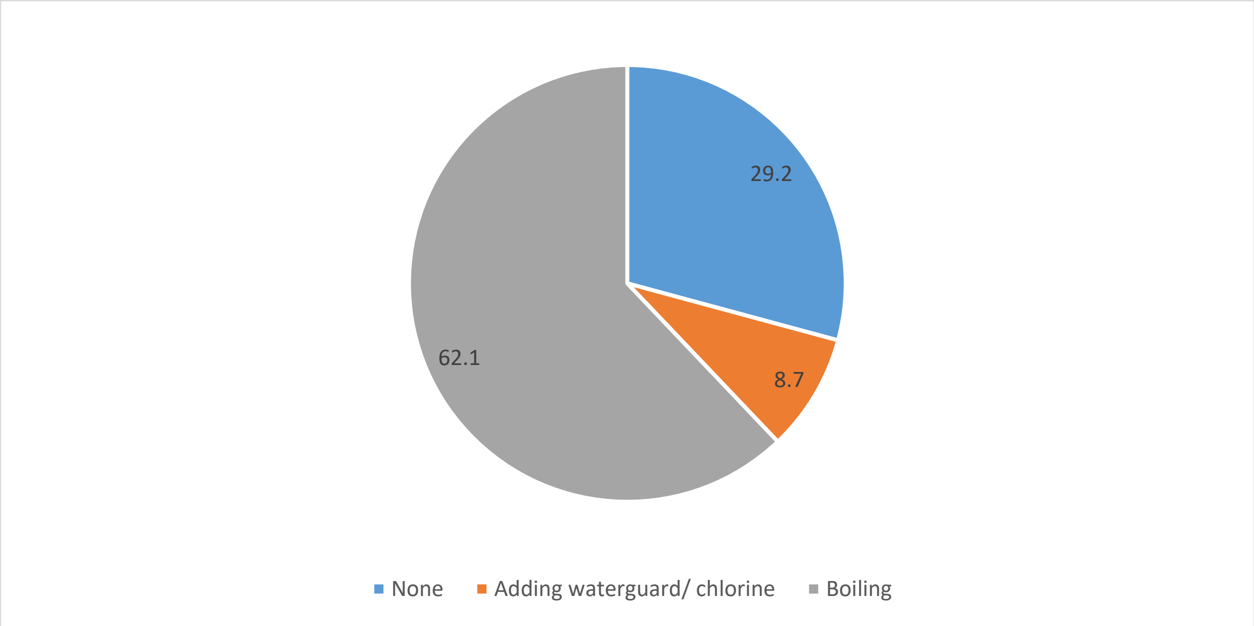

Figure 13: Respondent's most convenient POU water treatment method used.

Table 13: Predictors and odds ratio for respondents most convenient POU water treatment methods

		B	S.E.	df	Sig.	Exp(B)
Adding waterguard/ chlorine	Intercept	-1.345	1.184	1	.256	
	Community	.396	.146	1	.007	1.486
	Age	.058	.261	1	.825	1.059
	Education	.752	.502	1	.134	2.122
	Source of income	-.117	.403	1	.772	.890
	Sources of Information	-.349	.236	1	.140	.706
	Household assets	-.115	.138	1	.404	.892
	Monthly income	.000	.000	1	.450	1.000
Boiling	Intercept	-.056	.707	1	.937	
	Community	.211	.086	1	.014	1.235
	Age	.021	.160	1	.897	1.021
	Education	.117	.284	1	.681	1.124
	Source of income	.402	.240	1	.094	1.494
	Sources of Information	-.070	.130	1	.589	.932
	Household assets	-.272	.086	1	.002	.761
	Monthly income	.000	.000	1	.624	1.000

a. The reference category is: None.

Preference for treated water

The study results showed that majority (39%) of the respondents who used boiling to treat their water, did not have any problems with taste of the treated water. Most of the respondents (6%) who used waterguard/chlorine to treat their water also had no problems with taste of treated water. Interestingly, even majority (14%) of the respondents who did not treat their water also reflected that they had no issues with taste of treated water. Chi-square test revealed a significant association (X^2= 17.098, P= 0.002) between the POU water treatment method a respondent used and preference for treated water (Table 15).

Table 14: Respondent's perceptions towards treated water

	Treated water devour my liking for the water				
Convenient method	**Agree (%)**	**Disagree (%)**	**Undecided (%)**	**Chi square**	***P*-value**
None	9.01	13.66	6.52	17.098	0.002
Waterguard/ chlorine	3.11	5.59	0.00		
Boiling	18.32	38.51	5.28		

Ease of operation of POU water treatment methods/technologies

Majority of respondents (62%) who used boiling to treat water did not have any problems with operation of the method. Most of the respondents (8%) who used waterguard/chlorine, agreed to ease of operation of the method. Even most of the respondents (27%) who did not treat water had no issues with operation of the methods or technologies available. A chi-square test at 95% confidence level revealed a significant association (X= 15.446, P= 0.004) between a respondent's method of POU water treatment and ease of operation (Table 16).

Table 15: Ease of operation of POU water treatment methods/technologies

	It is easy to always treat drinking correctly				
Convenient method	**Agree (%)**	**Disagree (%)**	**Undecided (%)**	**Chi square**	***P*-value**
None	26.71	1.24	1.24	15.446	0.004
Waterguard/ chlorine	8.39	0.31	0.00		
Boiling	61.80	0.31	0.00		

Accessibility of POU water treatment methods/technologies in the area

The study showed that most of the respondents (42%) who used boiling as a POU water treatment method used it because it was easily accessible in their area. Likewise, (5%) of the respondents had easy access to waterguard/chlorine. It is also worth noting that (14%) of respondents who did not treat water in their homes had access to POU water treatment methods and technologies. Chi-square tests revealed a significant association (X^2= 34.859, P= 0.001) between a respondent's choice of POU water treatment method and its ease of access at (95%) confidence level (Table 17).

Table 16: Accessibility of POU water treatment methods/technologies

	POU water treatment methods or technologies are easily accessible in your area				
Convenient method	**Agree (%)**	**Disagree (%)**	**Undecided (%)**	**Chi square**	***P*-value**
None	13.66	11.80	3.73	34.859	0.001
Waterguard/ chlorine	4.97	3.73	0.00		
Boiling	41.61	20.50	0.00		

Affordability of POU water treatment methods/technologies in the area

The majority (56%) of respondents who used boiling to treat water agreed to having the method/technology affordable in their area. In addition, (7%) of the respondents who used waterguard/chlorine found the method/ technology affordable. Even those who did not treat water in their households (21%), agreed to having the methods/technologies affordable in their area. Chi-square tests revealed a significant association (X^2 =30.96, P=0.001) between a respondent's choice of POU water treatment method/technology and its affordability in their area.

Table 17: Affordability of POU water treatment methods/technologies

	Are POU water treatment methods or technologies affordable in your area?				
Convenient method	**Agree (%)**	**Disagree (%)**	**Undecided (%)**	**Chi square**	***P*-value**
None	21.43	3.73	4.04	30.957	0.001
Waterguard/ chlorine	7.14	1.55	0.00		
Boiling	55.59	6.21	0.31		

4.5 Factors affecting adoption of POU water treatment.

This section presents results pertaining to various factors influencing POU water treatment practices. These factors include self-efficacy, consequences, social norms, access, cues for action, susceptibility, severity, action efficacy, Devine will, policy, culture as well as resource availability, standards and certification, regulations, market strategies and user guidance. The integration of these results provides a comprehensive understanding of the complexities and influences shaping POU water treatment practices.

Quantitative results

Self-efficacy

This factor had two survey questions which dug the enablers and barriers to POU water treatment, thus, what makes it easier for those who practiced POU water treatment and what makes it difficult for those who did not practice POU water treatment. The enablers included availability of materials and access, availability of money, technical knowhow, knowledge of health benefits, convenience of the method, distance to the shops, support from other household members, belief that tap water is clean hence doesn’t need treatment, and belief in God's care. The barriers included lack of technical know-how, lack of money, lack of materials, long distance to shops, inconvenience of the method, lack of knowledge of health benefits, long waiting time, maintenance requirements, lack of support from other household members, belief that tap water is clean hence doesn’t need treatment.

A logistic regression was conducted to ascertain the effect the enablers and barriers had on POU water treatment.

Self-efficacy (enablers)

The overall model was statistically significant when compared to the null model, ($\chi^2(9)$ = 216.540, $p < .001$). The model explained 70% (Nagelkerke R^2) of the variance in POU water treatment and correctly classified 71% of cases.

The results revealed that availability of materials and access (B=2.135, p<.001) had a significant positive relationship with the dependent variable. Increasing one unit of availability of materials and access was associated with an increase in the likelihood of the respondent practicing POU water treatment. Availability of money (B= -2.443, p<.001) had a significant negative relationship with the dependent variable. Increasing one unit of availability of money was associated with reduced likelihood of the respondent practicing POU water treatment. Knowledge of health benefits (*B*=4.182, *p*<.001) also had a significant positive relationship with the dependent variable. Increasing one unit of Knowledge of health benefits was associated with an increase in the likelihood of the respondent practicing POU water treatment. Furthermore, convenience of the method (*B*= -1.405, *p*<.003) had a significant negative relationship with the dependent variable. Increasing one unit of convenience of the method was associated with a decrease in the likelihood of the respondent practicing POU water treatment (Table 19).

Table 18: Enablers to POU water treatment (self-efficacy)

	B	S.E.	df	Sig.	Exp(B)
Availability of materials and access	2.135	.626	1	.001	8.455
Availability of money	-2.443	.634	1	.000	.087
Technical knowhow	.877	.784	1	.263	2.404
Knowledge of health benefits	4.182	.617	1	.000	65.497
Convenience of the method	-1.405	.480	1	.003	.245
Support from other household members	-1.654	.958	1	.084	.191
Belief that tap water is clean and doesn't need treatment	-20.456	15373	1	.999	.000
Belief in God's care	-18.432	40192	1	1	.000
Constant	-1.367	.659	1	.038	.255

Self-efficacy (barriers)

The overall model was statistically significant when compared to the null model, ($\chi^2(9)$ = 66.612, p < .001). The model explained 27% (Nagelkerke R^2) of the variance in POU water treatment and correctly classified 79% of cases.

The results revealed that inconvenience of the method (*B*= -2.577, *p* < .001), long waiting time (*B*= -.825, *p* < .033) and belief that tap water is clean and doesn't need treatment (*B*= -3.282, *p* < .004) were the barriers with a significant negative relationship with the dependent variable. Thus, an increase in one unit of each of the variables was associated with a reduced likelihood of the respondent practicing POU water treatment (Table 20).

Table 19: Barriers to POU water treatment (self-efficacy)

	B	S.E.	df	Sig.	Exp(B)
Lack of technical know how	-.783	.643	1	.224	.457
Lack of money	-.228	.376	1	.544	.796
Lack of materials	-.214	.380	1	.572	.807
Long distance to shops	-.389	.817	1	.634	.678
Inconvenience of the method	-2.577	.436	1	.000	.076
Lack of knowledge of health benefits	1.343	1.530	1	.380	3.831
Long waiting time	-.825	.388	1	.033	.438
Lack of support from other household members	-1.131	.519	1	.029	.323
Belief that tap water is clean and doesn't need treatment	-3.282	1.130	1	.004	.038
Constant	1.844	.402	1	.000	6.321

Consequences

This factor looked at the advantages (positive consequences) and disadvantages (negative consequences) of POU water treatment. The advantages included reducing harmful germs and bacteria (pathogens), eliminating unpleasant smells (Odor), and clearing up cloudy water (turbidity). The disadvantages revealed included changed water taste, costly maintenance, persistent thirst, high operational expenses, boiling accidents from spills, diarrhoea from excessive chlorine, reduced effectiveness without technical knowhow, and longer adjustment time for consistency.

A logistic regression was performed to ascertain the effects; killing pathogens, removing Odor, reducing turbidity, changed water taste, costly maintenance, persistent thirst, high operational costs, boiling accidents from spills, diarrheal from excessive chlorine, reduced effectiveness without technical knowhow, and longer adjustment time for consistency on the likelihood of respondents practicing POU water treatment. The overall model was statistically significant when compared to the null model, ($\chi^2(8)$ = 24.607, p < .002). The model explained 11% (Nagelkerke R^2) of the variance in POU water treatment and correctly classified 71% of cases.

The results revealed that only Reducing turbidity (*B*= 1.011, *p* < .001) was statistically significant and had a positive relationship with the dependent variable. Thus, when POU water treatment effectively reduces turbidity in water, people are more likely to treat their water before consuming it.

Table 20: Advantages and disadvantages of POU water treatment

	B	**S.E.**	**df**	**Sig.**	**Exp(B)**
Reducing turbidity	1.011	.257	1	.000	2.747
Change of taste	-1.105	.991	1	.265	.331
High operational costs	.294	.385	1	.445	1.342
Diarrhoea from excessive chlorine	1.136	1.231	1	.356	3.113

Reduced effectiveness without technical knowhow	1.140	1.135	1	.315	3.127
Constant	.246	.194	1	.205	1.279

Social norms

This factor looked at the society's approval of people who practiced POU water treatment. This also included a look at all the people who approved or disapproved of the respondent's POU water treatment practice. Some of the subjects included spouse, parents, friends, relatives, block leaders, church leaders, ward councillor, health extension worker, teachers, and neighbours.

The results revealed that majority of the respondents (98%) had approval of most of the people they knew from the society. Chi-square test at 95% confidence level revealed a significant association (X^2= 13.493, P< 0.001) between the society's approval and the respondent's POU water treatment practice (Table 15).

Table 21: Approval and disapproval of POU water treatment by the society among individuals

	Frequency	Percent (%)	Chi Square	p-value
Maybe	8	2.5	13.493	.000
Yes	314	97.5		

A logistic regression was performed to ascertain the effects spouse, parents, friends, relatives, block leaders, church leaders, ward councillor, health extension worker, teachers and neighbours had on the likelihood of respondents practicing POU water treatment. The overall model was statistically significant when compared to the null model, ($\chi^2(6) = 13.065$, $p < .042$). The model explained 6% (Nagelkerke R^2) of the variance in POU water treatment and correctly classified 72% of cases.

The results revealed that only Friends (*B*= .956, *p* < .023) had a significant and positive relationship with the dependent variable. Thus, if friends would advocate more for POU water treatment, people are more likely to treat their water before consumption (Table 23).

Table 22: Approval and Disapproval of POU Water Treatment Practice among Individuals in the Society

	B	S.E.	df	Sig.	Exp(B)
Spouse	-.122	.357	1	.731	.885
Parents	-.606	.429	1	.158	.546
Friends	.956	.420	1	.023	2.602
Relatives	.474	.760	1	.533	1.606
Block leaders	.807	.692	1	.244	2.240
Church leaders	-.478	.758	1	.528	.620
Ward councillor	.057	.308	1	.852	1.059
Health extension worker	-.514	1.103	1	.641	.598
Neighbours	.247	.552	1	.654	1.281
Constant	-.131	.765	1	.864	.877

Access

This factor looked at how difficult it was for the participants who either practiced or did not practice POU water treatment to get the materials and services one needed to treat water before consumption. The results revealed that majority (78%) of the people who did not practice POU water treatment found it somewhat difficult to get the materials and services needed to treat water before consumption. Nevertheless, majority (73%) of those who practiced POU water treatment also found it somewhat difficult to get the materials and services needed to treat water before consumption.

A chi-square test at (95%) confidence level was used to determine if there was a significant association between the practice of POU water treatment and access to materials and services required for one to treat water before consumption. The chi-square test results revealed that there was no significant association ($\chi^2(2) = 1.893$, $p < .388$) between the practice of POU water treatment and access to materials and services required for one to treat water before consumption (Table 24).

Table 23: POU water treatment practice and access to POU water treatment materials and services

How difficult is it to get the materials and services you need to treat water before consumption?						
Do you treat water before consumption?		Not difficult at all (%)	Somewhat difficult (%)	Very difficult (%)	Chi Square	P-value
	No	20.2	77.7	2.1	1.893 (2)	.388
	Yes	25.9	73.2	0.9		

Cues for action

This factor looked at how difficult it was for the participants to remember treating water every time before consumption. The study revealed that majority (93%) of the people who practiced POU water treatment did not find it difficult at all remembering to treat water every time before consumption. Nevertheless, even those who did not practice POU water treatment, majority (65%) of them said that it wouldn’t be difficult at all remembering to treat water every time before consumption.

A chi-square test at (95%) confidence level was used to determine if there was a significant association between the practice of POU water treatment and remembering to treat water every time before consumption. The chi-square test results revealed that there was a significant association ($\chi^2(1) = 38.795$, $p < .001$) between the practice of POU water treatment and remembering to treat water every time before consumption (Table 25).

Table 24: POU water treatment practice and cues for action

		How difficult is it (would be) to remember to treat water every time before consumption?			
		Not difficult at all (%)	Somewhat difficult (%)	Chi square	P- value
Do you treat water before consumption?	No	64.9	35.1	38.795 (1)	.000
	Yes	92.5	7.5		

Susceptibility/ risk

This factor looked at the likelihood of the study participants (or anyone in their family) getting diarrhoea in each period (next two weeks). The results revealed that majority (92%) of those who did not practice POU water treatment were at medium risk of contracting diarrhoea in that period. Again, majority (83%) of the participants who practiced POU water treatment were at medium risk of contracting diarrhoea in the given period.

A chi-square test at (95%) confidence level was used to determine if there was a significant association between the practice of POU water treatment and susceptibility of the participants to diarrhoea. The chi-square test results revealed that there was no significant association ($\chi^2(2)$

= 5.033, p < .081) between the practice of POU water treatment and susceptibility of the participants to diarrhoea (Table 26).

Table 25: POU water treatment practice and the participants susceptibility to diarrhoea

		How likely is it that you (or anyone in your family) would get diarrhoea in the next two weeks?				
Do you treat water before consumption?		Not likely at all (%)	Somewhat likely (%)	Very likely (%)	Chi square	P- value
	No	8.5	91.5	0.0	5.033 (2)	.081
	Yes	13.2	83.3	3.5		

Severity

This factor looked at how serious it would be if the participants (or anyone in their family) would get diarrhoea. The results revealed that majority (93%) of the people who did not practice POU water treatment and (95%) of those who practiced POU water treatment concurred on the severity being very serious in case of any of their household members contracting diarrhoea.

However, conducting a chi-square test at a 95% confidence level, revealed an insignificant (χ^2 (1) = 0.867, p = 0.352) association between the practice of POU water treatment and the perceived severity in the event of participants or their household members contracting diarrhoea (Table 27).

Table 26: POU water treatment practice and perceived severity

	How serious would it be if you (or anyone in your family) would get diarrhoea?

Do you treat water before consumption		Somewhat serious (%)	Very serious (%)	Chi square	P- value
	No	7.4	92.6	.867 (1)	.352
	Yes	4.8	95.2		

Action efficacy

The factor examined the likelihood of the participants (or anyone in their family) contracting diarrhoea if they did not treat water. The results revealed that majority (96%) of the participants who did not practice POU water treatment perceived medium likelihood of contracting diarrhoea in the absence of POU water treatment. Conversely, among participants who practiced POU water treatment, majority (54%) perceived a high likelihood of contracting diarrhoea without POU water treatment.

A chi-square test at a 95% confidence level was conducted to determine if there was a significant association between the practice of POU water treatment and perceived action efficacy. The results revealed a significant (χ^2 (1) = 81.230, $p < .001$) association between the practice of POU water treatment and the perceived action efficacy (Table 28).

Table 27: POU water treatment practice and perceived action efficacy

How likely is it that you (or anyone in your family) would get diarrhoea if you did not treat your water?						
Do you treat water before consumption?		Not likely at all (%)	Somewhat likely (%)	Very likely (%)	Chi square	P value
	No	4.3	95.7	0.0	81.230 (2)	.000

	Yes	2.6	43.9	53.5

Divine will

This factor examined the participants perception towards God's approval of practicing POU water treatment. The results revealed that majority (99%) of the people who did not practice POU water treatment and (100 %) of those who practiced POU water treatment concurred on God approving the practice of POU water treatment.

A chi-square test at a 95% confidence level was conducted to determine if there was a significant association between the practice of POU water treatment and perceived divine will. The results revealed a significant (χ^2 (2) = 7.345, $p < .025$) association between the practice of POU water treatment and the perceived divine will (Table 29).

Table 28: POU water treatment practice and perceived divine will

		Do you think God approves of you treating water before consumption?				
		Maybe (%)	No (%)	Yes (%)	Chi square	P- value
Do you treat water before consumption?	No	2.1	1.1	96.8	7.345 (2)	0.025
	Yes	0.0	0.0	100.0		

Policy

This factor explored the presence of any community laws or rules that participants identified as contributing to a higher likelihood of water treatment before consumption. The results revealed that majority (70%) of the people who did not practice POU water treatment and (64%) of those who practiced POU water treatment concurred on there being no community laws or rules in place that influenced them to practice POU water treatment.

However, a chi-square test conducted at 95% confidence level, revealed a significant (χ^2 (2) = 9.082, p < .011) association between the practice of POU water treatment and the presence of community laws or rules related to water treatment (Table 30).

Table 29: POU water treatment practice and policy

		Are there any community laws or rules in place that you know that make it more likely that you treat water before consumption?				
Do you treat water before consumption?		Maybe (%)	No (%)	Yes (%)	Chi square	P value
	No	20.2	70.2	9.6	9.082 (2)	.011
	Yes	13.2	63.6	23.2		

Culture

This factor examined the presence of cultural rules or taboos identified by participants that either encourage or discourage the practice of treating water before consumption. The results revealed that majority (61%) of the participants who did not practice POU water treatment were in dissidence with the presence of cultural rules or taboos that either encourage or discourage the practice of treating water before consumption. However, the majority (57%) of participants who practiced POU water treatment acknowledged the presence of cultural rules or taboos that either promote or discourage the practice of treating water before consumption.

A chi-square test at (95%) confidence level was used to determine if there was a significant association between the practice of POU water treatment and the presence of cultural rules or taboos that either encourage or discourage the practice of treating water before consumption. The chi-square test results revealed that there was no significant association (χ^2(2) = 17.113, p

< .001) between the practice of POU water treatment and the presence of cultural rules or taboos that either encourage or discourage the practice of treating water before consumption (Table 31).

Table 30: POU water treatment practice and culture

		Are there any cultural rules or taboos that you know of for or against treating water before consumption?				
Do you treat water before consumption?		Maybe (%)	No (%)	Yes (%)	Chi square	P- value
	No	4.3	60.6	35.1	17.113 (2)	.000
	Yes	0.4	42.5	57.0		

Overall, a logistic regression was performed to ascertain the effects of self-efficacy, positive consequences, negative consequences, social norms, access, cues for action, susceptibility/ risk, severity, action efficacy, divine will, policy, and culture on the likelihood of respondents practicing POU water treatment.

The overall model was statistically significant when compared to the null model, ($\chi^2(12)$ = 154.906, p < .001). The model explained 54.5% (Nagelkerke R^2) of the variance in POU water treatment and correctly classified 81.4% of cases.

Self-efficacy (p < .001), cues for action (p< .002), action efficacy (p < .001) had a significant positive relationship with the dependent variable, thus an increase in one unit of these factors was associated with an increase in the respondents' likelihood of practicing POU water treatment (table 32).

Table 31: Factors affecting adoption of POU water treatment.

	B	S.E.	Df	Sig.	Exp(B)
Self-efficacy	.937	.195	1	.000	2.552
Positive consequences	.399	.386	1	.301	1.490
Negative consequences	.330	.434	1	.447	1.391
Social norms	3.605	2.136	1	.092	36.792
Access	.002	.426	1	.996	1.002
Cues for action	-1.305	.416	1	.002	.271
Susceptibility	-.725	.537	1	.177	.484
Severity	.347	.765	1	.650	1.415
Action efficacy	2.831	.551	1	.000	16.964
Policy	.293	.337	1	.385	1.340
Culture	.385	.380	1	.311	1.470
Constant	-46.651	25138.246	1	.999	.000

Qualitative results (Focus Group Discussions)

A total of five Focus Group Discussions (FGDs) were conducted with female participants to explore the factors influencing the adoption of Point-of-Use (POU) water treatment. The interviews took place in Mzilawayingwe, Chiputula, Zolozolo West, Area 1B, and Lupaso wards from April 8th to April 13th, 2022. Each group consisted of eight participants, with an equal representation of POU water treatment practitioners (Doers) and non-practitioners (non-doers). Participants were assigned numbers from 1 to 8, with the first letter of the ward's name followed by 'D' or 'N' to indicate their POU water treatment status.

Although specific demographic information was not recorded, there were variations in age across the groups. Nevertheless, all participants actively engaged in the discussions and demonstrated a high level of involvement throughout the sessions. The interviews were conducted for a minimum duration of 45 minutes.

Boiling emerged as the most prevalent Point-of-Use (POU) water treatment method across all wards, with 70% of the individuals who practiced POU water treatment (Doers) preferring boiling. The remaining 30% opted for chlorination or Waterguard. Interestingly, a significant portion of the non-practitioners (non-doers) also indicated a preference for boiling, with 60% expressing willingness to use this method if they were to treat their water before consumption.

Self-efficacy

1.3.2.1 Enablers

Among practitioners of Point-of-Use (POU) water treatment across all wards, several prominent enablers emerged. These included knowledge of health benefits, ease of access to POU water treatment materials and services, ease of operation and affordability.

When participants were asked about the factors that made it easier for them to treat water before consumption, the FGDs in Mzilawayingwe, Lupaso, Zolozolo and Area 1B identified awareness of health gains that comes with POU water treatment. Nevertheless, boiling emerged predominant, hence availability of firewood particularly during that time of the year made it easy for people to treat water before consumption especially in Mzilawayingwe, Zolozolo west and Chiputula which are close to Lunyangwa Forest.

As described in Mzilawayingwe focus group discussion: "*it is easy for me because I know that when I boil my water it will kill all the germs, and my family will be safe.*" -(MD1)

> "*Firewood for boiling is easily accessible especially this time of the year.*"- (MD4)

> As described in Lupaso focus group discussion: "*we always have firewood or charcoal for cooking, we use the same for boiling drinking water*"- LD7.

Furthermore, participants shed light on the remarkable ease of operation and affordability associated with POU water treatment products and services. One striking example emerged from their insights, highlighting the practicality of using chlorine for water treatment.

Participants shared that when they purchase a single bottle of chlorine, they experience extended usability due to its efficient dosage. A mere bottle top cup of chlorine was sufficient to treat an entire bucket of water (20 litre bucket), providing clean and safe drinking water for their families. This dosage ensured that a single bottle stretched over numerous treatments, making it a cost-effective and budget-friendly choice for water purification.

By utilizing the bottle top cup of chlorine for each treatment, families in Mzilawayingwe maximized the value of their purchase. This not only underscored the financial advantages but also aligned with the broader theme of ease of operation as the simplicity of the process empowered individuals to take charge of their water quality without any hassle.

As described in Zolozolo focus group discussion: "*When I buy one bottle of chlorine it lasts long because we use its bottle top to treat one bucket of water*"-ZD5.

Furthermore, a common sentiment emerged regarding the accessibility and affordability of water treatment products and services in Zolozolo.

One participant aptly remarked: "*Waterguard is mostly available at the small shops in our community, and it's not that expensive. It's very rare nowadays for one to fetch it in town.*"-ZD8.

This observation encapsulated the essence of easy access and affordability. The availability of Waterguard, at local shops within the community eliminated the need for residents to travel long distances to town, streamlining the process of obtaining effective water purification. This convenience underscored the pivotal role of accessibility in ensuring that individuals promptly and conveniently secured the tools they required to safeguard their water quality.

Interestingly, in Area 1B, a participant shared a personal experience that vividly highlighted the theme of ease of access. She noted, "*My husband works at the hospital, so it's easy for me to access chlorine which I share with my neighbours.*"- AD2.

This comment encapsulated the idea that proximity to key resources, in this case, chlorine for water treatment can significantly simplify the process of obtaining and using such products.

The participant's close connection to a hospital where chlorine was readily available, exemplified the tangible benefits of seamless access to water treatment solutions. This scenario speaks directly to the notion that convenience and accessibility go hand in hand, enabling individuals to incorporate effective water treatment practices into their daily routines effortlessly.

1.3.2.2 Barriers

Among non-practitioners of point-of-use (POU) water treatment across all wards, the primary barriers that prominently emerged were lack of essential materials and resources, a deficiency in technical know-how and support, lack of access to POU water treatment products and services as well as inconvenience of POU water treatment methods.

When the participants were asked about the factors that made it difficult for them to treat water before consumption in their household, several constraints were raised.

To begin with, affordability and availability of resources like charcoal or firewood were raised. As described in an FGD in Lupaso "*I feel like for our friends with electricity, it might be easier to boil their water because right now charcoal is very expensive, so maybe if I could have electricity, it would be easy for me to treat water.*" – LN1

Boiling was a common water treatment method, but the high cost of charcoal deterred individuals from using it as a viable option. In some sentiments, a small pack of charcoal which costed about MWK500 was only sufficient for a limited amount of cooking. This emphasised the financial strain that households faced when attempting to use charcoal for water treatment and the trade-offs they were subjected to.

As described in an FGD in Zolozolo: "*Charcoal is very expensive; we buy a small pack at MWK500, which is only enough to take us through a meal or two.*" – ZN4

Concurrently, the effort and challenges involved for one to get firewood for cooking made it impractical to use it for boiling water. This underscored the need for alternative sources of energy like electricity to be able to treat water in their households.

As described in an FGD in Chiputula: "*For me, I don't have firewood because I have to travel all the way to Lunyangwa Forest to get firewood, and sometimes we meet forestry rangers who chase us away. So, to think about using the same firewood for boiling water is difficult.*" – CN3

Furthermore, lack of technical know-how and support from health personnel in their localities emerged as one of the prominent drawbacks towards adoption of POU water treatment.

There was a common sentiment highlighting sporadic nature of technical support from health extension works. Participants expressed lack of regular visits by extension workers, who could have provided technical knowledge and support for POU water treatment. Participants expressed a desire for regular visits from extension workers, emphasizing the need for consistent guidance and education to ensure sustainable water treatment practices. However, technical support was only available during emergencies, such as cholera outbreaks thereby creating a tendency of people forgetting the information afterwards.

"If health extension workers could be visiting us often, it could be easy for me because they only come when there is a problem. Like this other time, there was a cholera outbreak, so we end up forgetting after a while." – ZN3

Furthermore, participants highlighted the need for comprehensive training to address challenges related to water quality. For instance, in Chiputula, concerns were raised about unpleasant odours and health effects caused by inadequately treated water. The lack of proper training was apparent as a barrier to effective water treatment, emphasizing the necessity of education to ensure proper methods are employed.

"We need more training on the methods like chlorine because sometimes the water smells really bad and causes heartburn." – CN2

Again, other sentiments underscored the interconnected challenges of resource availability and technical know-how. For instance, in Lupaso, absence of suitable materials like pots for boiling water and lack of training on use of Waterguard combined to hinder effective water treatment in their households. This highlighted the significance of both equipment and education for successful POU water treatment.

"I don't have a pot big enough to boil water for my family, and I have never received any training on how to use Waterguard." – LN3

Accessibility of POU water treatment was another issue that emerged during the discussions. In Area 1B, this came into the limelight due to discontinuation of chlorine distribution in the communities. People found it difficult to practice POU water treatment due to absence of and unaffordability of a product that was once available.

"They stopped distributing chlorine here; I don't think I can afford to buy it on my own." – AD8

In addition, a participant's personal experience in Lupaso underscored the importance of proximity to resources and technical support. In her view, relocation disrupted her access to chlorine, highlighting the role of local infrastructure in facilitating effective water treatment practices.

> *"I used to stay close to a hospital where I was getting chlorine, but since I relocated, it's pretty far now."* – LN4

Interestingly, majority of POU water treatment practitioners consistently expressed concerns regarding the time-consuming nature of these methods. Particularly, the requirement that boiled water should be left to cool down before consumption frustrated some.

As one practitioner noted, *"We know boiling water is good, but it takes so much time for the boiled water to cool down. Especially when we are in a hurry or have limited resources for storage, this becomes an inconvenience."*-MD4.

The inconvenience perceived by participants was influenced by various factors related to POU water treatment methods. These factors include the time needed for boiling, cooling, and storage. The cultural context of the community where fast-paced lifestyles are common also exacerbated the perception of inconvenience associated with these methods. The inconvenience of POU water treatment methods appeared to have a negative impact on adoption rates within the community.

Consequences

This study also examined the perceptions of participants regarding the positive and negative consequences of Point-of-Use (POU) water treatment methods. Majority of the participants acknowledged substantial health benefits associated with POU water treatment, viewing it as a positive outcome. While some voices contended that POU water treatment exclusively yields positive consequences, a notable portion of respondents highlighted potential negative outcomes, often stemming from a lack of technical knowledge and improper handling of treated water. These adverse effects encompassed issues such as the emergence of unpleasant odours from chlorinated water, instances of diarrhoea and heartburn due to excessive chlorine use, accidents arising from spills of boiling water, and the diminished efficacy of POU water treatment resulting from inadequate management of treated water. In this exploration of perceptions, a nuanced picture emerges, showcasing both optimistic gains and cautionary tales linked to POU water treatment methods.

When asked about the advantages of treating water before consumption, majority of participants in the FGDs shared a collective sentiment that Point-of-Use (POU) water treatment methods yielded positive outcomes, particularly in terms of health benefits.

In an FGD conducted in Lupaso, one participant emphasized, *"we are able to prevent diseases like diarrhoea in our families."* LD6. This assertion echoed a prevailing belief that POU water treatment contributes to a reduction in waterborne illnesses, enhancing the overall well-being of households.

Furthermore, a participant from Zolozolo recounted a historical event, stating, *"in 2003, there was a cholera outbreak, but our family survived through use of POU water treatment."*-ZD7. This anecdote served as a testament to the effectiveness of POU methods in averting disease outbreaks, underscoring their role in safeguarding public health.

However, the positive outlook was not without reservations, as participants in different FGDs highlighted potential negative consequences associated with POU water treatment.

An FGD in Chiputula revealed concerns about water quality, with a participant expressing, *"chlorinated water smells bad which affects my liking for the water."* – CN4. This perception emphasized the sensory aspects that may impact individuals' acceptance and preference for treated water.

Safety concerns also emerged from an FGD in Area 1B, where a participant noted, *"boiling water can cause accidents, especially to children if not properly handled because it takes time for the water to cool down."*- AD3. This observation emphasized the need for safe practices when employing POU methods and acknowledges the potential risks associated with hot water.

Furthermore, discussions in Mzilawayingwe highlighted apprehensions about excessive chlorine use. A participant said, *"too much chlorine can cause diarrhoea,"*- MD3, echoing a sentiment that improper application of chlorine may have unintended health consequences.

A related concern surfaced in an FGD in Lupaso where a participant remarked, *"if water hasn't been boiled long enough, it can still cause diarrhoea."*-LD5. This statement underscored the importance of proper execution of POU water treatment methods, indicating that inadequate treatment procedures might compromise their efficacy.

Social norms

The study delved into the societal perception and approval of participants' adoption of Point-of-Use (POU) water treatment practices. The exploration revealed a prevailing consensus among most participants, who reported receiving substantial support from their social circles, including traditional and religious leaders. Notably, this support appeared to be pronounced during the rainy season, a period characterized by a heightened emphasis on hygiene practices. Participants frequently recounted instances of encouragement and endorsement from their associates, contributing to an atmosphere of collective responsibility for water quality improvement.

Nevertheless, amidst the prevailing approval, a nuanced picture emerged. There were isolated accounts of resistance originating from friends and certain family members. These instances of opposition were often linked to issues of taste and smell associated with the treated water. It was noted that such concerns seemed to be rooted in misconceptions or inadequate directions for the proper use of POU water treatment methods.

When asked if most people approved of the participants treating water before consumption, majority of the participants stressed approval from neighbours and the broader community. The theme of substantial support from neighbours was prevalent across all communities in the study area.

One participant from Mzilawayingwe stated, *"my neighbours are very supportive,"*-MD1. This underlined the role of community solidarity in endorsing POU water treatment practices. Similarly, in another FGD in Zolozolo, a participant shared that their neighbour consistently provided chlorine, contributing to the availability of treated water during times of limited access.

Furthermore, Participants frequently mentioned the influence of traditional and religious leaders in promoting POU water treatment practices, particularly during the rainy season. In Area 1B, participants revealed that the block leader emphasized hygiene, including cleaning communal standpipes and surroundings to shallow wells. Additionally, in Lupaso, participants noted that discussions at church often revolved around water treatment, especially in preparation for the rainy season.

As described in Area 1B, *"Our block leader talks a lot about hygiene during rainy season including cleaning the surroundings of our communal standpipes and shallow wells"*- AD5.

The societal response to POU water treatment practices was not universally positive. Some participants expressed a sense of individual autonomy and scepticism about external advice. A participant from Mzilawayingwe remarked, *"I don't really know because everyone minds about his own family, and even if they did, no one could tell me what I should not do in my own house."*-MN6. This sentiment reflected a belief in personal decision-making within the household context.

In addition, the influence of social interactions and peer preferences emerged as a significant factor shaping participants' decisions regarding the adoption or rejection of Point-of-Use (POU) water treatment methods.

In Chiputula, a participant explained, *"my friends don't drink water with chlorine, so I also stopped because they used to mock me that I don't want them to be drinking water when they visit me "* – CN4

This statement perceived the pervasive role of peer influence in shaping individual decisions related to water treatment practices. Participants often found themselves in social networks where shared opinions on water treatment methods influenced their own choices. The pressure to conform to the preferences of their peers led to a ripple effect, resulting in the adoption or abandonment of specific treatment methods.

Moreover, the impact of children's preferences on water treatment practices emerged prominently across the communities in the study area. Children reportedly played a pivotal role in shaping family dynamics and decision making.

A participant's poignant remark encapsulated this phenomenon in Zolozolo: *"my children don't like the smell of waterguard in drinking water."*-ZN2.

This statement resonated as a testament to the profound influence that taste, and odour considerations held, particularly among younger members of the household. The significance of addressing these concerns cannot be overstated, as they hold the potential to shape not only individual behaviours but also the overall acceptance and sustained usage of POU water treatment methods within the community.

Access

The study investigated participants' perceptions on accessibility of materials and services required for water treatment prior to consumption. Among the materials examined, boiling emerged as the most accessible, with its ubiquity attributed to the integral role it plays in daily cooking routines. In contrast, obtaining chlorine, another vital treatment agent, proved to be more challenging due to its specialized nature requiring a dedicated purchase. Interestingly, the availability of chlorine, once common, has dwindled over time, necessitating longer trips to urban centres. This shift has rendered the price of waterguard, a popular chlorine product, unfamiliar to many. Notably, the government, previously involved in chlorine distribution through the Ministry of Health (MoH) has ceased such efforts. Although non-practitioners acknowledged the availability of water treatment materials and services, affordability emerged as an impediment to accessibility. The forthcoming exploration of these findings uncovers the intricate relationship between financial constraints and the acquisition of essential water treatment resources.

When asked about the ease of acquiring materials and services necessary for water treatment prior to consumption, most of the Point-of-Use (POU) water treatment practitioners expressed a sense of convenience, particularly those who utilized the boiling method. This consensus was grounded in the fact that daily energy consumption for cooking made boiling water for consumption a seamless practice. However, it is important to note that this ease of access was contingent on seasonal variations.

For instance, a participant from Mzilawayingwe highlighted this nuanced aspect, stating, *"It is easy, but like I said, it depends on the season in terms of firewood"*-MD1.

Furthermore, a significant number of practitioners highlighted a distinction between boiling and chlorine treatments. Boiling materials were seen as readily integrated into their daily cooking routines, setting them apart from chlorine, which was only procured for the sole purpose of POU water treatment.

A participant from Lupaso provided insight stating, *"We always have firewood or charcoal for cooking, so we use the same for boiling drinking water"*-LD7.

Moreover, while a significant number of both practitioners and non-practitioners acknowledged the availability of materials for POU water treatment, a noteworthy divergence emerged among non-practitioners. Many non-practitioners expressed that financial constraints were a significant barrier to accessing the required materials.

A participant from Zolozolo voiced this concern stating, *"The materials are there, but the problem is money to acquire them"*- ZN3.

The availability of Waterguard, a once-common water treatment product, was highlighted in contrast. Majority of participants from both groups noted that Waterguard had become increasingly scarce in their localities, necessitating journeys to town for its procurement. The scarcity of Waterguard had reached a point where its price had become unfamiliar to many.

One participant in Chiputula recalled, *"waterguard these days is nowhere to be seen perhaps in town might be found but, in the past, it was very common both bottled and in sachets"*- CD7.

Similarly, a participant in Area 1B stated, *"it's been a while since I last saw Waterguard in shops. I can't even tell the current price"*- AN5.

Nonetheless, many participants indicated that the government had ceased to distribute chlorine in their localities, and this greatly affected access to POU water treatment materials, let alone the adoption of the practice. Participants across various regions lamented the cessation of chlorine distribution through health extension workers and hospital channels.

As articulated by a participant from Lupaso, *"in the past the health extension workers used to give us chlorine from the hospital but not anymore"*- LN1.

Another participant from Area 1B shared, *"we used to get chlorine from the hospital through HSAs, especially during rainy season, but they've long stopped"*- AN2.

Cues for action

This section delves into the perceived cues for action among participants, aiming to uncover the challenges they faced in remembering to treat water before consumption. Understanding the factors that influence participants' ability to recall water treatment practices is pivotal in promoting safer consumption habits. The findings illuminated a prevailing trend that both practitioners and non-practitioners did not encounter difficulty in remembering to treat water before consumption. This phenomenon was attributed to the participants' familiarity with the practice and the unmistakable signs from the water source itself. For instance, water from shallow wells inherently signalled the necessity for treatment. The subsequent exploration of these outcomes' shed light on the cognitive processes and external triggers that contribute to the successful incorporation of water treatment practices into daily routines.

When queried about the difficulty of recalling the need to treat water prior to consumption, majority from both parties acknowledged that it was not at all challenging to remember. Notably, practitioners found this task even easier due to the integration of the practice within their routines.

For instance, a participant in Mzilawayingwe expressed, *"it's not difficult at all as we're used to doing it"*- MD2.

Similarly, in Chiputula, a participant echoed, *"We have developed a habit of treating our water, especially when there is doubt about its quality."*- CD6.

Moreover, some practitioners reported that specific circumstances, such as intermittent water supply, heightened the need to remember water treatment. This was often triggered by the reliance on shallow wells during these periods, which are more prone to contamination due to their uncovered nature.

A participant from Area 1B explained, *“generally the need arises when water stops running in our taps because then we’re to draw water from shallow wells. So, when the need arises, it is very easy to remember to treat water”*- AD7.

In addition, the study findings revealed a prevalent sentiment among non-practitioners: the act of remembering to treat water would not pose any difficulty if the necessary materials were readily available. This sentiment particularly underscored the significance of material accessibility in influencing their adoption of water treatment practices. This sentiment was especially pronounced when considering water drawn from unprotected sources, notably shallow wells, which are susceptible to contamination due to their uncovered nature and proximity to potential sources of pollutants such as toilets.

A participant from Lupaso expressed this sentiment stating, *“Remembering wouldn't be a problem as long as all the materials are available because most of the times, we get water from shallow wells without covers, with a lot of dirt and mostly close to toilets”*-LN2.

Susceptibility

The section on perceived susceptibility or risk in the study aimed to explore how likely the participants believed it was for themselves or any member of their household to contract diarrhoea within a two-week period. While most participants perceived a moderate likelihood, some were unsure. However, the reasons behind their uncertainty were similar, as participants recognized that the sources of diarrhoea are diverse and not solely limited to contaminated water. They also acknowledged the difficulty in controlling what young household members consume. Overall, the perceived susceptibility to diarrhoea was influenced by the source of water, with water drawn from shallow wells being perceived as posing a higher risk if not treated. Nonetheless, participants also acknowledged the other sources of diarrhoea.

When queried about the likelihood of the participants or any member in their household getting diarrhoea in the next two-weeks period, many practitioners, particularly in Mzilawayingwe, expressed a strong belief that if water was not adequately boiled it posed a high risk of causing diarrhoea. This highlighted their emphasis on the importance of thorough water treatment methods such as boiling to kill potential contaminants.

A participant in Mzilawayingwe stated, *"It is very likely if the water has not been cooked enough."*- MD2.

Furthermore, several other participants particularly non- practitioners, were not sure, highlighting their lack of awareness regarding the type of water their children consume, indicating uncertainty about its safety. This raised concerns about potential exposure to untreated or contaminated water from various sources outside the home environment.

As described from an FGD in Chiputula *"we don't know because we're not always aware of what type of water our kids are getting and it's not always that they get water from home"*- CN3.

Moreover, majority of the participants expressed moderate likelihood highlighting their perception that water quality concerns extend beyond untreated sources. The presence of debris in tap water served as a reminder that even seemingly treated water might carry risks.

For instance, in Zolozolo, a participant stated, *"It is somewhat likely because even water from the tap sometimes comes with some debris."*- ZD5.

In addition, participants in Lupaso mentioned the increased susceptibility to diarrhoea when tap water is unavailable, forcing them to rely on uncovered shallow wells. However, they also acknowledged that diarrhoea could originate from different sources, indicating a recognition of the multifaceted nature of the problem. Similarly, participants in Area 1b emphasized that diarrhoea can be caused by various factors, not solely limited to water.

As described in Lupaso, *"We're more susceptible when tap water stops running because then it means we have to draw water from shallow wells, and in our area, most of them are not covered. But diarrhoea can come from different sources."*- LD5.

As described in Area 1B, *"Generally, somewhat likely because it's not only water that can cause diarrhoea."*-AN6.

Severity

The section on perceived severity in the study aimed to explore how serious the participants believed it would be if themselves or any member of their household contracted diarrhoea. Most of the participants from both groups (practitioners and non-practitioners) expressed a belief that the illness would have serious consequences if they or any member of their household were to contract it. Concerns were raised about the potential spread of the disease through utensils and the disruption of day-to-day activities, particularly when children are affected, as it often necessitates seeking medical attention. However, it is worth noting that a significant number of participants also recognized that the severity of the disease would depend on its cause, as some instances may only require home remedies and not disrupt their daily routines.

When participants were asked to assess the seriousness of contracting diarrhoea for themselves or their household members, a consistent trend emerged among both practitioners and non-practitioners. The majority of participants, across the study area, shared the belief that diarrhoea would be a very serious matter. This perception was particularly pronounced in Mzilawayingwe.

In Mzilawayingwe, participants expressed heightened concerns about the severity of the disease, often citing its potential to rapidly spread throughout households, particularly through shared utensils.

As one participant from Mzilawayingwe succinctly stated, "*It would be very serious because it can easily spread throughout the household maybe through utensils*"-MD4.

Furthermore, participants in the study revealed that the seriousness of contracting diarrhoea extended beyond health concerns and could disrupt their daily lives and businesses. This sentiment was particularly pronounced in the Chiputula Area.

In Chiputula, one participant encapsulated this perspective by stating, "*It would be very serious because it would mean that my business has to come to a halt so that I can attend to the sick*"-CN2.

This quote vividly illustrated how the impact of diarrhoea reaches beyond health implications, potentially affecting participants' economic activities.

Similarly, participants across the study echoed concerns about their ability to work and provide for their families in the event of contracting diarrhoea. This worry extended to their capacity to tend to household duties.

One such participant, a woman engaged in the firewood business in Lupaso, expressed this sentiment succinctly, stating, "*It would be very serious because that would mean that I can't* *even work as I would when I am not sick, and my family suffers without me tending to them*"- LD8.

Furthermore, most participants shared a common belief that diarrhoea is particularly serious when it afflicts a child. This perception is rooted in the understanding that childhood cases of diarrhoea often required medical attention, resulting in additional costs for travel and medication.

One participant from Zolozolo conveyed this sentiment stating, "*it would be very serious because it would require going to the hospital, and when the hospital doesn't have medicine, we would have to buy the prescribed medicine from the local pharmacies*"- ZD7.

Conversely, there were participants who perceived the severity of diarrhoea as contingent upon its underlying cause. These individuals recognized that diarrhoea could originate from various sources, not solely linked to drinking water, and argued that the source of the disease played a crucial role in determining its seriousness. In some cases, they believed that home remedies could suffice, obviating the need for medical attention.

For instance, a participant from Area 1B expressed this viewpoint stating, "*it would be serious, however, depending on the cause of the disease because sometimes we just use home remedies then it goes away*"- AN3.

Action efficacy

The section aimed at exploring the likelihood of either the participants or any member of their household contracting diarrhoea if they did not treat water before consumption. The results revealed a notable disparity between practitioners and non-practitioners. Among practitioners, there was a prevailing belief in a high likelihood of contracting diarrhoea if water was not treated. For them, the key consideration was often the quality of the water source, which amplified the perceived risk when water remained untreated. In contrast, most non-practitioners perceived a moderate likelihood of contracting diarrhoea under these circumstances. Their perspective centred on the uncertainty of the source of diarrhoea, given that the disease could be contracted from various sources beyond drinking water.

When asked about the likelihood of contracting diarrhoea if water was not treated before consumption, most practitioners perceived a high likelihood. For these individuals, the determining factor was often the quality of the water source, which instilled a sense of certainty that untreated water posed a substantial risk to their families.

Particularly, certain sources of water were identified as posing a heightened risk. Shallow wells, a common water source in Mzuzu, were frequently cited as problematic. These wells, often dug in high-density areas, were noted for their proximity to pit latrines, a potential source of contamination.

As one participant in Zolozolo stated, *"Very likely especially water from shallow wells and here in Mzuzu toilets are dug very close to wells"*- ZD7. This quote encapsulated the sentiments shared by many practitioners, emphasizing the perceived high risk associated with specific water sources due to their proximity to sanitation facilities.

Conversely, there were households who adopted water treatment practices after experiencing the consequences firsthand. For these families, the decision to treat water was prompted by witnessing their own household members falling victim to diarrhoea after consuming untreated water.

One participant from Area 1B stated, "*Three people in our household once suffered from diarrhoea after consuming untreated water. That is the reason we started boiling water before consumption*"- AD1.

In contrast, most non-practitioners expressed a moderate likelihood of contracting diarrhoea if they did not treat water before consumption. This viewpoint emerged from a prevalent sense of uncertainty regarding the precise cause of diarrhoea in their households, recognizing that potential sources extend beyond just drinking water.

As articulated by a participant in Chiputula, "*Somewhat likely because we don't mostly know what caused the diarrhoea, might as well have come from something else and not water consumed*"-CN4.

Furthermore, some practitioners also expressed a moderate likelihood of contracting diarrhoea due to their concerns about post-handling practices of treated water, such as storage and hygiene practices associated with drawing water from storage containers.

As described by a participant in Lupaso, "*I always make sure to keep drinking water separate from the rest, and well covered. Even my children know that, and I don't keep drinking water for more than three days because beyond that algae start to grow at the bottom*"- LD8.

Devine will

This section aimed at exploring how participants incorporated their religious beliefs into practical actions like water treatment. The findings showed that regardless of their religious background, all participants agreed that treating water before consumption was approved by God. They expressed a strong conviction that God desired humans to live healthy lives and avoid the dangers of consuming unclean water. This belief was rooted in the understanding that God created humans to be safe from diseases and to prioritize their well-being.

A sentiment as expressed by an FGD participant from Mzilawayingwe read, "*He should because He created us to live and be safe from diseases*" MD4.

Policy

This section delved into the influence of local policies and community leadership on the practice of point-of-use (POU) water treatment among our participants. The findings revealed a nuanced landscape where the majority of participants initially denied the existence of specific laws related to POU water treatment within their communities. However, many acknowledged the historical presence of such policies in the past, which, in several instances, underwent changes due to shifts in leadership. This section also highlighted the pivotal role played by community leaders, often referred to as block leaders, in promoting good hygiene practices, particularly during the rainy season. While community leaders were recognized as influential advocates for health and hygiene by most participants, a minority expressed concerns regarding the lack of engagement from these leaders in addressing health-related issues. These insights provided a comprehensive understanding of the interplay between local policies, community leadership, and the practice of POU water treatment in the study areas.

When participants were asked about the existence of community laws either in support of or against POU water treatment in their respective areas, the overwhelming response, shared by both practitioners and non-practitioners was the absence of specific laws pertaining to this practice within their communities. Some participants even expressed a sense of self-reliance, emphasizing the lack of support from community leadership.

As stated by a participant in Mzilawayingwe, "*there are no community laws in particular, it is just everyone for himself*"- MD2.

However, participants acknowledged that in the past, certain areas had laws in place regarding water treatment, but these laws had changed due to shifts in leadership. In some areas, community leaders assigned individuals to work with community health extension workers, who supervised hygiene practices and provided training on POU water treatment, particularly during the rainy season. Currently, there are no specific community laws supporting or opposing POU water treatment. However, participants mentioned that block leaders still get involved, especially during the rainy season, indicating some level of community support and involvement in water treatment practices.

As expressed by a participant in Chiputula, "*at the moment there are no community laws but, in the past, there used to be some monitors from the block leaders who were working with health extension workers. They used to pay us visits checking how we were handling water in the house"*- CD6.

Similarly, in Area 1B a participant stated, "*yes, in the past there used to be some but with change of leadership, rules also changed but block leaders do get involved especially during rainy season*"- AN8.

Although the majority of participants acknowledged the influential role of community leaders in promoting health and hygiene practices, a minority expressed concerns about their lack of engagement in addressing health-related issues. Specifically, some participants highlighted the issue of improper disposal of diapers, which posed significant health risks. Diapers were being indiscriminately dumped in various locations, including streams and rivers, thereby polluting the environment.

One participant in Zolozolo, emphasized the need for effective community laws to control and regulate such practices stating, "*block leaders don't do anything here. We have a lot of hygiene issues here which causes health concerns like disposal of diapers which could be controlled with good community laws"*- ZN1.

Culture

This section examined the cultural influence on the adoption of point-of-use (POU) water treatment among participants. It was found that most participants acknowledged the traditional practice of boiling water passed down by their ancestors. Other traditional methods included use of leaves to cover water from point of collection. However, there was a growing concern among participants that many community members believed tap water was clean and did not require treatment, despite occasional findings of debris in the water. Some participants expressed health concerns regarding certain cultural beliefs related to water treatment. However, a minority of participants denied the existence of any cultural practices either supporting or opposing POU water treatment.

When asked about the presence of cultural practices either in support of or opposition to point-of-use (POU) water treatment, most participants readily acknowledged the deep-rooted tradition of boiling water as a method passed down through generations by their ancestors. This historical practice, as noted in Lupaso, served as a testament to the enduring influence of tradition.

As described in Lupaso, "*Our parents used to draw water from rivers and streams they had to boil the water in clay pots before consumption*"- LD6.

Additionally, many participants highlighted another culturally ingrained practice: covering water containers with leaves from the point of collection to their households. This practice was rooted in historical necessity, as people used to travel long distances to fetch water.

As one participant from Area 1B explained, "*in the past people used to cover water with leaves from the point of collection to the household since they used to walk long distances to fetch it. This helped to prevent dirt from getting into the water and spillage along the way. I still see it nowadays when I go to the village*"-AN7.

Furthermore, while participants acknowledged the influence of certain cultural practices supporting POU water treatment, they also raised concerns about aspects of their cultural heritage related to hygiene. Some participants indicated that their ancestors had lacked hygiene in some cultural beliefs and practices.

One such belief, as articulated by a participant in Zolozolo, read, "*Generally our ancestors lacked hygiene. They had beliefs like if you give water which elders washed their hands in to a child, he will grow stronger and healthier*"- ZD5.

Furthermore, participants voiced growing concerns about the prevailing belief held by many in their communities that tap water, supplied by the waterboard, was inherently clean and did not require any further treatment at the point of use. This belief persisted despite occasional instances of tap water containing debris. This belief was believed to be a contributing factor to the slow adoption of POU water treatment.

As highlighted by a participant in Mzilawayingwe, "*there is a belief that tap water supplied by waterboard is always clean and requires no further treatment. This is probably the reason why most of us do not treat our water. However, we do find debris in tap water sometimes*" MN8.

Qualitative results (Key Informant Interviews)

Key informant interviews were conducted with key technocrats in the field of Water, Sanitation and Hygiene (WASH) around Mzuzu. The officials and institutions interviewed include the Water and Sanitation Coordinator from Mzimba North District Health Department, the Water and Sanitation Officer from Mzuzu City Council, and the Centre Manager from Mzuzu CCAP Smart Centre. Data was collected on user preferences, integration and collaboration, standards, certification and regulations, resource availability, market strategies and user guidance on point-of-use water treatment products.

User preferences

This section highlighted the pivotal role played by institutions in motivating individuals to prioritize the enhancement of their health, particularly in the context of creating user demand for point-of-use water treatment. The findings revealed that most of these institutions primarily focused on health education promotion, with a particular emphasis on periods of outbreaks or during the rainy season. Additionally, they actively engaged in enforcing relevant regulations to ensure compliance.

Nonetheless, a significant challenge that emerged was the limited availability of resources necessary for the effective execution of these operations. Consequently, many of these initiatives heavily relied on special projects with specific components dedicated to addressing these critical areas.

"We actively encourage health education and enforce regulations but our ability to respond adequately is hindered by limited resources. As a result, we often depend on external projects that provide interventions related to this aspect."

Again, institutions played a vital role in educating individuals about the cost-benefit analysis of water quality, emphasizing the negative impact of poor water on disease incidence and the positive effects of potable water on health and productivity. This educational approach ensured that people comprehend the economic advantages associated with point-of-use (POU) water treatment methods. By highlighting the importance of POU water treatment, institutions effectively conveyed the message of improved health and increased productivity to the public.

When it came to aspiring technologies available for point-of-use water treatment, institutions like the CCAP Smart Centre were reported to have been actively involved in their development. The Centre actively promoted and supplied a range of water treatment products, including the Tulip siphon, Tulip tabletop, SAFI T9, SAFI T20 and Sawyer bucket filters. The efforts of these institutions aimed at providing innovative solutions to improved water quality and sanitation practices. Alongside these aspiring technologies, there were already established methods for water treatment that were readily available and promoted by both government and non-governmental organizations. These methods included boiling and pot chlorination using water guard. These interventions were proven to be highly effective in treating water and reducing the risk of waterborne diseases.

To encourage the adoption of POU water treatment, various approaches were implemented that included periodic water testing conducted by frontline staff and community education initiatives. These efforts aimed at making it easier for individuals to incorporate POU water treatment into their daily routines. However, the lack of adequate resources hindered the successful execution of these approaches. It is worth noting that, except for a small group of individuals who believed that water should remain natural based on their religious beliefs, there were no significant cultural barriers affecting people's decision to use POU water treatment.

Integration and collaboration

This section examined the networking and collaboration among key actors in the Water, Sanitation, and Hygiene (WASH) sector with a focus on advocating for Point-of-Use (POU) water treatment. Additionally, the study explored the integration of POU water treatment into other programs, and the pivotal role played by traditional leaders in this advocacy effort.

Results revealed a significant level of networking and collaboration among WASH actors in the Region. Notably, partnerships flourished among key institutions that including the Northern Region Water Board (the primary water supply agency), Mzimba North District Health Office, Malawi Bureau of Standards, Mzuzu City Council, World vision, United Purpose, Save the Children, Norwegian Church Aid and Red-Cross. These collaborations played a crucial role in advancing the cause of POU water treatment.

Moreover, POU water treatment was found to be successfully integrated into various other programs within the Region. This strategic integration proved beneficial in mitigating challenges stemming from limited resources especially from government institutions. As a result, POU water treatment efforts were more effective and sustainable.

According to one expert, traditional leaders were said to have played a vital role in advocating for POU water treatment. They actively engaged with health extension workers, providing education on Cholera prevention, and participating in the actual pot chlorination process using a 1% stock solution. Their direct involvement significantly contributed to raising awareness and promoting clean water practices within their communities.

Standards, certification, and regulations

This section investigated the priorities and role of the government in promoting clean water access. In urban areas, the government had placed a high priority on ensuring the presence of residual chlorine in water supplied by the Northern Region Water Board (NRWB). One participant underscored the proactive role of the government in advocating for Point-of-Use (POU) water treatment. This advocacy was manifested through initiatives such as the promotion of pot-to-pot chlorination, which included comprehensive training and the distribution of chlorine. Additionally, the government championed the adoption of a 'two cup system' to safeguard against potential contamination of treated water. These efforts were spearheaded by collaborative endeavours involving the Ministry of Health and Mzuzu City Council.

Moreover, the Malawi Bureau of Standards (MBS) was said to be playing a significant role in safeguarding water quality. MBS was entrusted with conducting microbial and chemical water quality tests, a critical step in ensuring the safety of drinking water. This included certifying the quality of water treatment methods and technologies.

In our discussions with key informants, it became evident that the government of Malawi played a significant role in promoting and endorsing innovative POU water treatment technologies. According to the informants, these technologies held considerable promise in addressing water quality challenges, particularly at the household level.

One informant highlighted the government's approach, which aimed to strike a careful balance. On one hand, the government actively encouraged the involvement of the private sector in the development and distribution of POU water treatment technologies. This encouragement served as a catalyst for innovation within the sector.

Simultaneously, the informant noted that the government placed a strong emphasis on regulating standards and ensuring product quality. By doing so, they not only fostered innovation but also safeguarded the public by ensuring that these technologies met established safety and efficacy standards. This dual approach, as emphasized by our key informants, contributed to a dynamic and promising landscape for POU water treatment technologies in Malawi.

Resource availability

This section focused on the role of institutions in ensuring that water treatment technologies remained accessible to all segments of the population. The government was reported to have taken proactive measures to make potable water accessible to the underprivileged. This included initiatives such as providing free connections to piped and treated water. This initiative was pivotal in ensuring that even the most vulnerable members of the community had access to safe drinking water.

Another noteworthy government intervention was the ongoing program to distribute free chlorine to households in high-density areas. Spearheaded by the Ministry of Health and Mzuzu City Council, this initiative aimed at bolstering water quality at the household level.

Private institutions were said to have played a crucial role in making water treatment technologies more affordable. By utilizing locally available materials, these institutions had significantly reduced the costs associated with the production and purchase of these technologies.

Furthermore, in our discussions, one of the prominent challenges highlighted was ensuring cost-effective implementation. This encompassed a spectrum of complexities that significantly impact the feasibility and efficiency of initiatives.

The informants stressed that limited financial resources posed a substantial obstacle. The allocation for water treatment initiatives, especially those involving POU technologies, was often constrained. This directly affected the ability to implement measures in a cost-effective manner.

The existing infrastructure's capacity to meet growing demands emerged as another critical concern. Aging pipelines, insufficient treatment facilities, and distribution networks in need of expansion were flagged as specific pain points. Optimizing these infrastructural elements was crucial for achieving cost-effectiveness.

Another persistent challenge reported was the shortage of skilled personnel and expertise in water treatment. Recruitment and retention of qualified professionals in this field proved to be a recurring difficulty, impacting the capacity for efficient implementation. Moreover, one expert stressed that keeping pace with technological advancements in water treatment also presented a challenge. Acquiring and deploying state-of-the-art POU technologies required significant investments, which were often constrained by budgetary considerations.

According to one informant, the need to judiciously allocate resources across competing priorities within the broader context of public services was emphasized. Achieving cost-effective implementation necessitated careful strategic planning to balance the demands for water treatment initiatives with other critical sectors especially in civil institutions.

Market strategies

This section delved into the pivotal roles of different WASH actors in ensuring a sustainable supply chain of POU water treatment technologies. Their efforts encompassed training communities and certifying individuals who completed the programs. Additionally, these initiatives focused on equipping entrepreneurs with production skills and vital business acumen. The emphasis was on technologies characterized by simplicity, market viability, affordability, and ease of repair.

One informant highlighted their role, stating, "*In our role, we focus on ensuring a sustainable supply chain of Point-of-Use water treatment technologies. We provide comprehensive training to communities and certify individuals who have successfully completed the program. These entrepreneurs are equipped with skills in both the production of POU water treatment technologies and essential business skills. The technologies we promote are designed to be simple, market-based, affordable, and easily repairable.*"

User guidance on point-of-use water treatment products

This section explored the instrumental roles of WASH actors in facilitating the effective utilization of Point-of-Use water treatment technologies/methods. Their initiatives were diverse and targeted sensitizing communities, providing training, and disseminating informational materials.

One crucial aspect reported of ensuring efficient use of POU water treatment technologies was community sensitization. This involved organizing village-level meetings, particularly during seasons with higher waterborne disease prevalence, such as the rainy season. These meetings served as platforms for educating communities about waterborne diseases and how POU water treatment methods can be effective in combating them. Additionally, mobile van campaigns were employed to reach even the most remote and underserved areas, ensuring that critical information reached all corners of the community.

"In our role, we put a strong emphasis on community sensitization. We organize village-level meetings, especially during the rainy season, to educate communities about waterborne diseases and how to combat them using POU water treatment methods. This effort is further bolstered by mobile van campaigns that reach even the remotest areas."

Providing hands-on training was said to be a pivotal component in ensuring the effective use of POU water treatment technologies. Communities were actively engaged and educated on a range of POU methods, including the vital technique of pot-to-pot chlorination. The training process involved practical demonstrations, ensuring that individuals gain proficiency in the application of these methods, thus enabling them to apply these skills independently in their daily lives.

"We take hands-on training seriously. Communities are educated on various POU water treatment methods, including pot-to-pot chlorination. We provide practical demonstrations, and ensure that individuals are proficient in the application of these techniques."

Moreover, visual aids played a critical role in reinforcing knowledge and serving as quick references. In line with this, flyers were distributed to communities. These materials provided step-by-step illustrations and instructions for implementing POU water treatment methods. By having access to these materials, individuals and households had a tangible resource that aided them in the correct and efficient application of POU water treatment techniques.

"We believe in the power of visual aids. Flyers are provided to communities, illustrating step-by-step procedures for POU water treatment. This serves as a handy reference for individuals and households in their daily practices."

Empowering district offices was a strategic approach in ensuring the widespread dissemination of knowledge about POU water treatment methods employed by most NGOs active in the city. To this end, these offices were equipped with essential training materials. Additionally, funds were allocated to facilitate educational endeavours at the local level. This support ensured that district offices had the resources necessary to effectively communicate and educate communities about the importance and proper use of POU technologies.

"Empowering district offices is crucial. We equip them with the necessary training materials and allocate funds to facilitate educational endeavours. This ensures that the knowledge is disseminated effectively at the local level."

4 DISCUSSION

4.6 Introduction

This chapter provides a comprehensive analysis of the findings, based on the three specific objectives of the study. These objectives aimed at providing a thorough understanding of the dynamics surrounding Point-of-Use (POU) water treatment in high-density areas of Mzuzu City. The objectives include level of awareness regarding POU water treatment methods among the communities studied; the diverse perceptions held by residents regarding these treatment methods and the underlying factors that influence the adoption of POU water treatment practices.

4.7 Awareness of Point-of-Use water treatment

The assessment of awareness regarding point-of-use (POU) water treatment followed the guidelines outlined by the WHO which define awareness as the understanding of at least one established method or technology for treating water at the point of use, comprehension of the associated health benefits, and knowledge of the sources for acquiring the necessary materials. The study revealed a notably high level of awareness regarding POU water treatment methods among the study participants, along with their well-informed understanding of the associated health benefits and accessibility of materials. This high awareness was found to be significantly associated with key demographic factors, including location, sources of water, level of education, income, and assets.

Location and Sources of Drinking Water:

Most people from Zolozolo-West ward demonstrated the highest level of awareness compared to other wards. This can be attributed to sources of drinking water for the respondents as Zolozolo-West had a higher proliferation of shallow wells. Moreover, most of its population accessed water through community standpipes which are subjected to intermittent supply and high non-functionality rates. These reasons compel most of the local population to access water from unimproved sources (Msilimba & Wanda 2013; Mzuzu City Council 2018). This notion was corroborated by findings of this study. The advocacy for POU water treatment was particularly strong in Zolozolo-West, contributing to higher awareness compared to other wards. This highlights the importance of adopting a holistic approach to advocacy in high-density areas of Mzuzu City, considering the potential neglect of other areas during emergencies.

Education, Income, and Assets:

Additionally, the study revealed a significant association between awareness and participants' level of education, income, and assets. Respondents with at least a secondary education demonstrated a higher level of awareness, likely due to the inclusion of public health issues in the school curriculum, and the ease of understanding information on POU water treatment associated with literacy. Surprisingly, those with middle to low-income levels demonstrated the highest level of awareness, challenging findings of previous studies (Bitew, et al. 2017; Daniel, et al. 2018; Masanyiwa, et al. 2019; Moropeng & Momba 2020) that had shown that higher levels of income translate to heightened awareness. This finding suggests that individuals with lower income levels are at the forefront of advocacy. The primary pathway of information dissemination were media, religious centres, and household visits by health workers, which predominantly reached those in the low- or middle-income classes, supporting the notion that these groups are pivotal in advocacy efforts.

Furthermore, this finding supports (Holm, et al. 2016) model of "leaving no one behind" in their study, emphasizing inclusiveness and equity, particularly in high-density areas. This model has revealed a correlation between heightened levels of awareness among individuals and low levels of income. The emphasis on inclusiveness in advocacy has evidently contributed to a more equitable distribution of awareness, challenging preconceived notions regarding the association between income levels and awareness.

The findings highlight participants' strong foundational knowledge and recognition of the importance of implementing household-level water treatment to ensure its safety for consumption. This positive receptiveness to POU water treatment interventions underscores the potential for effective public health initiatives aimed at promoting safe water practices within the community.

This finding is supported by findings of previous studies (Bitew, et al. 2017; Daniel, et al. 2018; Masanyiwa, et al. 2019; Moropeng & Momba 2020). The level of awareness uncovered in this research demonstrates a relatively higher knowledge of methods (92%), understanding of health benefits (95%), and knowledge of sources for acquiring necessary materials (100%). This comparison serves to underscore the robustness of the awareness levels observed in our study and highlights the potential for widespread acceptance and adoption of POU water treatment practices within the community.

Furthermore, the study by (Holm, et al. 2016) revealed a significant gap in information pertaining to the capacity of individuals living in high-density areas to ensure the availability of safe water, particularly as groundwater and surface water sources continue to rank highest. This gap extends to the capacity to adopt positive behaviours such as point-of-use water treatment. The receptiveness uncovered in our study presents an opportunity to address this gap, serving as a platform for public health practitioners to implement diverse models aimed at bridging the identified disparities. Despite the gradual scaling up of interventions related to POU water treatment, our findings suggest that these models have the potential to yield positive results, thereby contributing to the advancement of safe water practices within high-density communities.

4.8 Perceptions on point-of-use water treatment methods

Practice of POU water treatment.

The higher levels of awareness observed in this study significantly correlated with higher percentage (71%) of utilization of POU water treatment practices among participants. It is important to note that the utilization percentage was self-reported, which may introduce the possibility of over or under-reporting. For instance, a study conducted by Bitew et al. (2017) revealed that while 90% of participants reported practicing boiling, subsequent follow-up indicated that only 31% engaged in this practice. Despite the potential for reporting biases, majority of the participants in our study reported practicing POU water treatment, indicating a notable level of adoption within the community.

Comparatively, the present study demonstrates a significant difference in the retention of practice from awareness when compared to findings from previous studies. For instance, Bitew et al. (2017) recorded a 63% awareness of POU water treatment, which translated to only 23% practice, highlighting a considerable drop-off between awareness and actual implementation. Similarly, in a study by Hubbard et al. (2020), a mere 13% retention of practice was observed. These disparities underscore the complexity of translating awareness into sustained practice and emphasize the critical need to explore the underlying factors influencing the retention of POU water treatment practices.

The logistic regression model revealed a significant impact of the participant's community and household assets on the practice of point-of-use (POU) water treatment. Notably, belonging to a specific community, such as Zolozolo, was found to increase the likelihood of practicing POU water treatment, aligning with the significant association between community and awareness of POU water treatment. This underscores the influence of community dynamics on the adoption of POU water treatment practices.

Interestingly, the model also indicated that participants with more assets in their households were less likely to practice POU water treatment. This unexpected finding challenges previous studies that highlighted income as an enabler of POU water treatment (Bitew et al. 2017; Crider et al. 2023; Daniel et al. 2018). It was observed that higher asset ownership often corresponded to an increase in monthly income, leading to a decreased likelihood of POU water treatment practice. This was attributed to participants with more assets having piped water and perceiving a lower susceptibility to waterborne diseases, thereby reducing their motivation to engage in POU water treatment practices.

The findings underscore the need to consider the nuanced interplay of socio-economic factors and community dynamics in shaping the adoption of POU water treatment practices. While previous studies have emphasized the role of income in facilitating POU water treatment, the present research challenges this notion, highlighting the complex relationship between household assets, water access, and perceived susceptibility to waterborne diseases (Bitew et al. 2017; Daniel et al. 2018).

It is essential to address the prevailing notion that tap water or water from improved sources is always clean, as evidenced by previous studies (Daniel et al. 2018; 'Kumwenda et al. 2014; Mengistie et al. 2013; Zimmer & Dorea 2023). Efforts to promote POU water treatment interventions should encompass targeted messaging aimed at correcting misperceptions about water safety, regardless of the source. Additionally, ensuring equitable access to POU water treatment products and emphasizing the importance of consistent treatment practices can help bridge the gap in adoption across diverse socio-economic strata.

The most convenient POU water treatment method/technology used.

The study uncovered that boiling and adding waterguard or chlorine were perceived as the most convenient POU water treatment methods. A multinomial regression model predicted a positive association between the choice of POU water treatment and participants' community, while household assets exhibited a significant negative relationship with the likelihood of choosing these treatment methods.

This relationship was attributed to disparities in access to materials such as variations in the costs of firewood or charcoal, which significantly favoured certain areas over others, influencing the choice of treatment methods. Notably, during the rainy season, areas closer to sources of firewood or charcoal experienced relatively lower prices for these materials, influencing the preference for treatment methods such as boiling. Similarly, sentiments expressed in focus group discussions highlighted that proximity to health centres facilitated easier access to chlorine, thus influencing the preference for chlorination as a water treatment method. These sentiments were further articulated in discussions, emphasizing that individuals with family members working in health institutions had an advantage in accessing chlorine, indicating an underlying theme of technical know-how and access surrounding the preference for specific water treatment technologies.

The study demonstrated that individuals living in close proximity to health centres, especially those with family members working in health institutions, showed a higher preference for chlorination as a water treatment method. This observation underscores the influence of technical know-how and accessibility in shaping preferences for specific water treatment technologies. Furthermore, the findings indicated that limited coverage of health workers in providing chlorination services may be attributed to resource constraints, as emphasized by key informants during interviews. Previous training initiatives highlighted the potential of motivated health workers in imparting knowledge and scaling up the adoption of water treatment methods, indicating the opportunity for public health practitioners to make significant gains in knowledge dissemination with adequate resources (Daniel et al. 2018; Lantagne & Yates 2018).

Moreover, the study revealed that external support from non-governmental organizations is primarily reactive, focusing on emergencies, while public institutions face challenges in efficiently reaching out to all communities due to funding constraints. However, the study's findings underscore the potential for scaling up the adoption of point-of-use water treatment methods through comprehensive training initiatives (Daniel et al. 2018; Lantagne & Yates 2018). The availability of resources and support, especially for motivated health workers, presents an opportunity for public health practitioners to enhance knowledge dissemination and promote the widespread adoption of effective water treatment practices, highlighting the need for sustained efforts in resource allocation and support from both public and non-governmental sectors.

Preference for treated water

The study revealed a significant association between the choice of POU water treatment method and the preference for treated water (X^2= 17.098, P= 0.002). However, despite the higher preference for treated water indicated by the choice of POU water treatment method, the overall percentage of preference was slightly above 50%, suggesting that a considerable number of people do not favour the taste of treated water. This highlights a potential barrier to the sustained adoption of POU water treatment practices, stemming from a lack of technical know-how and potential issues related to the taste and smell of treated water.

The observed reluctance towards the taste and smell of treated water is consistent with previous studies that highlighted similar challenges (Fahiminia et al. 2014; Kgabi et al. 2014; Lantagne

& Yates 2018; Moropeng & Momba 2020). This emphasizes the need for targeted community trainings to enhance technical know-how, and address concerns related to taste and odour. By providing comprehensive training in the communities tailored to address the nuances of POU water treatment methods and dispelling misconceptions about treated water, it is possible to overcome these barriers and improve the acceptability of treated water among the participants.

The perceived taste and smell play a crucial role in the long-term adoption of POU water treatment practices. To effectively promote these practices, community-based training programs should take centre stage. These programs can focus on enhancing technical proficiency and addressing any taste-related concerns.

Furthermore, considering alternative treatment methods or improving the taste of treated water through community-led initiatives could significantly boost acceptability of POU water treatment. By involving the community in shaping solutions, we create a sense of ownership and foster sustainable practices.

Operation, Accessibility and Affordability of POU water treatment methods/technologies

The study revealed compelling insights into the perceptions and experiences of respondents regarding the ease of operation, accessibility, and affordability of various point-of-use (POU) water treatment methods/technologies. These findings shed light on the factors influencing the choice and utilization of POU water treatment practices and provide valuable implications for interventions aimed at promoting safe water practices within communities.

The study's findings shed light on the perceived ease of implementing boiling as a traditional water treatment method, as well as the utilization of waterguard/chlorine within the community. Surprisingly, a substantial proportion of respondents found no issues with the operation of available methods or technologies even among those who did not treat water. This underlines the inherent simplicity and familiarity associated with boiling as a water treatment method, potentially contributing to its widespread acceptance and utilization within the community (Daniel et al. 2018; Mkwate et al. 2017). However, the taste and odour concerns raised by a significant proportion 30% of the participants underscore the need for a nuanced approach. This suggests that while boiling and chlorination may be operationally straightforward, there is a crucial aspect related to user satisfaction that cannot be overlooked.

These taste and odour concerns highlight the necessity for targeted training programs aimed at addressing the nuances of water treatment, including the mitigation of taste and odour issues for both boiling and chlorination methods. It is essential to consider the development of community-based training initiatives that not only focus on technical proficiency in water treatment methods but also address user preferences and concerns for both boiling and chlorination practices. By integrating community engagement strategies such as involving local leaders and leveraging existing community networks, these training programs can be tailored to resonate with the specific needs and challenges of the community across different water treatment methods.

These findings align with previous research, emphasizing the need for more comprehensive training and support for POU water treatment practices, encompassing both boiling and chlorination methods. Low adherence rates, even when POU water treatment products are provided free of charge or at a subsidized price, indicate that the challenges extend beyond mere accessibility and affordability for both boiling and chlorination practices (Daniel et al. 2018; 'Kumwenda et al. 2014; Lantagne & Yates 2018; Masanyiwa et al. 2019). Therefore, the focus should be on developing sustainable behaviour change interventions that go beyond the provision of resources for both methods.

Furthermore, these insights have significant policy implications, suggesting the need to integrate taste and odour considerations into water treatment programs for both boiling and chlorination practices. By allocating resources for targeted community trainings and incorporating user feedback into program design, policy interventions can address the multifaceted challenges associated with POU water treatment practices across various methods. This inclusive approach can lead to more effective and sustainable outcomes, driving positive changes in community water treatment practices regardless of the chosen method.

The findings of this study emphasized the widespread availability of traditional boiling as a water treatment method, with a notable majority of respondents finding it easily accessible in their area, highlighting the prevalence of this practice within the community. However, the study also revealed disparities in the accessibility of waterguard/chlorine, with a smaller proportion reporting easy access to these methods. Additionally, sentiments from focus group discussions indicated variations in accessibility based on location and season. For example, in certain communities, the availability of energy sources such as firewood and charcoal were relatively higher, especially during the rainy season, influencing the accessibility of boiling as a water treatment method. Furthermore, proximity to health centres was associated with easier access to chlorine, demonstrating the influence of geographic factors on the accessibility of specific water treatment technologies.

The study's findings on disparities in the accessibility of point-of-use (POU) water treatment methods/technologies highlight the importance of adopting a multi-sectoral approach to address public health challenges. By engaging various stakeholder groups and sectors such as health and environment, we can foster deliberate collaboration to jointly tackle the challenges related to water treatment accessibility.

Improving energy sources is a critical aspect. While this may require further scientific novelty, it has the potential to enhance the accessibility of POU water treatment methods like boiling.

This emphasis on a multi-sectoral approach ensures a comprehensive response to public health challenges.

Additionally, the study highlighted the perceived affordability of POU water treatment methods/technologies within the community. A significant majority of respondents who used boiling found it affordable, reflecting the cost-effectiveness of this traditional practice. Similarly, even among non-users, there was acknowledgment of the affordability of these methods/technologies. This suggests the potential for broader adoption, given the perceived cost of accessibility.

Statistical associations revealed through chi-square tests highlight a consistent link between a respondent's choice of POU water treatment method/technology and their perceptions of ease of operation, accessibility, and affordability. These findings carry critical implications for designing and implementing POU water treatment interventions. It underscores the need to acknowledge diverse preferences, recognize perceived barriers, and consider existing practices within the community (Daniel et al. 2018; Lantagne & Yates 2018).

To enhance the adoption of POU water treatment practices, a strategic approach is essential. By leveraging the inherent advantages of traditional methods like boiling while also addressing potential barriers associated with newer technologies, interventions can be tailored to encourage more widespread and sustained adoption. This multi-faceted approach ensures that community-specific factors are considered, leading to more effective and sustainable water treatment practices.

4.9 Factors affecting adoption of POU water treatment

A binary logistic regression highlighted three main factors that affected adoption of POU water treatment i.e., self-efficacy, cues for action and action efficacy.

The study demonstrated that individuals with easy access to POU water treatment materials (*B*=2.135, $p<.001$) were more inclined to embrace this practice in their households. This finding contrasts with prior studies where even the provision of these materials for free or at a subsidized cost did not significantly boost adoption rates, and in some cases, led to the abandonment of the practice over time (Boisson et al. 2013; Daniel et al. 2018; 'Kumwenda et al. 2014; Masanyiwa et al. 2019).

Although self-efficacy emerged as a significant factor, historical evidence suggests that increasing awareness and bridging the knowledge and technical gaps among water practitioners could have a profound impact (Daniel et al. 2018; Kgabi et al. 2014). Correspondingly, the study brought to light the influential role of knowledge regarding health benefits (*B*=4.182, $p<.001$) in driving the adoption of POU water treatment. Individuals who perceived the practice as a safeguard against waterborne diseases were more likely to engage in it.

This underscores the urgency of intensifying awareness campaigns to enhance public understanding of the health benefits associated with POU water treatment. Simultaneously, efforts should focus on promoting innovative products to enhance both availability and accessibility. This was one end the private sector and the academia held.

Interestingly, the study revealed that availability of money (*B*= -2.443, $p<.001$) had a negative relationship with the practice of POU water treatment. Supposedly, having more income would improve access to POU water treatment (Bitew et al. 2017; Daniel et al. 2018; Moropeng & Momba 2020) but the study suggests otherwise. Thus, as people go up the income ladder, they are less likely to practice POU water treatment. Most people who had more money had water piped into their dwellings hence were less compelled to treat water since tap water was perceived to be clean, requiring no further treatment at POU (Bitew et al. 2017; 'Kumwenda et al. 2014; Masanyiwa et al. 2019). It doesn't come as a surprise that "*the belief that tap water is* *clean and doesn't need treatment*" (*B*= -3.282, $p < .004$) came out as a barrier as well. However, this did not come from only those with water piped into their dwellings, even those who drew water from community standpipes shared the same belief (Bitew et al. 2017; 'Kumwenda et al. 2014; Masanyiwa et al. 2019). Sentiments from FGD also revealed that this notion is long engraved in their culture.

Another noteworthy aspect influencing the adoption of POU water treatment is the perceived inconvenience of the method (*B*= -2.577, $p < .001$). Participants in the study shared sentiments during Focused Group Discussions (FGDs) that highlighted the time-consuming nature of some water treatment methods, with certain approaches, like boiling, particularly being singled out as exhausting. The process of boiling was reported to take longer, and the associated energy consumption posed challenges, especially considering the limited resources and escalating costs of firewood and charcoal in the vicinity of Mzuzu City. While the study uncovered that some non-governmental organizations and the academia are holding their end in developing aspiring products that could address this factor, previous studies revealed slow progress as most products still harbour operational and potability constraints (Lantagne & Yates 2018; Moropeng & Momba 2020).

These insights shed light on the practical hurdles individuals face in implementing POU water treatment practices, showcasing the importance of not only addressing beliefs and awareness but also making the methods more feasible and energy efficient. This aspect should be considered in broader strategies aimed at enhancing the overall adoption of POU water treatment, acknowledging the real-life constraints faced by individuals in their daily routines.

Cues for action (*B*= -1.305, $p< .002$) was another factor uncovered in this study. Even though the relationship is negative, it must be said that the question under this factor was negative thus it enquired about how difficult it was to recall the need to treat water prior to consumption. In this regard, increasing one unit in difficulty yielded a decrease in the likelihood of the participant practicing POU water treatment. Thus, if people found it more difficult to recall the need to treat water before consumption, they would not adopt the practice. However, majority of the participants acknowledged that it was not at all challenging to remember. Notably, practitioners found this task even easier due to the integration of the practice within their routines. The findings align with previous research, suggesting that individuals often initiate water treatment based on their perceived risk (Daniel et al. 2018; Kgabi et al. 2014). This observation underscores the significance of cues for action in influencing the practice of POU water treatment. The Health Belief Model, as well-demonstrated in existing literature, provides a solid framework to understand and address these cues for action.

Public health practitioners can leverage on the insights derived from the Health Belief Model to inform the design of effective programs aimed at promoting POU water treatment. By emphasizing perceived susceptibility, severity of waterborne diseases, benefits of adopting POU water treatment, and addressing barriers and cues for action, interventions can be tailored to resonate with individuals' perceptions and motivations. This strategic utilization of the Health Belief Model enhances the potential success of public health initiatives, fostering widespread adoption of POU water treatment practices for improved water safety (Ojomo et al. 2015).

In tandem with cues for action, the study brought to light the role of action efficacy (B= 2.831, $p < .001$) as a critical factor influencing the adoption of POU water treatment. Action efficacy delved into the participants' perception of the likelihood of contracting diarrhoea if water remained untreated before consumption, reflecting a keen awareness of the potential health risks involved. Interestingly, this echoes previous research findings, emphasizing the significance of perceived risk in motivating individuals to engage in water treatment practices(Daniel et al. 2018; Kgabi et al. 2014).

Notably, action efficacy gained prominence when the water's quality was in doubt, primarily stemming from concerns about the state of the water source. Participants were particularly attentive to the risks associated with consuming water directly from unprotected shallow wells, recognizing the heightened susceptibility to waterborne diseases in such scenarios.

By linking these findings to earlier research, a consistent pattern is vivid, reinforcing the critical role of perceived risk and efficacy in driving the adoption of POU water treatment. This emphasises the need for public health practitioners to craft interventions that not only heighten awareness but also emphasize the effectiveness of POU water treatment in mitigating health risks, especially in contexts where water quality remains a concern.

6 CONCLUSION AND RECOMMENDATIONS

4.10 Conclusion

In conclusion, the study revealed a high level of awareness and positive receptiveness to Point-of-Use (POU) water treatment methods among residents in high-density areas of Mzuzu City. The study highlighted key factors influencing awareness, perceptions, and adoption of POU water treatment practices, shedding light on the complex interplay of socio-economic factors, community dynamics, and individual beliefs.

The findings indicate that location, education, income, and assets significantly influence awareness, challenging traditional notions about the association between income levels and awareness. The study emphasizes the importance of holistic advocacy approaches, considering the diverse demographics within high-density areas.

Perceptions and practices regarding POU water treatment varied, with boiling and chlorination being perceived as the most convenient methods. Community dynamics, household assets, and proximity to health centres played crucial roles in shaping preferences for specific treatment methods.

Factors affecting the adoption of POU water treatment included self-efficacy, cues for action, and action efficacy. Easy access to materials, knowledge of health benefits, and perceived susceptibility to waterborne diseases were identified as significant drivers of adoption. Surprisingly, higher income levels were associated with lower adoption rates, suggesting a need to address the perception that tap water is inherently clean and doesn't require treatment.

This study contributes to the literature on water quality and health in developing countries, by providing empirical evidence and insights on the factors that influence POU water treatment practices in urban settings. The study also offers practical recommendations for policy makers, practitioners, and researchers who aim to promote POU water treatment methods to improve the health and well-being of the residents. The study concludes that POU water treatment methods have the potential to enhance the quality of life of the residents in high-density areas of Mzuzu City if the barriers to adoption are addressed and the benefits are communicated effectively.

4.11 Recommendations

Future studies should expand their research beyond the high-density settlement areas of Mzuzu city and include diverse urban settings across Malawi. By broadening the geographic focus, researchers can gather more comprehensive data on the factors influencing the adoption of POU water treatment methods. This approach will not only deepen our understanding but also enhance the generalizability of findings beyond Mzuzu City. Additionally, exploring similar dynamics in other low-income countries will provide valuable insights into commonalities and differences, ultimately contributing to universally applicable strategies for improving water quality in urban areas.

Public health practitioners develop advocacy strategies that consider the diverse demographics within high-density areas, ensuring inclusivity in awareness campaigns. This will help to challenge the traditional notion that income levels determine awareness, as we found that location, education, income, and assets all had a significant impact on awareness. This will also help to reach different income levels, education backgrounds, and community settings with tailored messages that emphasize the importance and benefits of POU water treatment methods.

The industry should develop and promote affordable and effective POU water treatment products tailored to the diverse needs and preferences of residents in high-density areas. Enhancing accessibility and attractiveness of POU methods is crucial for widespread adoption, customer satisfaction, and loyalty. Additionally, it is recommended that the industry should collaborate with local health centres and community leaders to raise awareness and educate residents on POU benefits. Building trust and credibility through such partnerships fosters positive social norms. Furthermore, it's essential that the industry prioritizes user-friendly product design for enhanced consumer convenience. We advocate for a focus on corporate social responsibility, emphasizing support for the less privileged. Balancing business goals with social impact will not only contribute to community well-being but also enhance the industry's overall reputation.

The government should take decisive actions to create an enabling environment for POU water treatment initiatives. While policies advocating for the less privileged exist, enforcement of regulations often falls short. We urge the government to bolster the effectiveness of these policies by rigorously enforcing regulations on service providers. This includes ensuring compliance with corporate social responsibility commitments and implementing stringent processes for the registration of new water treatment products.

Furthermore, recognizing water as a fundamental right, the government should actively oversee service providers to guarantee access to clean water for every individual. This oversight should extend to aspects such as fair pricing and service quality. By prioritizing and enforcing these regulations, the government can play a pivotal role in creating a conducive environment for POU water treatment, thus fulfilling its duty to safeguard citizens' right to access clean water.

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APPENDIX A: Household Survey Questionnaire

Interviewer's Name: ______________________________ **Questionnaire No.: _____**

Date: ____/____/____ **Community: ____________________**

Introduction
Hi, my name is __________________________ and I am part of a study team looking into point-of-use water treatment in high density areas of Mzuzu City. The study includes a discussion of this issue and will take about 20 minutes. I would like to hear your views on this topic. You are not obligated to participate in the study and no services will be withheld if you decide not to. Likewise, if you decide to be interviewed, you will not be compensated in any way or receive any gifts or services. Everything we discuss will be held in strict confidence. Would you like to talk with me? *[If not, thank them for their time.]*

Section A: Demographic and Socio- Economic Data

1. What is the gender of the respondent?
   a. Male
   b. Female
2. What is the age of the respondent?
   a. 15 – 24
   b. 25 – 34
   c. 35 – 44
   d. 45 – Above

3. What is the marital status of the respondent?

    a. Single

    b. Married

    c. Divorced/separated

    d. Widowed

4. What is the level of education of the respondent?

    a. No primary

    b. Primary

    c. Secondary

    d. Tertiary

5. What is the main source of income in your household?

    a. Formal Employment

    b. Casual labour

    c. Farming

    d. Entrepreneurship

6. Does the household own the following assets?

    a. Radio

    b. Television

    c. Cellphone

Section B: Awareness of point-of-use water treatment

7. What is your main source of drinking water?

    a. Borehole
    b. Community standpipe
    c. Piped into yard/plot
    d. Piped into dwelling
    e. Unprotected well
    f. Protected well
    g. River/stream
    h. Rainwater
    i. Others ……………….

8. Do you know point-of-use water treatment?

    a. Yes
    b. No

9. What point-of-use water treatment methods do you know/heard about?

    a. Boiling
    b. Adding water guard/chlorine
    c. Straining through a cloth
    d. Using water filter (ceramic, sand etc.)

e. Letting it stand and settle

f. Other methods. Specify________________

g. Don’t know

10. Do you think consuming untreated water puts a person at risk of contracting water diseases?

a. Yes

b. No

c. Don’t know

11. Do you think Point-of-use water treatment can reduce the risk of contracting water diseases?

a. Yes

b. No

c. Don’t know

Section C: Perceptions of point-of-use water treatment

12. Do you treat drinking water to make it safer at your household?

a. Yes

b. No

13. Which is the most common method for treating drinking water in your household?

a. Boiling

b. Adding water guard/chlorine

c. Straining through a cloth

d. Using water filter (ceramic, sand etc.)

e. Letting it stand and settle

f. Other methods. Specify______________________

14. Why did you choose the method in mention? __________________

15. Are point-of-use water treatment methods/technologies easily accessible in your area?

a. Yes

b. No

c. Don't know

16. Are the point-of-use water treatment methods/technologies affordable in your area?

a. Yes

b. No

c. Don't know

Section D: Factors affecting adoption of point-of-use water treatment

17. What makes (could make) it easy for you to treat your water before consumption?

18. What makes (could make) it difficult for you to treat your water before consumption?

19. What are (could be) the advantages of treating your water before consumption?

20. What are (could be) the disadvantages of treating your water before consumption?

21. Do most of the people that you know approve of you treating water before consumption?

a. Yes

b. Maybe

c. No

22. Who are all the people that approve that you treat water before consumption?

23. Who are all the people that disapprove that you treat water before consumption?

24. How difficult is it to get the materials and services you need to treat water before consumption?

    a. Very difficult

    b. Somewhat difficult

    c. Not difficult at all

25. How difficult is it (would be) to remember to treat water every time you need to do it?

    a. Very difficult

    b. Somewhat difficult

    c. Not difficult at all

26. How likely is it that you (or anyone in your family) would get diarrhoea in the next two weeks?

    a. Very likely

    b. Somewhat likely

    c. Not likely at all

27. How serious would it be if you (or anyone in your family) would get diarrhoea?

a. Very serious

b. Somewhat serious

c. Not serious at all

28. How likely is it that you or anyone in your family would get diarrhoea if you did not treat your water?

a. Very likely

b. Somewhat likely

c. Not likely at all

29. Do you think that God approves of you treating water before consumption?

a. Yes

b. Maybe

c. No

30. Are there any community laws or rules in place that you know of that make it more likely that you treat water before consumption?

a. Yes

b. Maybe

c. No

31. Are there any cultural rules or taboos that you know of for or against treating water before consumption?

a. Yes

b. Maybe

c. No

APPENDIX B: Focus Group Discussion Guide

Focus Group Discussion Guide

For men and women living in high density areas of Mzuzu City who are willing to participate, do not use piped water as primary source, store water in their homes and do not practice point of use water treatment. Each group will have a minimum of six and a maximum of eight participants.

Perceived self-efficacy

1. What makes (could make) it easy for you to treat your water before consumption?
2. What makes (could make) it difficult for you to treat your water before consumption?

Perceived positive consequences

3. What are (could be) the advantages of treating your water before consumption?

Perceived negative consequences

4. What are (could be) the disadvantages of treating your water before consumption?

Perceived social norms

5. Do most of the people that you know approve of you treating water before consumption?
6. Who are all the people that approve that you treat water before consumption?
7. Who are all the people that disapprove that you treating water before consumption?

Perceived access

8. How difficult is it to get the materials and services you need to treat water before consumption?

Perceived cues for action

9. How difficult is it (would be) to remember to treat water every time you need to do it?

Perceived susceptibility /perceived risk

10. How likely is it that you (or anyone in your family) would get diarrhoea in the next two weeks?

Perceived severity

11. How serious would it be if you (or anyone in your family) would get diarrhoea?

Perceived action efficacy

12. How likely is it that you or anyone in your family would get diarrhoea if you did not treat your water?

Perceived divine will

13. Do you think that God approves of you treating water before consumption?

Policy

14. Are there any community laws or rules in place that you know of that make it more likely that you treat water before consumption?

Culture

15. Are there any cultural rules or taboos that you know of for or against treating water before consumption?

APPENDIX C: Key Informant Interview Guide

Key Informant Interview Guide

For key players in Water, Sanitation and Hygiene in Mzuzu City. This interview guide covers six sections where information will be gathered thus User preference; Integration and collaboration; Standards, certification and regulation; Resource availability; Market strategies and User guidance on point-of-use water treatment

Section A: User preferences

User demand for point-of-use water treatment

1. What is your role in ensuring that people are motivated to improve their health?
2. What is your role in ensuring that people understand economic benefits of point-of-use water treatment?

User technology preferences

3. What aspiration technologies are available for people?
4. What approaches do you use to ensure that it is easy for people to incorporate point-of-use water treatment in their daily routine?
5. Are there any cultural barriers affecting people's decision making on point-of-use water treatment?

Section B: Integration and collaboration

6. Which other organisations have you partnered with in advocating point-of-use water treatment?
7. Has point-of-use water treatment ever been integrated into other programs?

8. What role does the tradition leaders play in advocating for point-of-use water treatment?

Section C: Standards, certification and regulations

9. Does the government prioritise point-of-use water treatment?

10. What role does the government play in supporting new innovative point-of-use water treatment technologies?

11. Are available technologies certified effective in our communities?

Section D: Resource availability

12. What role do you play in ensuring that available technologies and methods are affordable to people?

13. What challenges do you face to ensure cost effective implementation?

Section E: Market strategies

14. What is your role in ensuring a sustainable supply chain of point-of-use water treatment technologies?

Section F: User guidance on point-of-use water treatment products

15. What role do you play in ensuring that people know how to use point-of-use water treatment technologies/methods efficiently?

APPENDIX D: Consent Form

Mzuzu University Research Ethics Committee (MZUNIREC)

Informed Consent Form for Research in

Point of use water treatment in high density areas of Mzuzu city

Introduction

I am ___________________________from Mzuzu University Department of Water and Sanitation. We are doing research on point of use water treatment in high density areas of Mzuzu city**.** This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them of me or of another researcher.

Purpose of the research

This research aims to identify factors keeping people from practicing point-of-use water treatment in high density areas of Mzilawayingwe, Chiputula, Zolozolo west, Luwinga and Lupaso wards in Mzuzu City.

Type of Research Intervention

This research will involve your participation in an individual interview on the topic mentioned above.

Participant Selection

You are being invited to take part in this research because you draw water from a groundwater resource.

Voluntary Participation

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. If you choose not to participate nothing will change. You may skip any question and move on to the next question.

Duration

The research takes place for a period of about 20 minutes.

Risks

You do not have to answer any question or take part in the discussion/interview/survey if you feel the question(s) are too personal or if talking about them makes you uncomfortable.)

Reimbursements

You will not be provided any incentive to take part in the research.

Sharing the Results

The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public. Following, we will publish the results so other interested people may learn from the research.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact: Dr Mavuto Tembo +265 997 376 822/ +265 882 506 610.

This proposal has been reviewed and approved by Mzuzu University Research Ethics Committee (MZUNIREC) which is a committee whose task it is to make sure that research participants are protected from harm. If you wish to find out more about the Committee, contact Mr. Gift Mbwele, Mzuzu University Research Ethics (MZUNIREC) Administrator, Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2,

Phone: 0999404008/0888641486

Do you have any questions?

Part II: Certificate of Consent

I have been invited to participate in research about point of use water treatment in high density areas of Mzuzu city.

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study

Print Name of Participant__________________

Signature of Participant ___________________

Date ___________________________

Day/month/year

If illiterate [1]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness____________ **Thumb print of participant** ☐

Signature of witness _____________

Date ________________________

Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands the research project. I confirm the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm

[1] A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent__________________________

Date ___________________________

Day/month/year

APPENDIX C: Work Plan

Year 2 (2021-22)																																									
Semester 1																		Semester 2																							
#	Activity Details	Jul				Aug				Sep				Oct				Nov				Dec				Jan				Feb				Mar				Apr			
	Weeks	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.	Proposal preparation, presentation & submission	■	■	■	■																																				
2.	Field plan preparation					■	■	■	■																																
3.	Data collection								■	■	■																														

4.	Data analysis											■	■	■	■																										
5.	Progress report								■		■				■				■																						
6.	Documentation															■	■	■	■																						
7.	Draft thesis submission																			■	■																				
8.	Presentation of thesis																					■	■	■	■																
9.	Submission of final thesis																								■																
10.	Final corrections and submission																									■	■														

APPENDIX D: Budget

Proposed Budget (MWK)			
Item	**Quantity**	**Amount (MWK)**	**Sub-total (MWK)**
FGD refreshments			
FGD 1	10	800	8000
FGD 2	10	800	8000
FGD 3	10	800	8000
Sub-total			**24000**
Research Assistants			
Assistant 1	5	5000	25000
Assistant 2	5	5000	25000
Assistant 3	5	5000	25000
Sub-total	15	15000	**75000**
Stationary			
A4 Field notebooks	6	1300	7800
Ballpoint pens	1	5000	5000
Plain paper rims	3	7000	21000

Printing			150000
Sub-total			**183800**
Covid-19 preventive gear			
Face masks	2	5000	**10000**
Hand sanitizer	1	5000	**5000**
Sub-total			**15000**
Other costs			
Communication	5	2000	10000
Transport			40000
Sub-total			**50000**
NCST fees			
NCST application fee			112000
NCST compliance fee			45980
Sub-total			**157980**
Grand total			**505780**