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Nexus of water quantity, microbiological quality and diarrheal diseases in children under five: a case of Hosanna town, Central Ethiopia

By: Abiot Abera Aydamo (ID.No. GSR/9649/11)

A dissertation submitted to the Ethiopian Institute of Water Resources in partial fulfillment of the requirements for the degree of Doctor of Philosophy (PhD) in Water and Public Health

Primary Advisor: Dr. Sirak Robele (Addis Ababa University)
Associate Professor in Water and Health
Secondary Advisor: Professor Seid Tiku (Jimma University)
Professor in Environmental Health and Ecology

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DISSERTATION APPROVAL

This is to certify that the thesis prepared by Abiot Abera Aydamo (GSR/9649/11) entitled *"Nexus of water quantity, microbiological quality and diarrheal diseases in children under five: a case of Hosanna town, Central Ethiopia"* and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy in Water and Health (Water and Public Health) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Examination board members signature:

Dr. Sirak Robele (Assoc. Prof.) ______ 19/03/2025

Main Supervisor Signature Date

Prof. Seid Tiku ______ 21/03/2025

Co-Supervisor Signature Date

Dr.-Eng. Kinfe Kassa (Assoc. Prof.) ______ 18/03/25

External Examiner Signature Date

Prof. Argaw Ambelu ______ 14March 2025

Internal Examiner Signature Date

Dr. Geremew Sahilu (Assoc. Prof.) ______ 17/03/2025

Internal Examiner Signature Date

Taffere Addis (Ass. Prof.) ______ 21/03/2025

Chairman, Examining Committee Signature Date

Dr. Zeleke Agide (Assoc. Prof.) ______

EIWR Director Signature Date

Dr. Tilahun Derib (Ass. Prof.) ______

Education Coordinator Signature Date

DECLARATION

I, the undersigned, affirm that I am the sole author of this dissertation. This work has not been submitted for any other degree or qualification at any other institution. All sources of information used in this dissertation have been properly acknowledged and referenced.

Name: Abiot Abera Aydamo

Signature: ________________

Date: ___________________

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LIST OF ACRONYMS AND ABBREVIATIONS

AIRR	Adjusted Incidence Rate Ratio
AOR	Adjusted Odds Ratio
APHA	American Public Health Association
CIRR	Crude Incidence Rate Ratio
COR	Crude Odds Ratio
CSA	Central Statistical Agency
CBOs	Community Based Organizations
^{o} C	Degree Celsius
EG	Exposed Group
EPHI	Ethiopian Public Health Institute
EDHS	Ethiopia Demographic and Health Survey
FGDs	Focus Group Discussions
GEE	Generalized Estimating Equations
IR	Incidence Rate
HM	Hosanna Municipality
HTAHO	Hosanna Town Administration Health Office
HTWSE	Hosanna Town Water Supply Enterprise
HWISES	Household Water Insecurity Experience Scale
HWTS	Household Water Treatment and Safe Storage
JMP	WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene
KIIs	Key Informant Interviews
IDPs	Internally Displaced Persons
L/C/D	Liters per Capita per Day
MF	Membrane Filtration
NGOs	Non-Governmental Organizations
RR	Risk Ratio
SDG	Sustainable Development Goals
SNNPRS	Southern Nations, Nationalities and People's Regional State

SSA	Sub-Sharan Africa
UG	Unexposed Group
UN-Habitat	United Nations Human Settlements Program
UNECE	United Nations Economic Commission for Europe
UNICEF	United Nations International Children's Emergency Fund
VIF	Variance inflation factors
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization

ABSTRACT

While various studies worldwide have examined the impact of water quantity and quality on childhood diarrhea, there is limited evidence available on how seasonal changes in domestic water use and microbial water quality affect childhood diarrhea. Additionally, limited longitudinal studies have tracked diarrhea incidence, and those that measured domestic water use often miss the daily and seasonal variations. Hence, this study aimed to investigate seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children in the peri-urban and informal settlements in Hosanna town. The study employed a mixed-method approach. The study incorporated a prospective cohort study with a one-year follow-up period, along with cross-sectional and qualitative study, to fulfill all its objectives. The study was conducted in three Kebeles of Hosanna town, namely Bobicho, Sech-Duna, and Jelo-Naremo Kebeles. The sample size for the prospective cohort study and cross-sectional study was limited to 292 and 424 households, respectively. The original data was obtained through a structured questionnaire, observational checklist, observational spot-check method, storage container inventories, interviews, laboratory analysis, FGDs, KIIs, and HWISE Scale. The data was analyzed using bivariate and multivariable logistic regression, stepwise-multiple linear regression, GEE model, thematic analysis, non-parametric tests, and t-tests. All households had access to piped water, either on or off-premises. However, the reliability of these water sources was a significant issue, with only 8.9% of households having access to reliable water services. A total of 440 stored water samples were analyzed for E. coli presence during dry and rainy seasons. The prevalence of stored water contamination with E. coli was 43.2% (95% CI = 36.6% - 49.8%) and 34.5% (95% CI = 28.2% - 40.9%) during the dry and rainy seasons, respectively. The daily per capita water consumption was 19.4 liters (95% CI = 18.81 - 20.05) in the dry season and 20.3 liters (95% CI = 19.69 - 20.94) in the rainy season. The study found that 68.6% of the households experienced water insecurity, and 16% of children under the age of five suffered from diarrhea. Only 42.2% of the mothers practiced good handwashing. The incidence of diarrhea was 1.6 episodes per child-year, with high rates in exposed groups. Households without piped water on premises had 2.2 episodes per child-year, while those with piped water on premises had 1.0 episodes. Piped water off premises, unsafe disposal of child's stool, eating unheated food, and poor handwashing practices at critical times also contributed to the increased incidence of diarrheal diseases. Consuming water contaminated with E. coli during the dry and rainy seasons has significantly increased diarrhea risk. Additionally, consuming less than 20 liters of water per capita per day during the dry season has also significantly increased the risk of diarrhea. The study found that most households had access to unreliable drinking water sources and lacked basic sanitation and handwashing facilities. Seasonal changes significantly affected household water use and microbiological water quality. Diarrhea incidence and prevalence and household water insecurity were notably high, creating public health concerns. Most mothers exhibited poor handwashing practices. Therefore, the study emphasizes the need to enhance on-premises water access and improve the reliability of the drinking water sources to reduce diarrhea risk. Seasonal monitoring of drinking water safety is also recommended to maintain its health standards.

Keywords: *Diarrhea incidence, E. coli, household water use, peri-urban, seasonal variations, off-premises water access*

Chapter One. Introduction

1.1. Background and Justification

Adequate access to safe water, sanitation, and hygiene is essential for maintaining human health and well-being [1]. Although there has been significant progress in recent years, many people still lack access to safely managed drinking water and sanitation services. In 2022, only 73% and 57% of people have access to safely managed drinking water and sanitation services worldwide, respectively [2]. This number is disproportionally low in sub-Saharan Africa, including Ethiopia. In 2022, only 31% of people in sub-Saharan Africa had access to safely managed drinking water services, while 24% had access to safely managed sanitation services. In Ethiopia, only 13 % and 7% of people have access to safely managed drinking water and sanitation services, respectively. Water supply is posing an enormous challenge to urban areas of the developing countries due to three interconnected factors, such as the high rate of population growth, lack of infrastructure and investments, and limited access to natural water resources [3]. Additionally, natural urban expansion and migration from rural areas to cities have led to a rapid increase in urban populations, resulting in a substantial number of people lacking access to safe drinking water and adequate sanitation [4].

In sub-Saharan Africa, urban growth primarily takes place in informal settlements [5]. These areas lack sufficient access to water due to rapid population growth and the swift pace of urbanization in the region. A very recent report by WHO/UNICEF indicated that only 57% of the urban population in this region had access to improved water sources accessible on-premises in 2022, while in a rural area, 15% of households had access to improved drinking water sources accessible on-premises [2]. In this region, 43% of the urban population depends on shared water points for their water supply. In Ethiopia, 76% of urban households had access to improved drinking water sources accessible on-premises. The urban population generally enjoys better access to improved water sources compared to their rural counterparts in sub-Saharan Africa [5]. Nevertheless, significant disparities in water access often exist within urban areas in the region. This is due to the fact that residents of informal settlements, low-income neighborhoods, or unauthorized areas typically have less access to improved water supplies [6]. Adequate access to water and sanitation is a human right and is required for the success of other human rights, including the right to health and development [7]. But, the government usually neglects illegal settlement by not providing water and sanitation services, which is against human rights [8].

In Ethiopia, as in many other developing countries, the issue of urban water supply is becoming increasingly critical [9]. This has led to the proliferation of diseases, including diarrhea, which is a major health concern in the country [10]. However, the incidence of these diseases can be significantly reduced by providing sufficient, high-quality drinking water and basic sanitation [11]. A systematic review and meta-analysis have also demonstrated that improvements in drinking water, sanitation, and hygiene practices have significantly lowered the risk of diarrhea in low-income and middle-income countries [12]. In Hosanna town, similar to other urban areas in the country, the problem of water supply is quite apparent. The availability of drinking water is insufficient, particularly in the peri-urban and informal settlements, leading to various water-related diseases, which are the primary health issues in the area [13].

The goal of providing safely managed drinking water services, as outlined in Sustainable Development Goals (SDGs) target 6.1, is proving to be a significant challenge, particularly in peri-urban and informal settlements due to insufficient progress in water supply in these areas [14,15]. The majority of these settlements rely on off-premises water sources, which often fall short of providing adequate water in terms of quality and quantity. A review article has confirmed that the time taken to fetch water can negatively impact the quality and quantity of water that households are able to collect [16]. Similarly, a study has shown that off-premises water access results in poorer water quality and lower quantities compared to on-premises water sources [17]. Moreover, accessing water from off-premises water sources can have detrimental effects on health due to limited water availability, decreased water quantity for hygiene purposes, and increased risk of contamination [18].

Seasonal changes also significantly impact water quality, availability, and usage. In developing countries, even improved water sources that are typically safeguarded against external contamination show seasonal variation in fecal contamination levels [19]. Similarly, findings obtained from Ethiopia showed that the microbiological quality of water at the point of use exhibits significant seasonal differences [20]. Seasonal shifts can also affect the availability and consumption of drinking water [21]. Inadequate access to safe drinking water leads to numerous water-related diseases, including diarrhea [22]. Hence, to comprehend the effect of water on human health, it is crucial to assess both the microbiological quality and the quantity of water used for various household use in the study area.

Studies conducted in different parts of the world have assessed the effect of water quantity and quality on childhood diarrhea. Nevertheless, little evidence is available about the effect of seasonal variability of domestic water use and microbial water quality on childhood diarrhea. Studies that examined domestic water use and microbiological water quality have also failed to capture seasonal variability of domestic water use and microbiological water quality. Limited longitudinal studies, mainly prospective cohort studies that examined incidence and risk factors of childhood diarrhea in the country is also another gap, which affects the country's effort in addressing childhood diarrhea. This research aims to address these gaps in both the current literature and within the country.

1.2. Concise literature review

1.2.1. Access to drinking water, sanitation, and hand hygiene facilities and their determinant factors

1.2.1.1. Access to drinking water

According to the WHO/UNICEF report, nearly 91% of the global urban population collects their drinking water from improved water sources [23]. Drinking water sources in urban areas could be either improved or unimproved. Improved water sources can be explained as drinking water facilities that are expected to be safe and free of contamination due to the nature of their construction and the design, which adequately protects the source from outside contamination. This improved water includes piped water connection located inside the user's dwelling, plot, or yard, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection [24]. On the other hand, unimproved sources are more prone to contamination, which includes the unprotected dug well, unprotected spring, a cart with small tank/drum, tanker truck, and surface water (river, dam, lake, pond, stream, canal, irrigation channels) and bottled water. In 2017, WHO/UNICEF also introduced a new ladder for drinking water services [25]. This ladder categorizes drinking water sources into safely managed, basic, limited, unimproved, and surface water.

The WHO/UNICEF report showed that around 2.2 billion people are without safely managed drinking water services in 2022 [2]. The report further showed that still 411 million people use unimproved water sources. Access to water can be explained in terms of service reliability and availability, affordability, and physical access [26]. Physical access can be a household connection or a common source (on public grounds). Similarly, the WHO indicated that the adequacy of the drinking water supply should be measured by considering basic service parameters of a drinking water supply such as quantity, quality, accessibility, affordability, and continuity [27]. While global rural-urban disparities in water access have improved, significant gaps still exist [23]. Generally, urban areas enjoy better water access than rural areas in sub-Saharan Africa [5]. However, within urban areas, there remains an issue of inequality of water access between different neighborhoods in the region [28]. This problem is more pronounced in the peri-urban and informal settlements.

1.2.1.2. Access to sanitation and hand hygiene facilities

Access to adequate sanitation and hand hygiene facilities is a key determinant of health outcomes. Sanitation encompasses a range of practices aimed at safely managing human waste, including feces and urine [29]. Its purpose is to safeguard human and community health by minimizing the transmission of diseases. In urban areas, there are both unimproved and improved sanitation facilities, as well as open defecation. The WHO/UNICEF report indicated that 82% of the global urban population uses improved sanitation facilities. These improved facilities ensure the hygienic separation of human waste from human contact [23]. Improved sanitation encompasses facilities such as flush or pour-flush toilets linked to a piped sewer system, septic tanks, or pit latrine. It also includes ventilated improved pit (VIP) latrines, pit latrines with slabs, and composting toilets. In contrast, unimproved sanitation facilities such as pit latrines without a slab, hanging latrines, and bucket latrines do not adequately separate human waste from human contact [24]. Shared sanitation facilities, which include public toilets, are used by multiple households and do not meet the criteria for improved sanitation. Maintenance challenges associated with shared facilities contribute to their exclusion from the improved sanitation category, as they can become a source of disease transmission [30]. Additionally, open defecation, where individuals defecate in open areas like fields, forests, bushes, or bodies of water, poses environmental and public health risks, especially in developing countries like Ethiopia.

In 2017, WHO/UNICEF introduced a new sanitation ladder that classifies services into different levels, such as safely managed, basic, limited, unimproved, and open defecation/urination [25]. Great progress in improving safely managed sanitation services has been made globally. Globally, the proportion of people with access to safely managed sanitation services increased from 49% in 2015 to 57% in 2022 [2]. However, progress has been much slower in sub-Saharan Africa and Ethiopia. In sub-Saharan Africa, the proportion of people with access to safely managed sanitation services increased from 22% in 2015 to 24% in 2022. In Ethiopia, the percentage of the population with access to safely managed sanitation services increased from 6% in 2015 to 7% in 2022. Urban areas have a better sanitation service compared to rural areas in sub-Saharan Africa [5]. In addition to the disparity between urban and rural areas, there is also a significant disparity in access to sanitation within the urban areas in sub-Saharan Africa [5]. This is because the peri-urban and informal settlement areas have lower access to sanitation than other urban areas. The poor economic level of the households and the nature of settlement has contributed to lower access to sanitation in peri-urban areas [31]. Over half of the population in sub-Saharan Africa resides in informal settlements, where they are deprived of essential infrastructure and services, such as sanitation [32]. This could have a number of negative consequences for human health and well-being, which include increased risk of waterborne diseases. Handwashing plays a vital role in enhancing public health and stopping the spread of infectious diseases. In 2017, a new hygiene ladder was introduced, categorizing hygiene services into three levels, which include basic, limited, and no facility [25]. A basic facility means having a handwashing station on-site with both soap and water, whereas a limited facility means having a handwashing station on-site but without soap and water.

1.2.1.3. Determinant factors of WASH facilities

The determinants of access to drinking water, sanitation, and hand hygiene facilities include a range of factors at the household level. Having a household head’s wife at home significantly improved access to clean water in per-urban settlements of Abidjan [31,33]. This underlines the crucial role women play in ensuring clean and safe water availability. Better education and income of household heads were associated with greater access to improved water sources [34]. Several other studies also supported these findings [33,35,36]. Households having a larger family size have better access to improved water sources than smaller households [35]. The availability of piped water on premises can be influenced by the income of the households. Households having a better income are likely to have private water connections [35].

Access to improved sanitation is influenced by a range of factors, including socio-demographic factors. Highly educated household heads and a better household income were associated with increased access to improved sanitation facilities than their counterparts [35,36]. A study conducted mainly focusing on access to safely managed sanitation services in Jimma town showed that female-headed households, better education, and income of the households were significantly associated with access to safely managed sanitation facilities [37]. Findings obtained from Uganda demonstrated that being a homeowner was significantly associated with increased access to improved sanitation facilities [38]. A number of factors have also been identified as a determinant of the availability of hand hygiene facilities at home. Findings obtained from Ethiopia verified that a better educational level of household head, higher income of the household, and the presence of improved latrines at home were significantly associated with the presence of basic handwashing facilities [39]. Furthermore, the findings highlighted that having radio and television at home has increased access to basic handwashing facilities. The findings from the pooled binary logistic regression model reveal that several factors significantly influence the availability of handwashing facilities in households across four Eastern Africa countries. These predictors include the age, sex, and educational level of the household head, the type of place of residence, the number of children, and the household's wealth [40]. Essentially, these variables play a crucial role in determining whether households have access to handwashing facilities in these countries. Households that were homeowners had a higher likelihood of having a handwashing facility [38].

1.2.2. Seasonal variations in household water use and quality

1.2.2.1. Household water use, microbiological water quality, and diarrhea

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Household water use and diarrhea

The various micro-components that make up a household's overall water usage include drinking, watering the garden, cooking, cleaning dishes, showering, bucket baths, handwashing, toilet flushing, home washing, and car washing [21]. In a typical urban East African household, water serves four main purposes [41]. First, there are consumptive uses, which involve water used for drinking and cooking purposes. Second, hygiene purposes include water for bathing, washing clothes, cleaning, and flushing toilets. Third, amenity purposes cover water used for watering lawns, car-washing, garden-watering, and other non-essential tasks. Finally, productive uses encompass activities such as watering livestock, constructing homes, and brewing beer. Overall, residential water is used for various domestic needs, including drinking, food preparation, bathing, washing clothes, flushing toilets, and watering lawns and gardens [42].

Sufficient access to safe water is crucial for good health [43]. Conversely, a lack of adequate water supply can negatively impact public health and hinder proper sanitation and hygiene [22]. Inadequate water supply can stem from poor access, low quality, unreliability, high cost, or management challenges, all of which pose significant health risks. Enhancing various aspects of the water supply is crucial in preventing diarrhea [44]. The attributes associated with the features of water supply include consistency, predictability, and pressure [45]. According to Hunter et al., six important factors determine the effectiveness of a water supply in maintaining good health [22]. These factors are water's quality, its quantity and use, physical access to water, reliability of water supplies, the cost of water to the user, and the end-users' ease of management.

Per-capita water use is indirectly linked to fecal-oral and other hygiene-related diseases, as shown by Howard *et al.* [46]. Their finding indicates that lower water usage increases the risk of these diseases. Another study found that more water at home reduces the risk of diarrhea [47]. Specifically, households with 20-50 liters of water per capita per day have a 30% lower risk of diarrhea compared to those with less than 10 liters per capita per day. Howard et al. recommend a minimum of 20 liters per capita per day for essential activities like drinking, cooking, maintaining food hygiene, washing hands and faces. This recommendation does not cover other hygiene practices [46]. An inadequate amount of domestic water supply may lead to poor hygiene practices [48]. Shrestha *et al*. emphasized that having enough water, regardless of the source, is more crucial than limited access to improved water for reducing diarrhea [49]. In the Greater Irbid area of northern Jordan, Abu-Ashour and Al-Sharif used linear regression analysis to study the relationship between daily water consumption and diarrhea incidences over five years [50]. The study found that higher daily water consumption reduced diarrhea incidences.

A study aimed to evaluate the impact of water quantity on human health, separate from water quality, indicated that interventions to increase water quantity are linked to a lower risk of diarrheal disease [51]. Similarly, a systematic review showed that having more water at home is linked to a lower risk of diarrheal disease in low-and middle-income countries [52]. The review also indicated that the health benefits obtained from increased quantities of water depend on the individual's behavior in the way they use the water. Research in Eastern Africa showed that higher household water usage significantly reduces diarrheal diseases [53]. Conversely, a study conducted in Atwima Nwabiagya District, Ghana, found no significant link between the daily per-capita water use in liters and childhood diarrhea [54]. This is because higher per capita water use alone may not be enough to reduce the risk of diarrhea if proper hygienic practices are not followed.

Microbiological water quality and diarrhea prevalence

Globally, approximately 1.8 billion people, predominantly in low- and middle-income countries, rely on water sources contaminated with fecal matter [55]. Research from Bangladesh has shown a connection between fecal contamination in household drinking water and diarrhea in young children [56]. Enhancing the microbiological quality of drinking water at the point of use provides greater health benefits than improvements at the source alone. Studies indicate that the health benefits of improved or protected water sources are limited without ensuring safe transport and storage [57]. Drinking water containing pathogens poses risks and leads to diarrheal diseases [10,58,59]. Another study emphasized that unsafe drinking water is a major transmission route for infectious diarrheal and other diseases [60]. In Cameroon and Chad, descriptive analysis revealed that 60% and 59% of childhood diarrhea cases are due to the consumption of unsafe drinking water, respectively [61].

A study in the slums of Addis Ababa found that contamination of household stored water with *E. coli* was independently linked to acute diarrhea [62]. Similarly, research in the Kersa and Omo Nada districts of Jimma Zone, Ethiopia, showed that higher *E. coli* levels in the water were associated with increased odds of diarrhea [63]. However, this analysis used bivariate logistic regressions without accounting for potential confounding factors, failing to show the true relationship between *E. coli* levels and diarrhea. In rural areas of Bangladesh and Northwest Ethiopia, studies have identified a notable link between the levels of indicator bacteria in water and the occurrence of diarrhea [59,64]. A recent study in Bangladesh also found a significant association between *E. coli* levels in drinking water and childhood diarrhea [65]. Likewise, a systematic review and meta-analysis found a significant link between exposure to *E. coli* in drinking water and the occurrence of diarrhea [66]. Various other studies also indicate a weak but positive link between *E. coli* counts in household drinking water and diarrhea [67,68]. Conversely, several studies have found no association between indicator bacteria levels in drinking water and childhood diarrhea [69–71]. The small sample size in the study, with few cases of diarrhea recorded, may contribute to the lack of a significant association between microbial water quality and diarrhea.

1.2.2.2. Seasonal Variations in Household Water Use and Microbiological Water Quality

Seasonal variations significantly influence both water quantity and quality, impacting human health [72]. However, there are limited studies on seasonal variation in water quantity and microbiological water quality, which poses significant challenges for public health initiatives. A systematic review found that fecal contamination in improved drinking water sources exhibits a seasonal pattern, with higher contamination during the wet season [19]. This trend remains consistent across various factors, including source types, fecal indicator bacteria, climatic zones, and both urban and rural areas. Findings obtained from rural communities in South Africa showed that in the analyzed water sources sample, bacterial levels during the wet season consistently exceeded those during the dry season [72]. This difference may result from increased runoff or infiltration, which transports bacteria from contaminated sources to these water bodies. However, household stored water exhibited the opposite trend, with lower mean total coliform levels during the wet season than in the dry season. Findings obtained from Addis Ababa, Ethiopia, confirmed that microbial contamination of drinking water at the point of use varied significantly between the dry and rainy seasons [20]. This finding highlighted the importance of proper sanitation and effective water treatment at home to mitigate health risks associated with microbiological contamination. In South India, a study has shown that both tap and household microbial water quality exhibit seasonal variations [73]. Specifically, fecal coliform levels vary seasonally in both public taps and household stored water. Other studies have also highlighted seasonal variations in water quality [74,75]. Findings from Northwest China, however, revealed that there were no significant seasonal variations in major ions in groundwater [76].

Similar to water quality, seasonal changes in water availability and consumption affect public health. In the context of Freetown city, Seirra-Leone, researchers discovered a notable seasonal variation in per capita water consumption [21]. It also indicated that higher family income and the use of more water containers positively correlated with water consumption. Conversely, factors such as distance to the water sources and time spent fetching water negatively impacted water consumption. Findings from Ghana revealed a higher daily water consumption during the wet season [54]. In essence, different factors play a role in water usage depending on the season. Key predictors in the wet season include the volume of water storage vessels, family size, and number of water storage vessels. In the dry season, water storage duration, volume of water storage containers, water service hours, and family size were significant predictors. In the wet season, higher water quantity corresponds to increased treated water from municipal water [72]. The findings also highlighted that wet season water availability influences residents' water use habits. Evidence indicates that water scarcity during the dry and hot seasons has led to a rise in diarrhea cases, with hygienic practices playing a crucial role in shaping the seasonal pattern of these diseases [77]. Despite the profound implications of seasonal changes on human health, there are inadequate studies focusing specifically on the seasonal variations in water quantity and microbiological water quality. This gap in research hinders our understanding of how seasonal dynamics affect public health, complicating efforts to address water-related health issues.

1.2.2.3. Methods used for measuring water use and microbiological water quality

Unlike water quality measurements, where there is an accepted standard method for measuring water quality [78], lack of standard methods for measuring water use, especially in the areas where water meters may not be an option, is the major problem [79]. Household water use can be estimated using two predominant quantification approaches, which are the consumption and supply-based approaches. In determining household water use, each approach considers different data collection tools, including household surveys, water diaries, direct observations, and measurements [80]. The same study indicated household water use from taps under multiple source dependence quantified by combining household surveys and well-designed water diaries of supply and pumping, coupled with simple one-time field measurements. In developing countries, people usually collect water in large containers to cope with the lack of water pressure, the intermittent water supply, and the impurities within the water. Hence, the water consumption can be estimated through either direct measurements or the interview method [81]. Another study determined household water consumption by combining metered data, storage container inventory, and structured observations [82]. These mixed methods helped estimate water use under infrequent intermittent water delivery conditions.

Evidence from a study in Hanoi, Vietnam, indicated that combining methods like direct metering, questionnaire survey, and toilet tank and shower flow rate measurement is the viable method for measuring residential indoor water use [83]. Various other studies also combined questionnaires with other methods to estimate water use [21,84]. Despite the susceptibility of water use measurements via questionnaires to recall bias, several studies from various global regions have employed this method [54,85,86]. A recent systematic review on measuring unmetered water use in low-income settings recommended water use recall, suggesting that a 24-hour recall period is acceptable to estimate water use [79]. Furthermore, the review showed that measurements of unmetered water use should take into account the day-to-day variation and seasonal variation of water use for reliable results.

Fecal contamination in drinking water is prevalent in lower- and middle-income countries, affecting all water sources, including piped supplies [55]. Pathogens such as bacteria, viruses, and parasites pose significant health risks when ingested through contaminated water [87]. However, the primary health concern is infectious diarrheal diseases transmitted via the fecal-oral route [88]. *E. coli* is the most suitable indicator for monitoring and assessing microbiological water quality, as it signifies recent fecal contamination [89] and has a strong association with diarrhea risk in household drinking water [66].

1.2.2.4. Challenges to the Provision of Adequate Drinking Water

The global challenge of providing adequate drinking water is influenced by factors like economic growth, rapid population growth, industrialization, and increased standards of living in many regions of the world [90]. Moe and Rheingans identified key barriers to progress in water access globally, including insufficient investment in water infrastructures, lack of political commitment, and reluctance to explore innovative approaches [91]. Evidence from studies in urban areas of sub-Saharan African countries highlights inadequate water access resulting from rapid population growth and urbanization [5]. The problem is more critical in the informal settlement of the region where they experience inadequate water supply. Informal settlements, which arise haphazardly on public or private land, lack essential infrastructure such as water, sanitation, electricity, garbage collection, and paved roads [92]. Socio-economic factors also play a role in influencing the availability of water in households in Malawi's informal settlements [93]. Similarly, the peri-urban areas, which contain slum areas and informal settlements, face a unique set of water and sanitation-related challenges, and they generally lack essential services like water and sanitation [94]. A systematic review identified six primary barriers to water, sanitation, and hygiene policy development, adoption, and implementation in informal settlements in low and middle-income countries [8]. These barriers encompass economic, spatial, social, institutional, political, and informational factors.

1.2.3. The Nexus between Household Water Insecurity, Mother's Handwashing Practices, and Diarrheal Diseases among Under-five Children

1.2.3.1. Household water insecurity, mother's handwashing practices, and diarrheal diseases

Nearly 58% of diarrheal deaths in low-and middle-income countries associated with inadequate water sanitation and poor hygiene [95]. Maintaining proper handwashing practices among mothers is essential for controlling childhood diarrhea [96]. Evidence from a multi-country study highlights that caretaker handwashing with soap is associated with reduced diarrhea in children [97]. Hygiene practices, which include handwashing with soap at critical moments and safe storage and treatment of water, effectively reduce the risk of diarrheal disease [98]. Findings from Addis Ababa highlighted that washing hands with soap after defecation and before preparing food is crucial for preventing diarrhea [99]. Multiple studies also emphasize the importance of handwashing with soap at critical times to interrupt pathogen transmission [96,100]. A systematic review concluded that using soap and water to wash hands can reduce the likelihood of diarrheal diseases by 42–47% [101]. Another review showed that handwashing with soap at key times can reduce diarrhea by 48% [102]. However, the effectiveness of handwashing relies on having enough water available in households.

Mothers with access to private, piped water and sewerage connections tend to practice better hand hygiene [103]. In Burundi, researchers found that the frequency of handwashing is influenced by the available water per person in households [104]. Similarly, findings from Ethiopia highlighted that water availability in households, along with maternal knowledge and attitudes, significantly impacts handwashing practices [105]. Other studies also suggest that having more water in households is associated with better handwashing habits [106,107]. On the other hand, insufficient access to water can lead to water insecurity, potentially compromising hygiene practices and elevating the risk of waterborne illnesses [46]. Research conducted in rural households in West Cameroon found that greater distance to the water source was linked to water insecurity and reduced household water availability [108].

Household water insecurity is the inability to access sufficient, affordable, reliable, and safe water for well-being and health [109]. It assesses households' experiences with water access and usage, serving as a crucial indicator of water security [110]. Globally, achieving water security remains a significant challenge, particularly in sub-Saharan African countries [21]. Various studies have demonstrated that water insecurity was associated with several health outcomes, including psychological distress and diarrhea [108,111,112]. Ensuring household water security is essential for promoting child health by reducing diarrhea incidents and encouraging better hygiene practices among caregivers [108]. Findings obtained from multi-site analysis revealed that experiencing water insecurity was associated with an elevated risk of diarrhea [113]. Likewise, a study conducted in rural Ethiopia by Hadley and Freeman also discovered a significant link between water insecurity and childhood diarrhea [114]. The existing studies on the connection between water insecurity, maternal handwashing habits, and diarrhea are insufficient, indicating a need for further research to address this gap.

1.2.3.2. Prevalence of diarrhea and associated risk factors

Childhood diarrhea remains a significant health concern for children under the age of five in developing countries, including Ethiopia [115]. The majority of deaths from diarrhea in children under five occur in South Asia and sub-Saharan Africa [116]. The disparity in diarrhea prevalence among under-five children is common across sub-Saharan African countries. The highest diarrhea prevalence among under-five children is 51% in Hargeisa IDPs [117]. Despite progress in reducing diarrhea-related morbidity and mortality, it remains a major cause of death in sub-Saharan Africa [118]. A recent systematic review and meat analysis focused on 34 sub-Saharan countries showed that the pooled prevalence of diarrhea among under-five children was 15.3% [119]. Factors such as maternal age, income, education, occupation, breastfeeding initiation time, child's age, and time to access a water source are significantly linked with diarrhea.

Like other sub-Saharan countries, there is a disparity in diarrhea prevalence across different parts of Ethiopia. The highest prevalence is 36.5% in West Guji Zone, Ethiopia [120], while the lowest prevalence is 9.4% in Bahir Dar, Northwest Ethiopia [121]. The overall prevalence of diarrhea among children under five years old in Ethiopia is 22%. Regionally, Afar has the highest rate at 27%, followed by Somali and Dire Dawa at 26% and Addis Ababa at 24%. Factors associated with childhood diarrhea included maternal education level, latrine availability, urban residence, and maternal handwashing practices [115]. A very recent review confirmed that the pooled prevalence of childhood diarrhea in Ethiopia was 20.8% [122]. The review also identified various factors associated with diarrhea, which include lack of rotavirus vaccination, undernourishment, and age of child. Mother's poor handwashing habits, failure to treat drinking water, a history of recent diarrhea in the mother, lack of a toilet, and handwashing stations were also identified as risk factors for diarrhea in Ethiopia.

Different studies conducted across different parts of Ethiopia also identified factors associated with diarrhea. A lower maternal education status is a significant predictor of childhood diarrhea [123–126]. This is because maternal education influences hygiene, sanitation, and child feeding practices, contributing to disease prevention [122,123]. Various studies also indicate that a mother's poor handwashing practices [127–130], recent diarrhea history in the mother [123,129,131,132], and a mother's employment status are significantly associated with increased risk of diarrhea among under-five children [133]. Children whose mothers do not work have a lower likelihood of experiencing diarrhea compared to those with working mothers. This could be due to the fact that maternal employment status influences the duration of breastfeeding [133].

Child related factors such as exclusive breastfeeding practices [132], age of child [99,134,135], malnutrition [126,136,137], and lack of rotavirus vaccination were considered as significant risk factors for diarrheal diseases among under-five children [134]. The absence of exclusive breastfeeding is a significant risk factor for diarrhea. Breast milk provides crucial antibodies and immune factors that protect infants from infections, including those causing diarrhea [138]. Without exclusive breastfeeding, infants miss out on this passive immunity, making them more vulnerable to pathogens [139]. Additionally, breast milk's nutritionally completeness and balanced composition during the first six months of life supports optimal growth and development, including the establishment of a healthy gut microbiome that guards against diarrheal pathogens [140]. Malnourished children are more vulnerable to diarrhea diseases because malnutrition weakens their immune system, making them more prone to infections, including those that cause diarrhea [141].

Several studies also identified environmental and behavioral factors such as the use of unimproved water sources [128], lack of toilets [128], unsafe child stool disposal practices [125,132], improper solid waste disposal practices[126], and lack of handwashing facilities as risk factors for childhood diarrhea [125]. Inadequate disposal of child stools can significantly contribute to the spread of diarrheal diseases among young children. When children's stools are disposed of unsafely, such as through open defecation or improper diaper disposal, they can contaminate the surrounding environment. This contamination may harbor pathogens that cause diarrhea. Children under-five, with their developing immune system and an increased exposure to contaminated substances, are particularly vulnerable to these pathogens. Having more than two under-five children [128] and the absence of drinking water treatment at home were also significantly associated with increased diarrheal diseases [132]. Findings obtained from Addis Ababa and Jimma showed that the presence of *E. coli* in household stored water increased the risk of acute diarrhea [62,63].

1.2.4. Incidence of Diarrhea and Associated Risk Factors Among Under-five Children

1.2.4.1. The causes, transmission and effects of diarrheal diseases

Diarrhea is characterized by having three or more loose or watery stools within a 24-hour period [142]. It can be caused by various bacteria, viruses, and protozoa. Key pathogens include Rotavirus, the leading cause of acute diarrhea, as well as *E. coli, Shigella, Campylobacter, Salmonella, V. cholera,* and *Cryptosporidium*. Several studies show that rotavirus is the main cause of childhood diarrhea [143,144]. Cryptosporidium is also a major contributor to moderate to severe diarrhea in children under the age of two [145]. Cholera, another type of diarrheal illness, is caused by the bacterium *Vibrio cholerae*. It spreads through the fecal-oral route and by consuming water or food contaminated with the bacterium [146]. It is common in various regions, including African countries, and can lead to large-scale outbreaks [147]. Enterotoxigenic *E. coli* and *Shigella* are also a significant cause of diarrheal disease worldwide [148]. The occurrence of specific pathogens varied based on the season [149]. While viral pathogens were more commonly detected during the dry season, Cryptosporidium was more common during the wet season. During the rainy season, bacterial pathogens had a slightly higher prevalence compared to in the dry season.

Pathogens that cause diarrhea are transmitted through a fecal-oral route, where the infection spreads from feces to mouth [48]. Diarrheal diseases can also occur from consuming food and water contaminated with these pathogens. This transmission route can be prevented by implementing primary and secondary barrier practices (Figure 1.1). Primary barriers involve proper disposal of stools to isolate them from human contact and removing fecal material from hands after contact with excreta. Secondary barriers include washing hands before preparing food, eating, and reheating food to prevent fecal pathogens from spreading. Additionally, protecting water supplies from fecal contaminants, water treatments, keeping play spaces free of fecal material, preventing children from eating soil, and controlling flies are crucial practices. Childhood diarrhea can also have significant consequences on a child's health. It is associated with malnutrition and can also affect cognitive development [150]. Diarrhea can also lead to stunted growth in children, making them more vulnerable to fatal infections [151]. Research has shown that a greater cumulative burden of diarrhea before 24 months of age is significantly linked to stunting [152]. Additionally, other studies found an association between early childhood diarrhea and slow linear growth [153,154].

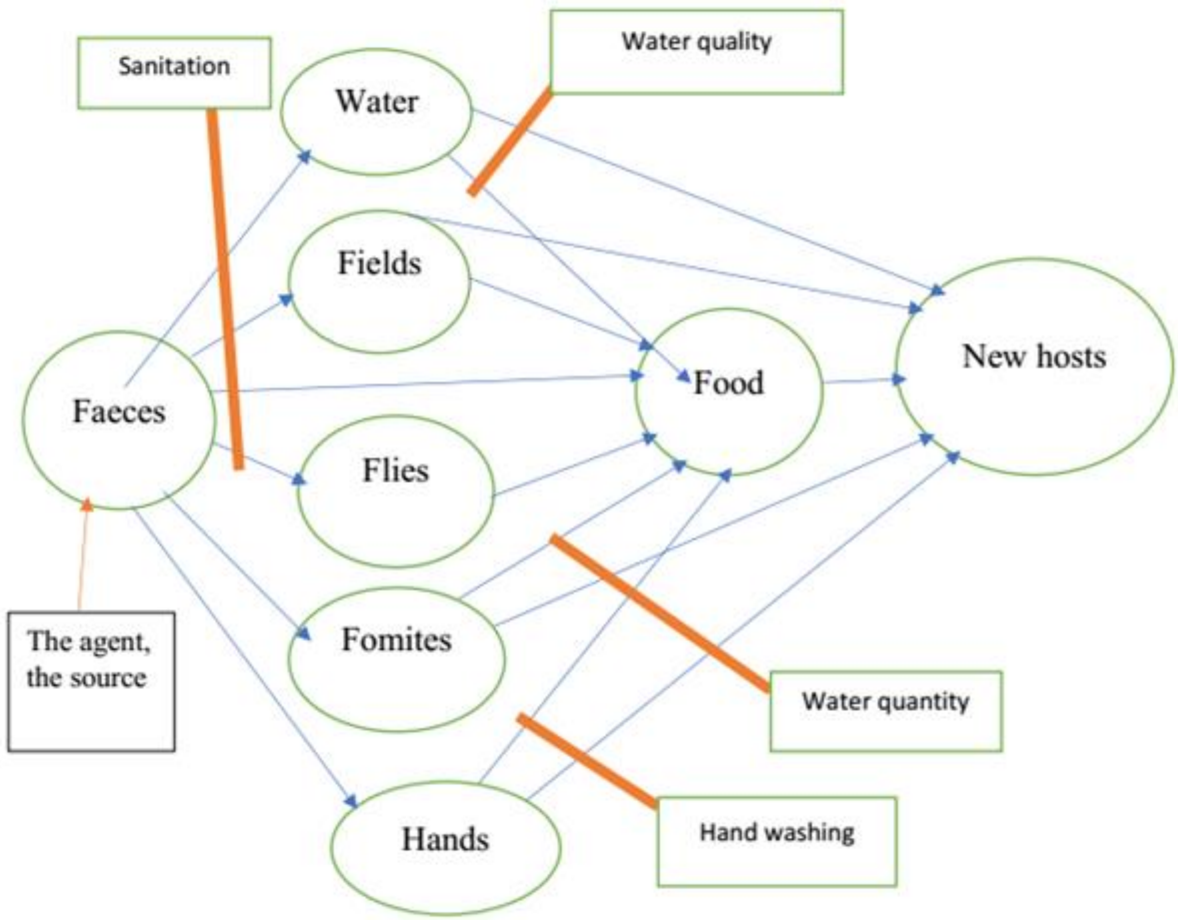

Figure 1.1. Faeco-oral transmission pathways adapted from Cairncross and Feachem [48]. Fomites are items like utensils or bedding that become contaminated and act as a carrier for pathogenic organisms.

1.2.4. 2. The implications of off-premises water supplies on diarrhea

In the literature, the health benefits obtained from improved water access have been documented in various studies [155,156]. Nevertheless, there is limited understanding of how off-premise water access impacts human health, including diarrhea, in comparison to on-premises water access. Additionally, the existing literature generated mixed evidence regarding the effect of on-premises water access on health when compared to off-premises water access. Childhood diarrhea risk is influenced by the distance from a water source, which may lead to reduced personal hygiene due to a lower availability of water [157]. The presence of on-premises water access directly impacts health through the quality and quantity of water within the household [158]. A systematic review demonstrated that the quantity of water accessible within households is influenced by the location of the water source [16]. Decreasing the time spent walking (15 minutes) to reach the water source is linked to a 41% decrease in the prevalence of diarrhea, which has been shown to significantly improve the health of children in households with sanitation facilities. The positive health outcomes observed may be attributed to the close-proximity to a water source, enabling more hygienic utilization of sanitation facilities [106]. Likewise, findings from Kenya indicated that the likelihood of contracting diarrheal disease rises when the time spent fetching water exceeds 30 minutes [159]. Additionally, the study showed that the amount of water used for hygiene is influenced by household water availability. Several studies have verified that on-premises water supplies can lower the risk of diarrhea [17,18,47,160,161]. However, other research indicates that on-premises water supplies do not significantly impact the occurrence of diarrhea [162–165]. This is because simply having water on premises does not provide complete health benefits unless it is supported by improved sanitation and better water storage practices.

1.2.4.3. Diarrhea incidence and associated risk factors

While cross-sectional studies have provided valuable insights into diarrhea prevalence and risk factors globally, there is a need for more longitudinal studies in Africa, especially Ethiopia. Longitudinal studies, which track incidence over time, offer a better understanding of diarrhea risk [161]. Conducting such research is crucial to addressing these prevalent health issues. A longitudinal study conducted in Salvador, northeastern Brazil, found that the overall incidence rate was 3.1 episodes per child per year. Risk factors included poor sanitation, intestinal parasites, poor socioeconomic status, and lack of prenatal examination [166]. In Papua New Guinea, diarrhea incidence varied from 3.4 episodes per 100 child-weeks in 12 to 17-month-old children to 0.17 episodes per 100 child-weeks in children 48 to 59-month-old children [160]. In a cohort study in Guinea-Bissau, the incidence of diarrhea was 10.2 episodes per child-year at risk. The study pinpointed seven variables that were independently linked to a higher likelihood of experiencing diarrhea. These factors include recent diarrhea history, lack of maternal care, having a young household head, use of unsafe drinking water, being male, consumption of cold leftovers, and cessation of breastfeeding [161].

Etiler and colleagues found that the incidence rate of overall diarrhea in Turkey was 2.76 episodes per child per year [167]. Factors such as the nutritional status of the child, possessing an unhygienic toilet, low level of mother's education, residing in a slum, income of the family, and self-employed fathers were among the factors associated with diarrhea incidence. Findings from rural Bangladesh revealed that the overall incidence of diarrhea among children was 4.25 episodes per child per year [168]. The highest rates of diarrhea occurred in the 6-11- and 12-17-months age groups. Several risk factors were associated with diarrhea incidence, including previous history of diarrhea, age of the child, not exclusively breastfeeding, dry spring season, and owning chickens in the household. A study carried out in Afghanistan revealed that the recorded rate of diarrheal illness was 3.51 episodes per child per year. The study also confirmed that factors including malnutrition, lower levels of maternal education, summer season, failure to wash hands with soap, and lack of improved sanitation facilities were significantly linked to an increased risk of diarrhea [165].

Research conducted in Eastern Ethiopia revealed that the incidence of diarrhea was 4.5 episodes per 100 persons-weeks in the intervention group, compared to 10.4 episodes per 100 persons-weeks in the control group [169]. The study demonstrated that treating household water with chlorine significantly reduced the incidence of diarrhea among children under five in the intervention group compared to those in the control group. A systematic review analyzed diarrhea incidence rates among children under five in low-and middle-income countries across six WHO regions for the years 1990 and 2010 (Table 1.1). The findings revealed a reduction in diarrhea incidence from 3.4 episodes per child per year in 1990 to 2.9 episodes per child per year in 2010 [170]. Notably, children aged 6-11 months had the highest incidence. Despite this decline, under-five children in these countries still face significant risk, emphasizing the need for additional resources to enhance prevention and treatment efforts. A very recent study showed that the incidence of diarrhea was 0.81 episodes per person per year among children under five years old [171]. The study also identified water source and type of toilet as potential risk factors for diarrhea.

Table 1. 1. Incidence of diarrhea for under-five children by WHO region for the years 1990 and 2010

S/no	Region	Diarrhea episode per child year for under five children (0 – 59 months)	
		1990	2010
1	South East Asian	3.0 (2.2, 3.8)	2.4 (1.5, 3.3)
2	Eastern Mediterranean	3.5 (2.0, 5.2)	3.0 (1.6, 4.4)
3	Africa	4.2 (3.0, 7.3)	3.3 (2.2, 5.1)
4	Western Pacific	2.5 (1.4, 2.8)	2.3 (1.3, 2.6)
5	Americas	4.5 (3.4, 5.3)	4.0 (3.1, 4.7)
6	Europe	4.4 (3.4, 5.2)	4.0 (3.1, 4.7)
7	Global	3.4 (2.9, 3.9)	2.9 (2.3, 3.4)

Source. Adapted from Fischer *et al*. [170]

1.2.5. Conceptual Framework

Diarrhea remains a significant public health issue in developing countries like Ethiopia, particularly affecting under five children. Understanding the factors contributing to childhood diarrhea in the study area is essential for creating effective interventions. The study identified several factors linked to childhood diarrhea, such as the type of water sources, the quantity of water used for domestic purposes, and the microbial quality of water at the point of use during both dry and rainy seasons. Additionally, mother's handwashing practices and household water insecurity were identified as critical factors. Other risk factors include maternal behaviors, child-related factors, and socio-demographic factors. Based on these insights, a conceptual framework is developed to illustrate the risk factor of childhood diarrhea in the peri-urban and informal settlements of Hosanna town, as depicted in Figure 1.2.

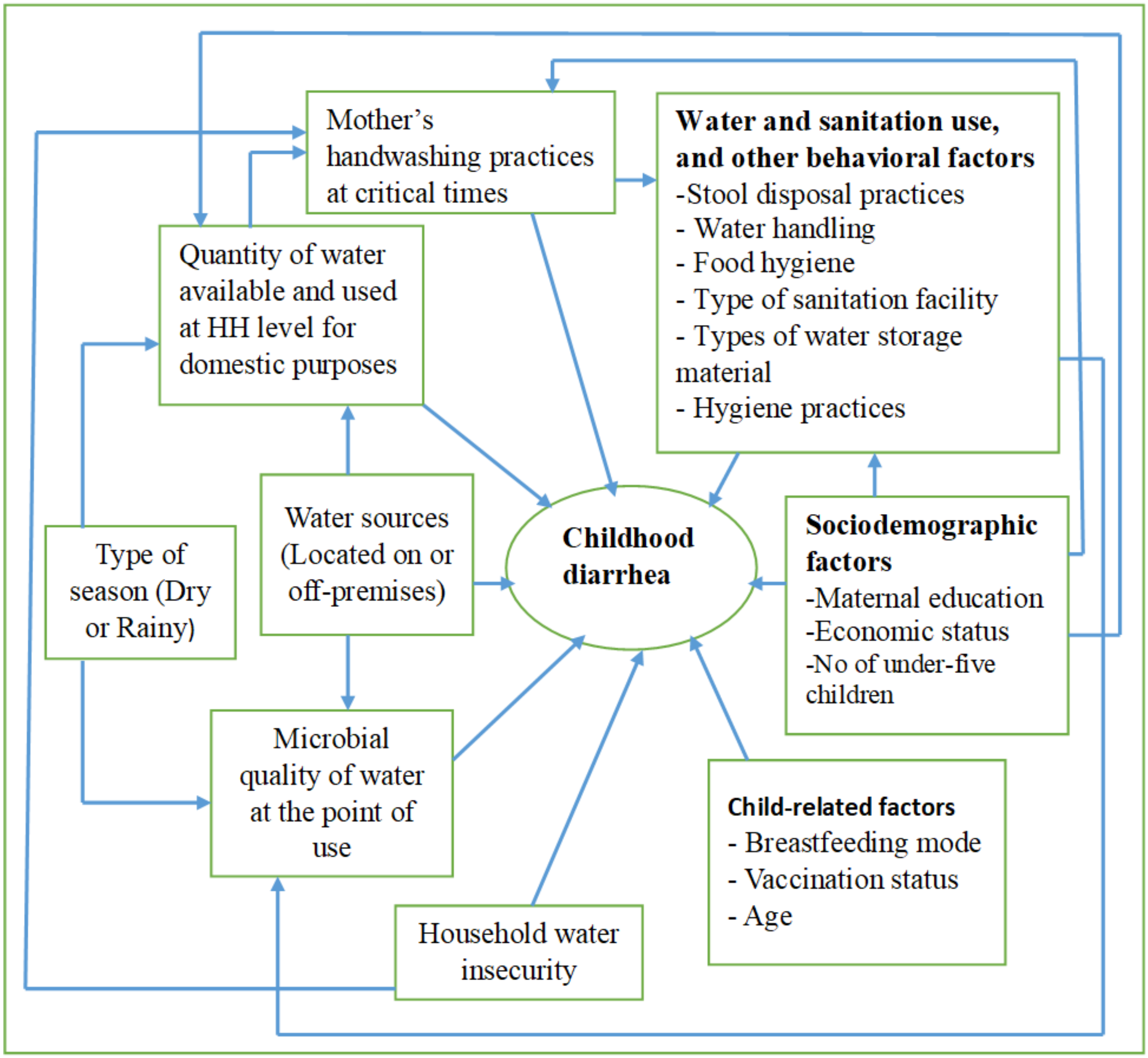

Figure 1.2. A conceptual framework on factors associated with childhood diarrhea in the peri-urban and informal settlements of Hosanna town.

1.3. Problem Statement

Diarrhea is a symptom of gastrointestinal infections caused by bacteria, viruses, and protozoa [172]. It is a leading cause of morbidity and mortality among under-five children in developing countries [173]. There are nearly 2.5 billion cases of childhood diarrheal disease globally each year. The majority of these cases occur in South-East Asia and sub-Saharan Africa [142]. The primary culprits behind diarrheal deaths globally are inadequate access to safe water, sanitation, and poor hygiene, accounting for 88% of such fatalities [174]. A recent report indicated that inadequate access to safe drinking water, sanitation, and poor hygiene contribute to 60% of diarrheal deaths in low- and middle-income countries [175]. Evidence obtained from Ethiopia has also confirmed that diarrheal diseases significantly contribute to under-five mortality [115]. Ethiopia has embraced the goal of enhancing access to safe drinking water and sanitation facilities, leading to notable improvements in both urban and rural areas [176]. However, challenges persist in urban areas, especially in slums and informal settlements. Hosanna town, like other parts of the country, faces critical issues related to water quantity and quality, particularly in the peri-urban and informal settlements.

In peri-urban and informal settlements, most households rely on off-premises water access, which is insufficient and susceptible to microbial contamination. The absence of on-premises water access heightens the risk of exposure to waterborne pathogens due to potential water contamination during the process of collection, transport, or storage [177]. The necessity to store drinking water for prolonged periods further increases the risk of microbial contamination. Besides the degradation of water quality, fetching water from off-premises water access also limits the quantity of water available for household use [17]. Studies have shown that consumption of microbiologically contaminated water leads to various waterborne illnesses [178,179]. Off-premises water access also has implications for childhood diarrhea. Some studies have found off-premises water access is associated with an increased risk of childhood diarrhea [17,18,160,161], while other studies have found no association [163,164]. Given the mixed evidence in the literature, it is important to conduct further research to clarify the effect of off-premises water access on the occurrence of childhood diarrhea.

Likewise, the water sources located off-premises can negatively impact the quality and quantity of water delivered to households, leading to various waterborne illnesses in the study area. According to Hosanna Town Administration Health Office (HTAHO), diarrheal diseases are the most common cause of illness among children under the age of five in the town [13]. The problem is believed to be more critical in the peri-urban and informal areas of the town due to inadequate infrastructure, such as water supply, sanitation, paved roads, and electricity. Ensuring consistent and adequate access to safe water is essential for improving human health and living standards in developing countries [180]. The availability of a sufficient quantity of water for consumption and hygiene is associated with water supply accessibility. Water availability and consumption, as well as microbiological water quality, can also vary from season to season, which could have a number of implications for public health [20,21]. These findings highlighted the importance of understanding seasonal variations in water quantity and quality to improve public health. A systematic review has suggested that direct measurement of water quantity is vital for understanding its impact on human health, rather than merely using water accessibility as a proxy for water quantity [52]. Simply quantifying the water gathered by families may not offer sufficient insights into its usage [79]. Hence, it is imperative to measure the quantity of water utilized for personal and household tasks to fully comprehend the influence of water quantity on health [52].

Various studies have investigated how household water usage and microbial water quality impact childhood diarrhea. However, there have been few studies examining the seasonal changes in domestic water use and microbial water quality and their link to childhood diarrhea. These limited studies have not comprehensively defined all aspects of domestic water use, which is crucial for understanding the impact of water quantity on human health. These gaps exist in the current literature as well as in the study area and in the country which this research seeks to fill. Besides, being a longitudinal study could offer an opportunity to clearly observe the temporal relationship between independent and outcome variables and also determine risk factors of childhood diarrhea over time, which would generate reliable data for informing public health policy. Therefore, this study tried to examine seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children in the peri-urban and informal settlements in Hosanna town.

1.4. Research Questions

The study was guided by the following research questions: -

1. What is the level of access to drinking water, sanitation, and hand hygiene facilities and their determinant factors in the study area?
2. What is the association between microbial water quality at the point of use and childhood diarrhea during the dry and rainy seasons?
3. What is the quantity of water used for domestic purposes and its association with childhood diarrhea during the dry and rainy seasons?
4. What are the challenges to the provision of adequate drinking water and its implications on childhood diarrhea in the study area?
5. What is the relationship between household water insecurity, mother's handwashing practices, and childhood diarrhea?
6. What is the incidence and risk factors of diarrheal disease among under-five children?

1.5. Research Hypotheses

The Alternative (H_1) hypotheses of the study were: -

H_1: There is a statistically significant association between per-capita water use and diarrheal diseases among under-five children during the dry and rainy seasons.

H_1: There is a statistically significant association between the microbial quality of drinking water at the point of use and diarrheal diseases among under-five children during the dry and rainy seasons

H_1: There is a statistically significant association between household water insecurity, mother's handwashing practices, and childhood diarrhea

H_1: Children exposed to water sources located off-premises could be at higher risk of diarrhea than children with water sources located on-premises.

H_1: There is a statistically significant difference in per capita water consumption and microbiological water quality at the point of use among households connected with piped water on and off-premises during the dry and rainy seasons.

1.6. Objectives of the Study

1.6.1. General objective

The major objective of this study was to investigate the seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children in the peri-urban and informal settlements in Hosanna town.

1.6.2. Specific objectives

- To examine access to drinking water, sanitation, and hand hygiene facilities and their determinant factors
- To assess seasonal variations in household water use, microbiological water quality, and challenges to the provision of adequate water
- To assess the nexus between household water insecurity, mother's handwashing practices, and childhood diarrhea
- To measure incidence and risk factors of diarrheal disease among under-five children

1.7. Significance of the Study

The study identified factors influencing WASH facilities and highlighted challenges in providing adequate water in the peri-urban and informal settlements of Hosanna Town. These findings are crucial for designing WASH interventions and addressing socio-demographic factors contributing to WASH inequity. The study also provides comprehensive data on the seasonal variability of domestic water use and microbiological water quality that can serve as a basis for designing an action plan to improve drinking water quality and quantity at the household and town levels in the study area. New insights into the relationship between the lack of on-premises water access, and water consumption, and microbiological water quality can inform future research. These insights can also enable policymakers to better allocate resources to improve water access, particularly in low-resource settings.

The daily per capita water consumption data would be helpful for the future planning of water supply and serve as baseline data nationally to provide evidence-based guidelines concerning water quantity requirements in the country. The study sheds light on the association between household water insecurity, mother's handwashing practices, and childhood diarrhea, aiming to inform efforts to improve water security and child health. It also provides data on the prevalence, incidence, and risk factors of childhood diarrhea, aiding in the development of preventive interventions. Furthermore, the study provides evidence of how seasonal changes in water availability and microbial water quality affect childhood diarrhea, which can enhance disease surveillance in the town. Finally, the findings provide baseline information for local leaders, policymakers, and other stakeholders who are working to improve water quantity and microbial water quality in the study area as well as in the country.

1.8. Scope of the study

The study area was limited to Hosanna town, particularly in Sech-Duna, Bobicho, and Jelo-Naremo Kebeles. These kebeles were purposely selected due to the presence of extensive peri-urban and spontaneous informal settlements. They are characterized by inadequate infrastructure, including water supply, sanitation, road construction, and other facilities. The study was limited to examining seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children. The study incorporated a prospective cohort study with a one-year follow-up period, along with cross-sectional and qualitative study, to fulfill all its objectives. The microbial water quality analysis at the point of use and sources and water quantity measurement were carried out during the dry and rainy seasons.

1.9. Limitations of the Study

Diarrhea data was collected through self-reports from mothers/caregivers without clinical confirmation. The analysis did not consider the children’s malnutrition status, presenting another limitation. Future research should include this factor to determine if there is a connection between children’s malnutrition status and diarrhea. The study was unable to detect the specific pathogens causing the diarrheal diseases. Hence, the study suggests that molecular detection of specific pathogens causing diarrhea is needed to better understand the causes and create more effective treatments for diarrhea in the study area. The study did not account for the temporal relationship between local weather conditions such as temperature, precipitation, and humidity and the incidence of diarrhea. This represents a limitation of the research, and future studies should examine how these weather conditions correlate with the risk of diarrhea over time. In some cases, households may wash their clothes outside their compound, potentially leading to an underestimation of the average per capita water consumption. Additionally, a few households collected water for backyard farming, which was not included in the analysis and might also underestimate water usage.

While the study has assessed the bacteriological quality of water at the point of use, storage reservoir, and point of water collection, other confounding factors might influence the current level of microbial water contamination in households. Factors such as leakage and microbial contamination within the distribution system need further investigation. Therefore, to gain a comprehensive understanding of microbial contamination problems in the study area, it is essential to sample water from both household private taps and the water distribution systems. Moreover, even though the sampled water was confirmed to be from primary sources, households might use alternative unsafe water sources during water supply interruption. This could contaminate water storage containers and stored water collected from main water sources, potentially affecting microbial contamination levels at the household level.

1.10. Structure of the Dissertation

The dissertation is organized into six interconnected chapters, each serving a specific purpose. In the introductory chapter, a brief overview of the background and justification, concise literature review, problem statement, research questions, research hypotheses, objectives, significance, scope of the study, and limitations of the study are included. Subsequently, chapters two through five present the findings from four distinct research articles. The last chapter provides an overall discussion, summarizes the conclusions drawn from the collective results, provides recommendations, outlines the study’s contribution, and discusses future prospects of the study.

Chapter Two. Access to drinking water, sanitation, and hand hygiene facilities in the peri-urban and informal settlements of Hosanna town, Southern Ethiopia

Adopted from

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Chapter Two. Access to drinking water, sanitation, and hand hygiene facilities in the peri-urban and informal settlements of Hosanna town, Southern Ethiopia

2.1. Background

Access to safe drinking water, sanitation, and good hygiene (WASH) are fundamental in promoting good health and development [181]. However, globally, around 2 billion and 3.6 billion people are without safely managed drinking water supply and sanitation services, respectively [182]. A significant improvement has been achieved from 2000-2017, where globally, the population using safely managed drinking water services increased from 61% to 71%, and safely managed sanitation services increased from 28% to 45% [183]. A recent report also indicated that 74% and 54% of the population had access to safely managed drinking water services and sanitation services in 2020 worldwide, respectively [182]. This coverage is much lower in sub-Saharan Africa, where only 30% of the population in the region had access to safely managed drinking water services, and 21% had access to sanitation services in 2020. Achieving sustainable development goals (SDGs) targets 6.1 and 6.2, which include ensuring access to safely managed drinking water, sanitation, and basic hygiene services for all, is a big hurdle, particularly in the peri-urban and informal settlements due to inadequate progress in water, sanitation, and hygiene services [14].

Urban growth in sub-Saharan African cities occurs mainly in informal settlements, where access to water is often inadequate [5]. This informal growth is due to rapid population growth and rapid urbanization in the region. Despite an increase in access to improved drinking water facilities, the coverage of improved water sources accessible on premises was the lowest in sub-Saharan Africa compared with other regions in 2020. A recent report by WHO/UNICEF indicated that only 31% of the population, which includes urban and rural areas of sub-Saharan Africa, use improved water sources accessible on-premises. Furthermore, the report showed that only 59% and 36% of them use supplies that are available when needed and free from contamination, respectively [182]. In general, urban places have better water access than rural areas in sub-Saharan Africa [5]. However, the intra-urban disparity in water access is a common problem in the region. This is because people living in low-income, informal, or illegal settlement areas had lower access to an improved water supply than other urban areas [184].

Sub-Saharan Africa (SSA), including Ethiopia, is one of the regions with low levels of improved sanitation coverage. In the region, only 52 % of the population had access to improved sanitation facilities in 2020 [182]. A 2019 Ethiopian mini-demographic survey also indicated that 41.6% and 9.7% of households in urban and rural areas of Ethiopia had improved sanitation facilities, respectively. However, the report includes only the non-shared improved sanitation facilities, excluding shared facilities. The report also showed that 87% of households in urban areas and 61% of households in rural areas of Ethiopia had access to improved water sources [185]. A recent finding from Ethiopia indicated the existence of inequalities in access to improved drinking water and sanitation in Ethiopia [186]. Improving access to safe drinking water and sanitation facilities is a long-standing development goal that Ethiopia has adopted, and much improvement has been observed in both urban and rural settings [176]. Despite progress in recent times, there is still a significant problem in urban areas of the country, particularly in urban slums and informal settlements. A study conducted in Uganda indicated that ensuring access to improved sanitation has become a big problem in the majority of low-income countries, particularly in poor urban informal settlements [14].

Likewise, ensuring access to water and sanitation was a critical problem in Hosanna town, particularly in the peri-urban and informal settlements [13]. The rapid urbanization along with rural people migration and lack of capacity for the local government to control informal settlements in Hosanna town has created massive peri-urban and informal settlements. The peri-urban areas refer to places located in the peripheral areas of the town, which contain predominantly legal settlements, and in a few cases, settlements that emerge illegally on private land, which lack access to adequate water, sanitation, and other infrastructure. On the other hand, informal settlements refer to places that lack land tenure rights, which are located in the transition zone between urban peripheral and rural areas, which include predominantly settlements that emerge illegally where there is inadequate infrastructure like roads, electricity, water, and other infrastructure. Informal settlements are not part of the urban development planning process as no land information is officially collected, and thus leads to low security of land tenure and poor living conditions due to lack of basic urban infrastructure and services [187].

Inadequate access to safe water, sanitation, and poor hygiene are responsible for 62% of diarrheal deaths in low- and middle-income countries [175]. Various studies in Ethiopia also verified that poor access to water and sanitation was associated with diarrhea [188–190]. A study conducted in semi-urban areas of northeastern Ethiopia showed that 78.3% of the studied households used pit latrines without slabs, indicating that unimproved sanitation was the most commonly used sanitation facility in the area [191]. Likewise, access to water and sanitation is inadequate in Hosanna town, particularly in the peri-urban and informal settlements [13]. This has increased the risk of various water-related diseases, including diarrhea in the study area. The risk of various water-related diseases can be minimized through better water, sanitation, and hygiene services [192]. Evidence obtained from a systematic review also shows that improvements in drinking water, sanitation facilities, and hygiene practices have significantly reduced the risk of diarrhea in less developed countries [193,194].

Access to water, sanitation, and hygiene facilities and practices has been extensively studied in urban and rural areas of developing countries, including Ethiopia. However, there is little information on access to water, sanitation coverage, and hygiene facilities, particularly in the peri-urban and informal settlement areas in the study area. Therefore, a baseline survey was conducted to examine access to water, sanitation, and hand hygiene facilities and their determinant factors in the peri-urban and informal settlement settings of Hosanna town. It is hoped that the findings obtained from this study provide the basis for local leaders as well as policymakers to make informed decisions on which water, sanitation, and hygiene systems fit for peri-urban and informal settlement settings of Hosanna town and other major towns of the country.

2.2. Method

2.2.1. Study area

Hosanna town is the capital city of Hadiya zone and central Ethiopia region, which is located 232 km from Addis Ababa, the capital of Ethiopia [195]. The town was established in 1904 and had 8 administrative kebeles and three sub-cities before 2018. However, following a new reform in 2018, the town was divided into six administrative urban kebeles, namely, Bobicho, Arada, Sech-Duna, Lich-Amba, Jelo-Naremo, and Heto. Kebele is the lowest administrative structure in Ethiopia. The population size of Hosanna town was estimated to be 145,399 in 2021-2022, of which 50.8% were males and 49.2% were females [196]. Geographically, the town is located at 7^0 30′ 00′ - 7^0 35′ 00″ North latitude and 37^0 49′ 00″ - 37^0 53′ 00″ East longitude (Figure 2.1).

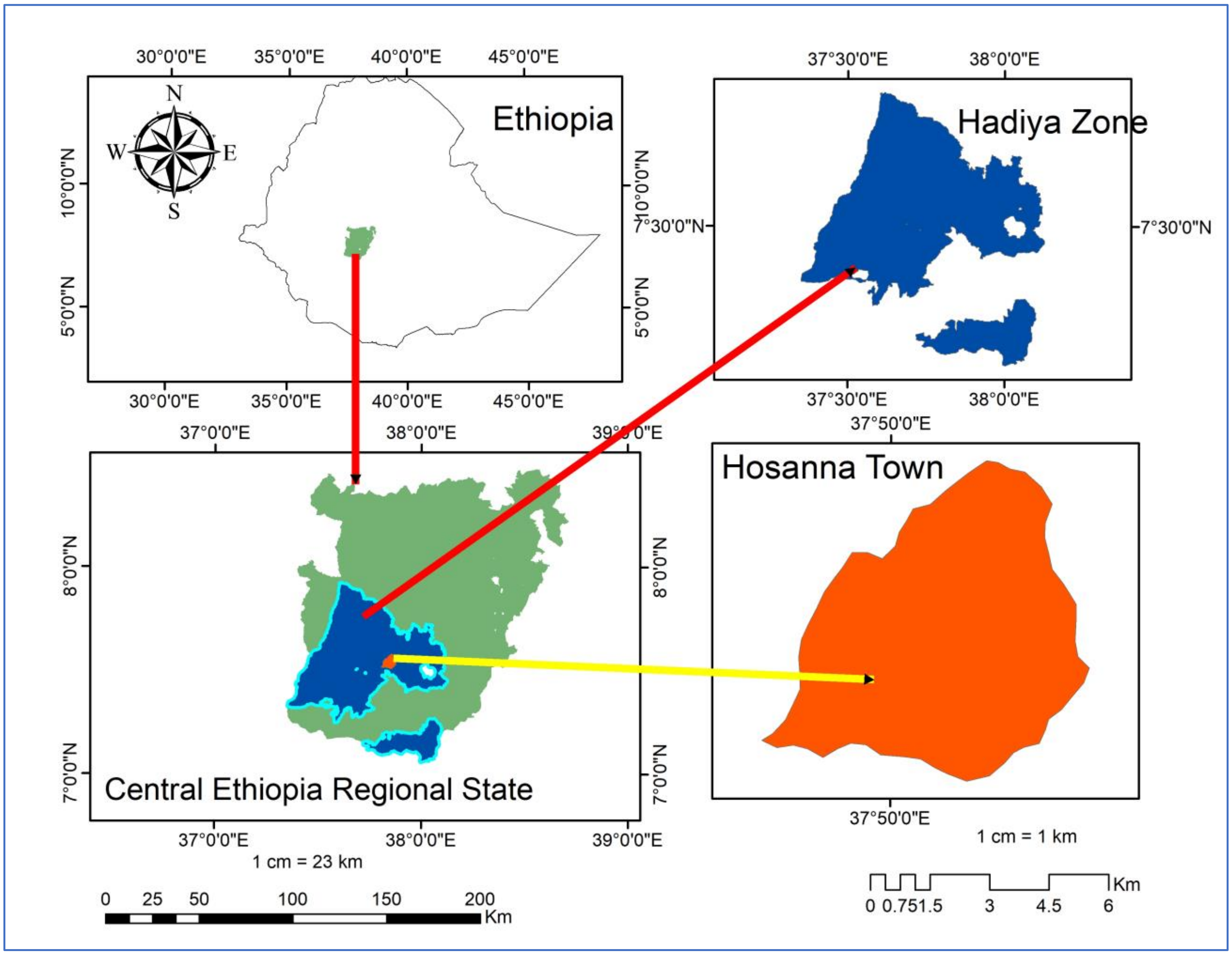

Figure 2.1. Map of the Study Area

2.2.2. Study design

A community-based cross-sectional study was conducted from December 1/2021 to January 1/2022.

2.2.3. Sample size determination

Since this study was a baseline survey for a prospective cohort study, the sample size was calculated based on the cohort-study sample size calculation formula using Epi-info version 7.2.3.1

software. The following statistical assumption was considered to determine the sample size. The sample size calculation was based on the detection of a risk ratio of 1.56 among children lacking on-premises water access compared to children with on-premises water access from a cohort study in Papua New Guinea [160]. The percentage outcome in an unexposed group was 37.5%, obtained from a study in Nicaragua conducted to determine changes in childhood diarrhea incidence [197]. The ratio between unexposed and exposed groups was assumed 1:1; Alpha = 0.05% (95 % CI), and the power of the study was assumed 90%. Then, the sample size was calculated, which was 254. After considering a 15% follow-up loss, the total sample size of the study was 292 (146 households for each exposed and non-exposed group). Then, the total sample size (292 HHs) was shared into the selected three kebeles based on the proportional sizes of each kebele.

2.2.4. Sampling techniques and selection of study households

The study was conducted in three kebeles of Hosanna town, namely Bobicho, Sech-Duna, and Jelo-Naremo kebeles, and the kebeles were purposely selected due to the existence of vast peri-urban and informal settlements in those three kebeles. The study households were selected using a simple random sampling technique from the selected kebeles, which includes households connected with piped water on premises and off premises. To ensure randomization, a number was assigned to each household in the study population. Then, households were randomly selected from a list of households living in the peri-urban and informal settlement areas. Based on the proportional sizes of each kebele, 100, 90 and 102 households were selected randomly from Bobicho, Sech-Duna, and Jelo-Naremo kebeles, respectively. Then, the data collectors team conducted transect walks in each kebele, which involved house-to-house visits to check whether the selected households fulfilled the inclusion criteria. This was done to ensure a 1 to 1 ratio of households connected with piped water on premises and off premises was accurate and complete.

2.2.5. Inclusion and exclusion criteria for study households

Households living in the peri-urban and informal settlements of the selected kebeles that lacked water on pre-premises and received water services from piped and other un-piped improved water sources were considered as an exposed group, whereas households living in the same or nearby areas that had access to improved water sources located on-premises, which include house and yard connection, were considered as unexposed. On the other hand, households with less than six months of stay in the area were excluded from the study.

2.2.6. Data collection strategy and quality assurance

The data was collected using a pretested structured questionnaire and an observational checklist. The questionnaire for the study participants was prepared in English and translated into Amharic and back to English to ensure its consistency. The data was collected by experienced trained health professionals. Before commencing data collection, pre-testing was conducted on 8% of the study participants so as to ensure that the questions were complete and comprehensive. The feedback obtained during pre-testing was incorporated into research questions before being directly administered to study participants. To minimize biases in the study, the study participants and data collectors were blinded to the research objectives and hypothesis during the data collection process. The data collection process was also subjected to continuous follow-up and all the data collected was checked for consistency and lack of any errors.

2.2.7. Study variables and measurement

2.2.7.1. Dependent variables

The dependent or outcome variables of the study were piped water on premises, improved sanitation facilities, and the presence of a handwashing facility. Water sources located inside the user's dwelling, plot, or yard, which include improved water sources located on premises such as house and yard piped water connections, were categorized as piped water on premises. Whereas improved water sources located off premises, which include piped and un-piped improved water sources, were categorized as water sources out of premises. Sanitation facilities were also classified as either improved or unimproved facilities. Improved facilities include facilities that are not shared with other households as well as facilities that are shared between two or more households. The improved sanitation facilities include flush or pour-flush, pit latrine with slab, and twin pit with slab. Whereas households that had a pit latrine without slab/open pit and twin pit without slab were categorized as unimproved facilities. Regarding handwashing facilities, households that lack any fixed or mobile handwashing facilities in their compound were considered as not having handwashing facilities. On the other hand, households that had a fixed or mobile place for handwashing were categorized as having a handwashing facility.

Then, binary variable codes were created for dependent variables Yes (1) and No (0). Yes (1) to indicate the presence of piped water on premises, an improved sanitation facility, and a handwashing facility. No (0) to indicate the absence of piped water on-premises (presence of piped water off-premises), unimproved sanitation facility, and absence of a handwashing facility. Water sources and sanitation facilities were categorized as improved and unimproved facilities according to the WHO and UNICEF Joint Monitoring Program (JMP) for water supply and sanitation [25].

2.2.7.2. Independent variables

The explanatory variables of the study were socio-demographic factors (i.e., sex of the head of household, educational status of the head of household, mother's education level, house ownership, family size, income of the household, marital status mothers/caregivers, occupation of mothers/caregivers, religion, number of under-five children). Besides, the location of water sources was also identified as an explanatory variable for predicting improved sanitation and hand washing facilities.

2.2.8. Data Analysis

Descriptive statistics such as frequency and percentages were used to summarize and present the data obtained from the participating households. Both bivariate and multivariable logistic regression at 95% CI were used to analyze the data. Bivariate logistic regression was used to examine the associations of independent variables with the outcome variable without controlling confounding factors, whereas a multivariable logistic regression model was used to examine the associations of outcome variables with different independent variables by controlling for potential confounding factors. Any independent variables scoring a *P*-value less than 0.25 in bivariate logistic regression analysis were included in the multivariable model. Assumptions of logistic regressions were tested using different methods. Multicollinearity among independent variables was checked by calculating the variance inflation factor (VIF). The goodness of fit of the model was also tested by Hosmer-Lemeshow statistics. A *P*-value associated with the log-likelihood ratio was also calculated to evaluate the goodness of fit of the multivariable model for the data. In all data analysis, a *P*-value less than 0.05 was considered statistically significant. Generally, all quantitative data was entered into Excel and exported to STATA 14 software for analysis.

2.2.9. Operational definition of terms

Proper waste disposal practices: - It refers to waste collected by a formal service provider, incinerated or buried, stored in a storage container, or disposed of in a designed site in a way that cannot affect the environment and public health.

Improper waste disposal practices: - If waste is discarded elsewhere in an open space, collected by an informal service provider, or discarded within a household yard or plot in a way that affects the public health and environment, it is considered improper waste disposal practice.

Proper liquid waste disposal practices: - If liquid waste is connected to a sewer, septic tank, or pit, then it is considered proper liquid waste disposal practices.

Improper liquid waste disposal practices: - If liquid waste is disposed of directly on open ground or water body, or if a sink/drain is connected to an open drain or open ground, then it is considered improper liquid waste disposal practices.

Piped water off premises: - It is located outside the living areas. It includes improved water sources located off premises, and households collect their water from piped improved water sources located off premises.

Piped water on premises: - It is located inside the user's dwelling, plot, or yard. It includes households that do have access to improved water sources located on-premises, which include house and yard piped water connections.

Open defecation: - A self-reported behavior, which includes defecating in open spaces, fields, forests, bushes or open bodies of water.

Basic sanitation facility: - It includes improved facilities that are not shared with other households.

Basic handwashing facility: - Availability of a handwashing facility with soap and water at home.

Basic sanitation: - It involves using improved facilities that are exclusively for a single household and not shared with others.

Limited sanitation: - It involves using improved facilities that are shared by two or more households.

2.3. Results

2.3.1. Socio-demographic characteristics of study households

A total of 292 households participated in the study with a 100% response rate. The majority of the study households (92.1%) were male-headed households, and most of them completed primary school (35.6%). More than one-fourth of them (25.7%) have completed secondary school, and only 2.4% of households had no formal education. Nearly one-fourth of the study households (25%) had completed a first degree and above. Regarding a mother's education status, most of them have completed primary school (38.4%), and only 6.8% of mothers had no formal education. Among the total study households, the majority (77.7%) were Protestants, followed by Orthodox Christians (15.1%). Religions such as Apostolic, Muslim, and Adventist constituted 7.2% of the study households. Other socio-demographic characteristics of study households are summarized in Table 2.1.

2.3.2. Characteristics of drinking water sources

The result revealed that 50% of the households had access to piped water on premises, and the remaining had access to piped water off premises. This shows that all households (100%) were using piped water on and off premises as their main dry and rainy season drinking water sources. On the other hand, 68.8% of the study households used rain water for other domestic purposes, such as cooking and handwashing during the rainy season. Households who accounted for 40.8% spent more than 30 minutes collecting water from their main water sources. Besides, the reliability of the water supply was questioned by the majority of the study households. Only 8.9% of the studied households had access to reliable water services that received water services regularly or with a known schedule from their main water sources. The reliability of the water sources was assessed in terms of accessibility of the water sources and availability of water from the main water sources when water is needed (Table 2.2).

2.3.3. Sanitation and Hygiene

The majority of the study households (97.6%) had access to toilet facilities, and the common types of sanitation facilities (50.4%) were pit latrines with slabs. Only 2.4% of the studied households had no access to sanitation facilities. More than half of the study households (55%) had improved sanitation facilities, and the remaining 45% had access to unimproved sanitation. The improved sanitation facilities shared by two or more households were categorized under improved sanitation facilities. The result also revealed that two-thirds of the households (65%) had access to a fixed or mobile place for handwashing. Of these households, as confirmed by observation, only 25.8% had water and soap near the handwashing facility. On the other hand, more than one-third of the households (35%) didn’t have any handwashing place in their living compound. Both solid and liquid waste management practices were poor in the study area, indicating that wastes were indiscriminately dumped into an open space. The majority of households (51.4%) had improper solid waste disposal practices, which dispose their solid waste improperly in an open space in a way that affects public health and the surrounding environment. Likewise, more than 84% of households managed their liquid waste inappropriately by discarding their liquid waste in an open ground, water body, and open drain (Table 2.3).

Table 2. 1. Weighted descriptive statistics of socio-demographic characteristics

Variables	Frequency	Percentage (%)
Sex of the head of Household		
Female	23	7.9
Male	269	92.1
Educational status of the head of household		
No formal education	7	2.4
1-8 grades complete	104	35.6
9-12 grades complete	75	25.7
Certificate and Diploma	33	11.3
First degree and above	73	25
Mother's education level		
No formal education	20	6.8
1-8 grades complete	112	38.4
9-12 grades complete	76	26
Certificate and Diploma	44	15.1
First degree and above	40	13.7
Marital status of mothers/caregivers		
Married	268	91.8
Single	7	2.4
Divorced	9	3.1
Widowed	8	2.7
Occupation of mothers/caregivers		
House wife	152	52.1
Government employee	67	22.9
Self-employed	72	24.7
NGO employee	1	0.3
House ownership		
Private house	186	63.7
Private rental house	106	36.3
Family size		
2-4	97	33.2
5-6	135	46.2
≥7	60	20.6
Religion		
Protestant	227	77.7
Orthodox Christian	44	15.1
Muslim	8	2.7
Apostolic	11	3.8
Adventist	2	0.7
No. of under-five children		
1	141	48.3
≥ 2	151	51.7
Average monthly HH income		
< 3201 Ethiopian Birr	140	47.9
3201– 7800 Ethiopian Birr	120	41.1
> 7800 Ethiopian Birr	32	11

Table 2. 2. Weighted descriptive statistics of characteristics of drinking water sources

Variables	Frequency	Percentage (%)
Main sources of drinking water during dry and rainy seasons (n=292)		
Piped water to compound, yard or plot	146	50
Piped to neighbor	27	9.3
Public tap/standpipe	90	30.8
Water vendors	29	9.9
Main source of water for other domestic purposes, such as cooking and handwashing in the dry season		
Piped water to compound, yard or plot	146	50
Piped to neighbor	27	9.3
Public tap/standpipe	90	30.8
Water vendors	29	9.9
Main source of water for other domestic purposes, such as cooking and handwashing in the rainy season		
Rainwater collection	201	68.8
Piped water on or off premises	91	31.2
Location of water sources		
Piped water off premises	146	50
Piped water on premises	146	50
Time taken to fetch water for return trip		
Water on-premises	146	50
Less than 15 minutes	6	2
15 - 30 minutes	21	7.2
30 – 60 minutes	72	24.7
Greater than 60 minutes	47	16.1
Is water always available from your main water source? (Availability of water from water sources with a known schedule)		
Yes, water is always available	26	8.9
No, water is available most of the time	59	20.2
No, water is available some of the time	122	41.8
No, water is rarely available	85	29.1
The main reason for not always getting water from your water source?		
Source is not accessible	108	37
Water is not available from source	158	54.1
None respondent (Water is always available)	26	8.9

Table 2. 3. Weighted descriptive statistics of sanitation and hygiene facilities

Variables	Category	Frequency	Percentage (%)
Access to latrine facility	Yes	285	97.6
	No	7	2.4
Type of toilet facility	Flush or pour flush	8	2.7
	Pit latrine with slab	147	50.4
	Twin pit with slab	2	0.7
	Pit latrine without slab/open pit	123	42.1
	Twin pit without slab	5	1.7
	Share with neighborhood	4	1.4
	Open defecation	3	1
Sharing status of toilet facility	Yes	95	33.3
	No	190	66.7
Sanitation Status	Improved	157	55.1
	Unimproved	128	44.9
Household solid waste disposal method	Proper disposal practices	142	48.6
	Improper disposal practices	150	51.4
Household liquid waste disposal method	Proper disposal practices	45	15.4
	Improper disposal practices	247	84.6
Do you have a HW facility?	Fixed or mobile place for HW	190	65.1
	No HW place in dwelling/yard/plot	102	34.9
Availability of both water and soap at the place for HW	Yes, it is available	49	16.8
	No, it is not available	141	48.3
	No HW place in dwelling/yard/plot	102	34.9
Is HWF available near the toilet?	Yes	57	19.5
	No	235	80.5

2.3.4. Factors associated with piped water on premises in the binary and multivariable logistic regression analysis

The educational status of the head of household, the education level of mothers, and the income of the household were significantly associated with the presence of piped water on-premises in the binary logistic regression analysis. A first-degree and above education level of mothers (OR = 3.89; 95% CI = 1.23-12.29) and the head of households (OR = 2.19; 95% CI = 1.2-4.00) was significantly associated with increased access to piped water on premises. Households with a middle and high income were also associated significantly with increased access to piped water on premises (Table 2.4). Before conducting the multivariable logistic regression analysis, a *P*-value associated with the log-likelihood ratio (LLR) was calculated to evaluate the goodness of fit of the model for the data. The calculated *P*-value associated with the log-likelihood ratio was very small, which was 0.0046 (less than 0.05), indicating that the model was a good fit for the data. Seven variables with a *P*-value < 0.25 in bivariate analysis, which includes the educational status of the head of household, mother's education level, marital status of mothers, house ownership, income of the household, religion, and number of under-five children were included in the multivariable logistic regression analysis. However, only the income of households was significantly associated with piped water on premises in the multivariable logistic regression analysis (Table 2.7). Households with a middle income were 2.2 times more likely to have piped water on premises compared to low-income households at *P* value < 0.01 (AOR = 2.23; 95% CI = 1.24 – 4.00).

2.3.5. Factors associated with improved sanitation in the binary and multivariable logistic regression analysis

The binary logistic regression analysis indicated that the sex and educational status of the head of the household, marital status of mothers/caregivers, income of the household, and location of water sources were significantly associated with improved sanitation (Table 2.5). Male-headed households were 3 times more likely to have improved sanitation compared to female-headed households at *P*-value < 0.05 (OR = 3.06; 95% CI = 1.22-7.69). Households with piped water on premises were also 3.6 times more likely to have improved sanitation compared to households lacking piped water on premises at *P*-value < 0.01 (OR = 3.57; 95% CI = 2.18-5.83). A *P*-value associated with the log-likelihood ratio was calculated to evaluate the goodness of fit of the model for the data before starting the regression analysis. The calculated *P*-value associated with the log-likelihood ratio was *P* < 0.05, indicating that the model was a good fit for the data. Seven variables with a *P*-value < 0.25 in the bivariate logistic regression analysis were included in the multivariable logistic regression analysis. These variables include the sex of the head of household, educational status of the head of household, mother's education level, occupation of mothers/caregivers, income of the household, religion, and location of water sources. The variable marital status of mothers/caregivers was excluded from the multivariable logistic regression analysis due to a multicollinearity effect on the sex of the head of household.

The multivariable logistic regression analysis verified that the income of the household, religion, and the location of water sources were significantly associated with improved sanitation (Table 2.7). Households with a middle income were 2.2 times more likely to have improved sanitation compared to low-income households (AOR = 2.17; 95% CI = 1.17 – 4.03). Likewise, households with a Protestant religion were 2 times more likely to have improved sanitation compared to other religions (AOR = 2.05; 95% CI = 1.09 - 3.86). Households having piped water on premises were also 3.3 times more likely to have improved sanitation than households lacking piped water on premises at *P*-value < 0.001 (AOR = 3.34; 95% CI = 1.99 – 5.62).

2.3.6. Factors associated with the presence of handwashing facilities in the binary and multivariable logistic regression analysis

The binary logistic regression analysis indicated that the sex of the head of household, educational status of the head of household, mother's education level, marital status of mothers/caregivers, occupation of mothers/caregivers, income of the household, and location of water sources were significantly associated with the presence of handwashing facilities (Table 2.6). Households with a high income (OR = 12.52; 95% CI = 3.61 – 11.62) and piped water on premises (OR = 6.83; 95% CI = 3.91 – 11.94) were 12.5 and 6.8 times more likely to have handwashing facilities, respectively. The fitness of the model was checked using a *P*-value associated with the log-likelihood ratio. The calculated *P*-value associated with the log-likelihood ratio was $P < 0.05$, indicating that the model was a good fit for the data. Eight variables with a P-value < 0.25 in the bivariate analysis, which includes sex of the head of household, educational status of the head of household, mother's education level, occupation of mothers, house ownership, family size, income of the household, and location of water sources were included in the multivariable logistic regression analysis.

The multivariable logistic regression analysis indicated that variables such as male-headed households (AOR = 5.07 95% CI = 1.36 - 18.90), mothers with a first degree and above education level (AOR =29.37 95% CI = 2.54 - 339.62), households with middle income (AOR = 4.36; 95% CI = 1.98 - 9.62), and piped water on premises (AOR = 8.18; 95% CI = 4.08 - 16.42) were significantly associated with the presence of handwashing facilities. Besides, household heads with a certificate and diploma education level (AOR = 3.69; 95% CI = 1.09- 12.51) and with a first degree and above education level (AOR = 11.77; 95% CI = 2.74- 50.52) were significantly associated with the presence of handwashing facilities (Table 2.7). Male-headed households and households with a middle income were 5 and 4.4 times more likely to have access to handwashing facilities, respectively. Households having piped water on-premises were also 8.2 times more likely to have access to handwashing facilities compared to households lacking piped water on-premises.

Table 2. 4. Bivariate analysis of socio-demographic factors with piped water on premises

Variables	Frequency	Percentage (%)	Piped water on premises (Yes)	OR (95% CI), *P*-value
Educational status of the head of household				
≤ Primary education	111	38.0	47	RC
Secondary education	75	25.7	39	1.48(0.82-2.65), 0.196
Certificate and diploma	33	11.3	15	1.13(0.52-2.48), 0.751
First degree and above	73	25.0	45	2.19(1.2-4.00), 0.011*
Mother's education level				
No formal education	20	6.8	6	RC
1-8 grades complete	112	38.4	54	2.17(0.78-6.06), 0.138
9-12 grades complete	76	26.0	39	2.46(0.85-7.08), 0.095
Certificate and Diploma	44	15.1	22	2.33(0.76-7.18), 0.140
First degree and above	40	13.7	25	3.89(1.23-12.29), 0.021*
Marital status of mothers/caregivers				
Married	268	91.8	137	RC
Other marital status	24	8.2	9	0.57(0.24- 1.36), 0.206
House ownership				
Private rental house	186	63.7	48	RC
Private house	106	36.3	98	1.35(0.83-2.17), 0.224
Monthly HH income				
Low income	140	47.9	53	RC
Middle income	120	41.1	72	2.46(1.49-4.06), 0.000*
High income	32	11.0	21	3.13(1.40-7.01), 0.005*
Religion				
Protestant	227	77.7	108	RC
Other religions	65	22.3	38	1.55 (0.89-2.71),0.123
No. of under-five children				
1	141	48.3	65	RC
≥ 2	151	51.7	81	1.35(0.85-2.14), 0.198

RC – Reference Category

OR – Crude odds ratio

* – Variables significant at P-value < 0.05

All variables with a P-value < 0.25 in the bivariate logistic regression analysis are presented in this regression table and included in the multivariable logistic regression analysis.

Table 2. 5**.** Bivariate analysis of socio-demographic factors and location of water sources with improved sanitation facilities

Variables	Frequency	Percentage (%)	Improved sanitation (Yes)	OR (95% CI), *P*-value
Sex of head of the HH				
Female	23	8.1	7	RC
Male	262	91.9	150	3.06(1.22-7.69), 0.017*
Educational status of head of the household				
≤ Primary education	108	37.9	54	RC
Secondary education	74	26.0	40	1.18(0.65-2.13), 0.591
Certificate and diploma	32	11.2	14	0.78(0.35-1.72), 0.535
First degree and above	71	24.9	49	2.23(1.19-4.18), 0.013*
Mother's Education level				
No formal education	20	7.0	6	RC
1-8 grades complete	108	37.9	60	2.92 (1.04-8.16), 0.041*
9-12 grades complete	76	26.7	45	3.39 (1.17-9.78), 0.024*
Certificate and Diploma	41	14.4	20	2.22 (0.71-6.92), 0.168
First degree and above	40	14.0	26	4.33(1.36-13.77), 0.013*
Marital status of mothers/caregivers				
Married	261	91.6	150	RC
Other marital status	24	8.4	7	0. 30(0.12 -0. 75), 0.011*
Occupation of mothers/ Caregivers				
House wife	149	52.3	86	RC
Government employee	64	22.4	37	1.00(0.55-1.82), 0.99
Other occupation	72	25.3	34	0. 66(0.37-1.15), 0.143
Monthly HH income				
Low income	137	48.1	60	RC
Middle income	116	40.7	76	2.44(1.46-4.06), 0.001*
High income	32	11.2	21	2.45(1.10-5.47), 0.029*
Religion				
Protestant	223	78.2	128	1.53 (0. 87 -2.70), 0.138
Other religions	62	21.8	29	RC
Location of water sources				
Piped water off premises	141	49.5	56	RC
Piped water on premises	144	50.5	101	3.57(2.18-5.83), 0.000*

Households who lacked sanitation facilities were excluded from the bivariate analysis
RC – Reference Category
OR – Crude odds ratio
* – Variables significant at *P*-value < 0.05
All variables with a *P*-value < 0.25 in the bivariate logistic regression analysis are presented in this regression table and included in the multivariable logistic regression analysis.

Table 2. 6. Bivariate analysis of socio-demographic factors and location of water sources with the presence of handwashing facilities

Variables	Frequency	Percentage (%)	Handwashing facility (Yes)	OR (95% CI), *P*-value
Sex of the head of HH				
Female	23	8.1	6	RC
Male	262	91.9	184	6.13(2.34-16.11), 0.000*
Educational status of the head of household				
≤ Primary education	111	38.0	49	RC
Secondary education	75	25.7	47	2.12(1.17-3.87), 0.014*
Certificate and diploma	33	11.3	25	3.95(1.64-9.53), 0.002*
First degree and above	73	25.0	69	21.83(7.45-63.97), 0.000*
Mother's education level				
No formal education	20	6.8	6	RC
1-8 grades complete	112	38.4	61	2.79(1.00-7.79), 0.050
9-12 grades complete	76	26.0	50	4.49(1.54-13.05), 0.006*
Certificate and Diploma	44	15.1	35	9.07(2.72-30.27), 0.000*
First degree and above	40	13.7	38	44.33(7.99-246.00), 0.000*
Marital status of mothers				
Married	268	91.8	184	RC
Other marital status	24	8.2	6	0.15 (0.06 -0.40), 0.000*
Occupation of mothers/caregivers				
House wife	152	52.1	98	RC
Government employee	67	22.9	59	4.06(1.81-9.13), 0.001*
Other occupation	73	25.0	33	0.45(0.26-0.80), 0.007*
House ownership				
Private rental house	106	36.3	62	RC
Private house	186	63.7	128	1.57(0.95-2.57), 0.076
Family size				
2-4	97	33.2	53	RC
5-6	135	46.2	98	2.20(1.27-3.81), 0.005*
≥7	60	20.6	39	1.54(0.79-2.99), 0.201
Monthly HH income				
Low income	140	47.9	61	RC
Middle income	120	41.1	100	6.48(3.61-11.62), 0.000*
High income	32	11.0	29	12.52(3.64-43.03), 0.000*
Location of water sources				
Piped water off premises	146	50.0	66	RC
Piped water on premises	146	50.0	124	6.83(3.91-11.94), 0.000*

RC – Reference Category
OR – Crude odds ratio
* – Variables significant at *P*-value < 0.05
All variables with a *P*-value < 0.25 in the bivariate logistic regression analysis are presented in this regression table and included in the multivariable logistic regression analysis.

Table 2. 7. Multivariable logistic regression analysis for piped water on premises, improved sanitation, and the presence of handwashing facilities (*P*-value < 0.05)

Multivariable logistic regression analysis of socio-demographic factors with piped water on premises		
Variables	AOR (95% CI)	*P-value*
Monthly HH income		
Middle income	2.23 (1.24– 4.00)	0.007**
High income	2.65 (1.02– 6.89)	0.046*
Multivariable logistic regression analysis of socio-demographic factors and location of water sources with improved sanitation		
Monthly HH income		
Middle income	2.17 (1.17-4.03)	0.014*
Religion		
Protestant	2.05 (1.09 - 3.86)	0.025 *
Location of water sources		
Piped water on premises	3.34 (1.99– 5.62)	0.000**
Multivariable logistic regression analysis of socio-demographic factors and location of water sources with the presence of handwashing facilities		
Sex of the head of household		
Male	5.07 (1.36 - 18.90)	0.015*
Educational level of the HH head		
Certificate and diploma	3.69 (1.09- 12.51)	0.036*
First degree and above	11.77 (2.74- 50.52)	0.001**
Mother's education level		
First degree and above	29.37 (2.54 - 339.62)	0.007 **
Monthly HH income		
Middle	4.36 (1.98 - 9.62)	0.000 **
Location of water sources		
Piped water on premises	8.18 (4.08 - 16.42)	0.000**

AOR – Adjusted Odds Ratio
**– Variables significant at *P*-value < 0.01
* – Variables significant at *P*-value < 0.05
All variables with a *P*-value < 0.25 in the bivariate logistic regression analysis were included in the multivariable logistic regression analysis.

Only those variables with a *P*-value < 0.01 and < 0.05 in the multivariable logistic regression analysis are included in this regression table.

The variable marital status of mothers/caregivers was excluded from the multivariable logistic regression analysis due to a multicollinearity effect on the sex of the head of household.

2.4. Discussion

The findings of this study showed that almost all households (100%) had access to improved water sources. Although all the households had access to piped water supply, the reliability of the water sources was a big challenge in the study area. The findings indicated that only 8.9% of the study households had access to reliable water services that received water regularly from their main water sources during the dry and rainy seasons. The remaining households (91.1%) had access to unreliable water sources. Households who accounted for 37% and 54.1% responded that the main reason for not always getting water from their water source was due to the inaccessibility of the water source at a given time and unavailability of water from the source when water is needed, respectively. They responded to unreliable water sources using different coping strategies to fulfill their water needs, including storing water at home and using alternative water sources such as springs and water vendors. The result is in line with the findings obtained from four regions in Ethiopia, which indicated that the main limiting factor associated with the water supply was the reliability of the water supply [198]. As indicated by the study, of those households who had access to piped water supply, only 32% of them got reliable services from their main source of water supply during the dry season. Various other studies also confirmed that piped water supply lacks consistency and is associated with frequent interruptions in low- and middle-income countries [62,199,200]. Evidence indicates the reliability of the water services can be expressed in terms of adequacy of water quantity, quality, availability of water from water sources with a known schedule, and punctuality of water service, even if it is not continuous. Water services are considered as problematic if there is down time, significant breakdown, and slow repair [201]. Regarding factors determining the presence of piped water on-premises, only the income of the households was significantly associated with water piped on premises at a P-value of < 0.01.

The result revealed that 97.6% of the study households had access to sanitation facilities, and pit-latrine with slab (50.4%) was the most commonly used sanitation facility in the study area. The result is in line with the study conducted in Jimma town and in a slum community in Kampala, Uganda, where 94.5% and 66.9% of the households were using pit-latrine with slab, respectively [37,38]. Open defecation practice (1%) was very low in the study area. This result is consistent with a study conducted in Benin city, Nigeria, in which 1.5 of the households practiced open defecation [202]. In contrast to this finding, a study conducted in Addis Ababa slums (5.2%), eastern Ethiopia (11%), Jimma town (5.5%), Ethiopian urban areas (6.9%), in peri-urban areas in Northwest Ethiopia (11.3%) and small towns in four regions of Ethiopia (13%) was reported high rate of open defecation [37,62,176,198,203,204]. A self-reported data was used to assess open defecation practices that might increase the likelihood of underreporting. Evidence also indicates that open defecation was underreported [205], and self-reported data on open defecation practices generate less reliable data [62]. Hence, a lower open defecation practice in the study area might be due to underreporting.

The finding indicated that 55.1% of the study households had improved sanitation, and more than one-third (44.9%) had unimproved sanitation facilities. Of those improved sanitation facilities, 35.1% were categorized as basic sanitation facilities, and the remaining 20% as limited sanitation facilities. The result is lower than other studies conducted in Northeast Amhara, Kandahar city in Afghanistan, and small towns in four regions of Ethiopia, where 59.8%, 85.7%, and 57% of the households had access to improved latrines, respectively [198,206,207]. This variation could be associated with poor urban service provisions, socioeconomic factors, and unplanned settlement in the peri-urban and informal settlement settings in the study area. This finding is higher than the findings from Ethiopia (25.4%) and Ghana (12%) [208,209]. This could be associated with national progress on access to improved sanitation facilities in recent years as well as with the study's finding being recent. However, the progress was not as expected because there were still a large proportion of households without improved sanitation facilities in the study area. Regarding the predictors of the availability of improved sanitation, the findings identified the income of the household, religion, and location of water sources as determinants of improved sanitation.

Almost two-thirds of the households (65%) had access to handwashing facilities in the study area. This result is lower than a report obtained from the 2016 Ethiopian Demographic and Health Survey (EDHS), where 81% of the households in urban areas had a place for handwashing [176]. This could be associated with low handwashing promotion, socio-economic factors, and inadequate coverage of piped water on premises, which might affect the availability of water at home. Besides, of the total study households, only 16.8% had basic handwashing facilities. This result is slightly higher than the studies done in Ethiopia (8%) and Benin (10.1%) [39,210]. However, the result is too far from the SDG's ambitious monitoring indicator, which focused on ensuring access to adequate and equitable sanitation and hygiene services for all by 2030. With this limited effort, households in the study area will remain at great risk of water-related infectious diseases, including diarrhea.

Various studies claimed that the availability of handwashing facilities was positively associated with effective handwashing practices [211,212]. Hence, determining the availability of handwashing facilities and factors affecting their presence would support the installation of handwashing facilities, thereby playing a role in reducing the spread of infectious diseases that could be prevented through effective handwashing practices [39]. Findings obtained from this study also indicated that various factors were associated with the presence of handwashing facilities. Results from the multivariable logistic regression analysis showed that sex of the household head and his/her educational status, mother's education level, income of the household, and location of water sources were significantly associated with the presence of handwashing facilities. This is consistent with findings obtained from a study conducted in Ethiopia, which indicated that the educational status of the head of household and household wealth rank was positively associated with the presence of basic handwashing facilities [39]. Likewise, a result from the pooled logistic regression model verified that sex of the household head, education of the household head, and household wealth were determinant factors for the presence of handwashing facilities in four East African countries [40].

2.5. Conclusion

The study revealed that the majority of households living in the selected peri-urban and informal settlements had access to unreliable drinking water sources. The unreliability of the water sources was mainly associated with the unavailability of water from water sources when water is needed and the inaccessibility of the water sources. Although the findings indicated that open defecation was low, the existence of a large proportion of households with unimproved sanitation facilities would make people highly vulnerable to infectious diseases in the study area. The result revealed the existence of inadequate handwashing facilities and specifically low basic handwashing facilities in the study area. This inadequate availability of handwashing facilities might reduce the potential to control the spread of infectious diseases that could be prevented through effective handwashing practices. Monthly household income was identified as a strong predictor of the availability of piped water on premises, improved sanitation, and handwashing facilities. Hence, the findings call for solid government interventions to improve the reliability of the main water sources, basic sanitation facilities coverage, and availability of basic handwashing facilities in the study area. This could be achieved by improving various urban services, awareness creation, and through engaging households in various poverty reduction activities, particularly in the peri-urban and informal settlement settings of the town.

Chapter Three. Seasonal Variations in Household Water Use, Microbiological Water Quality, and Challenges to the Provision of Adequate Drinking Water

Adopted from

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Chapter Three. Seasonal Variations in Household Water Use, Microbiological Water Quality, and Challenges to the Provision of Adequate Drinking Water

3.1. Background

Access to safe drinking water remains a pressing issue, with an estimated 2 billion people lacking safely managed drinking water services worldwide [182]. Although 94% of the world population had access to improved drinking water sources, only 77% of the population had improved drinking water accessible on premises in 2020. In sub-Saharan Africa and Ethiopia, only 31% and 20% of the population had improved drinking water accessible on premises, respectively. Drinking water supply improvement with quality, quantity, and reliability is crucial for good health [22]. A systematic review indicated that the availability of enough quantities of water for consumption and hygiene is associated with water supply accessibility [16]. Evidence obtained from various studies also indicated that off-premises water access results in lower quantities and quality of water when compared to water sources located on premises [17,18]. Cairncross also discussed the concept of the water plateau, which describes the non-linear relationship between the quantity of water collected and the time or distance required to fetch water [213]. In general, as the time or distance increases, the quantity of water collected decreases. However, there is a point at which the quantity of water collected begins to plateau. The term water plateau is an important concept that helps us understand the difficulties of accessing water in developing countries and the effects of water interventions. Water access located off premises can also affect an individual's health adversely through lower water availability, reduced water quantity for hygiene, and increased contamination risks [18].

In urban areas of Ethiopia, a significant improvement has been made in the coverage of improved water sources accessible on premises from 2000-2020. A recent report by WHO/UNICEF indicated that 75% of the urban population in Ethiopia had access to improved water sources accessible on premises in 2020 [182]. The same report showed that only 13% of the population had access to safely managed drinking water services in Ethiopia. However, rapid population growth and informal peri-urban settlement have placed additional burdens on cities in sub–Saharan Africa, which struggle to adequately provide safe drinking water to residents, particularly in the informal peri-urban areas [214]. Evidence also indicated that piped water supply interruption was a big problem, particularly in slum areas of Addis Ababa [62]. According to a recent study, households residing in the peri-urban and informal settlements areas of the town had access to piped water located on and off premises [215]. However, the reliability of the water sources was a major challenge in the area. The details about peri-urban and informal settlements are discussed elsewhere. The majority of households living in the peri-urban and informal settlements of the town has access to water sources located off premises, which is very inadequate and highly vulnerable to microbial contamination. Lack of access to household water connections increases exposure to waterborne pathogens due to contamination during collection, transport, or storage [177]. Households are also forced to store their drinking water for an extended time, thereby making the water vulnerable to microbial contamination. Evidence showed that consumption of fecally contaminated water was responsible for the occurrence of diarrhea [178]. Collecting water from off-premises water sources can also reduce the amount of water available in households [17].

Seasonal changes are another crucial factor that affects water quality and the availability and consumption of water. A recent study discovered that the quality of groundwater is affected by climatic factors, with better water quality observed during the dry season compared to the wet season. This finding highlights the significant impact of climatic factors on groundwater quality [74]. Evidence from Northwest China also showed that some parameters of Lake Sha exhibit seasonal variations [75]. Similarly, a study that assessed the microbiological quality of drinking water in Ethiopia showed that microbiological water quality at the point of use varies seasonally [20]. However, a different study that assessed groundwater quality found that the major ions analyzed in groundwater did not exhibit significant seasonal variations [76]. The study also verified that groundwater quality is influenced by various factors such as human activities, hydrogeological conditions, water-rock interactions, and rock weathering. The availability and consumption of domestic water can also vary seasonally [21]. Therefore, it is crucial to measure the quantity of water used for personal and domestic purposes to understand the impact of water quantity on human health [79]. Likewise, measuring the microbiological characteristics of water is an important way to ensure that the water is safe to drink and prevent water-related diseases [27]. Lack of sufficient access to safe water is responsible for several water-borne illnesses, such as diarrhea [22]. Inadequate water in terms of quantity and quality is also becoming a cause of various health problems in Hosanna town [13]. Hence, it is essential to comprehend the factors influencing the quantity and quality of water consumed in households.

Different studies have examined household water use and microbial water quality in different parts of the world [84–86,178,216–218]. However, studies that considered seasonal variability of household water use and microbial water quality and their determinant factors were limited, which makes it difficult to understand the full extent of water supply problems and develop effective interventions. Therefore, the objective of this study was to assess the seasonal variability of household water use, microbial water quality, and challenges to the provision of adequate water. It is believed that the result obtained from this study provides comprehensive data on household water use and microbiological water quality that can serve as a basis for designing an effective intervention to improve the quality and the quantity of water at the household and town level in the study area.

3.2. Method

3.2.1. Study area

Hosanna town's altitude ranges from 2400 meters above sea level at the Bale-Wold Church to 2200 meters above sea level at Tekle-Haymanot Church [219]. The yearly average rainfall of the town ranges from 920.4 mm to 1436.5 mm, and the highest rainfall occurs between July and September. The town has a mean annual temperature of 17.1 ^{o}C. The maximum temperature is experienced between January and March, whereas the lowest temperature is between July and September. The town is found in the Woina-Dega agro-climatic zone. The town's geology is diverse. The hillsides and valleys are composed of mostly igneous and metamorphic rocks, while the plain part of the town is characterized by sedimentary rock. The soil in the hillsides and valleys of the town is lithosol, while the plain part of the town has vertisol soil with poor drainage and infiltration rate [220]. Additional information about the study area is given in chapter 2 section 2.2.1.

3.2.2. Study design

A longitudinal study was conducted to explore the seasonal variability of household water use and microbial water quality. The study design involved collecting data on water consumption and microbiological water quality from the same individuals during both the dry and rainy seasons. This method can offer a more precise picture of changes over time and can help to identify factors that contribute to changes in water consumption and microbiological water quality. Additionally, a qualitative study was also conducted to examine the challenges to the provision of adequate drinking water and its implications on childhood diarrhea. The study collected qualitative data on the challenges to the provision of adequate drinking water through focus group discussions and key informant interviews.

3.2.3. Sample size determination and selection of study households

A cohort study sample size calculation formula using Epi-info software was used to calculate the study sample size. The statistical assumptions, which include risk ratio = 1.56 [160], percentage outcome in an unexposed group = 37.5% [197], the ratio of unexposed/exposed groups = 1:1; α = 0.05% (95 % CI), and desired power= 90%, were considered to calculate the sample size. Considering a 15% follow-up loss, the total sample size of the study was 292. Three focus group discussions and 6 key informant interviews were also conducted to collect qualitative data. Qualitative data was collected on lived experiences of people regarding water quantity and quality issues and their implications on childhood diarrhea. These issues include water accessibility, major problems associated with primary water sources, challenges faced when accessing water, water shortage and coping strategies, and the role of government and community participation in water supply projects. The study was conducted in three purposely selected kebeles; Bobicho, Sech-Duna, and Jelo-Naremo kebeles. A randomly selected 288 households participated in the study. The details about sample size determination and sampling techniques are discussed elsewhere [215].

3.2.4. Inclusion and exclusion criteria

Households connected with improved water sources located on premises were considered as unexposed groups, whereas households connected with improved water sources located off premises were considered as exposed groups. Off-premises refers to the water sources located outside the living areas, whereas on-premises refers to the water sources located inside the user's dwelling, plot, or yard. Those households who had an interest in being involved and were able to explain the problem frankly participated in the qualitative study. In all cases, the households living in the peri-urban and informal settlement areas who fulfill inclusion criteria were involved in the study. The study excluded households with less than six months of stay in the selected kebeles and households lacking improved water sources located either on or off premises. The study also excluded households with known mental health problems to avoid causing further anxiety to households and also because such households might also provide inaccurate information.

3.2.5. Data collection tools and collection strategy

Various data collection tools were used for this study, including a pretested structured questionnaire, an observational checklist, a questionnaire for the daily water consumption data collection, water storage container inventories, interviews, and laboratory analysis. The observation checklist was used to assess the covering of drinking water, cleanliness of water storage container, mouth size of a water storage container, presence of garbage in the living area, level of water changes in water storage containers, water withdrawal method, the size and number of different storage containers, types of water sources, and availability of handwashing facilities and soap. The qualitative data was also collected using focus group discussions (FGDs) and key informant interviews (KIIs). The data was collected by twelve trained health professionals, which was checked timely for consistency and lack of any errors.

3.2.5.1. Measuring household water consumption during the dry and rainy seasons

The quantity of water was measured from May 9 to 15/2022, and August 22 to 28/2022, during the dry and rainy seasons, respectively. In most parts of the country, the dry season begins from October to May, while the rainy season begins from June to August. The quantity of water used for various domestic purposes was estimated using a mixed-method, which includes a questionnaire for the daily water consumption data collection, storage container inventories, observation, and interviews. Several studies have used only questionnaires [54,85,86] or in combination with other methods to estimate water use [21,83,84]. Although the questionnaire is the most commonly used method in developing countries, it is highly subject to reporting and recall biases [79]. Hence, a mixed method was used to minimize the limitations associated with questionnaire and generate reliable water use data. In this case, the other three methods were combined with a questionnaire in a way that complements the questionnaire and produces complementary information. The final total amount of water consumed by households was obtained by summing up the amount of water used daily, which was obtained from the questionnaire, and the amount of water used directly from taps, which was obtained from interviews. In this study, the other methods are designed in a way that complements the questionnaire and does not generate different results. Households were visited for 7 consecutive days during the dry and rainy seasons to account for changes in the daily and seasonal variation of household water use. A twenty-four-hour recall period was considered for estimating household water use. Evidence from a systematic review showed that measurements of unmetered water use should consider the day-to-day and seasonal variation of water use for reliable results [79]. It also indicated that a 24 or fewer hours recall period has to be considered for reliable water use estimation.

During water use measurements, both the amount of water collected for use and the amount of water consumed for different household activities were considered. The quantity of water collected by households connected with piped water off premises was estimated by considering factors such as the number of person-trips per day made for the collection and the amount of water collected per trip by the person. Hence, the total amount of water collected was determined by multiplying the amount of water carried per trip by the person by the reported number of trips. For households connected to piped water on premises, the quantity of water collected from their tap was estimated by considering factors, which include the number of times they filled storage containers and the amount of water in liters filled storage containers per time. The amount of water used directly from taps was estimated by multiplying the duration of time households directly used water by the water flow rate in liters. The water flow rate in liters per minute was measured on the field in three sampled households, and then average results were used to estimate directly used water.

Storage container inventory was also carried out to estimate the volume of water collected and consumed at household levels. The storage container inventory involves identifying the size and number of different storage containers in which households store water and the frequency of water collection. Besides, pictures of water storage containers of different types and their equivalent volume were used, which can be used to estimate the volume of water storage vessels in households. Furthermore, the data collectors were trained to estimate the size of the water storage vessel and the level of water change in the water storage vessel using a tape meter when they visited households during seven consecutive days in both the dry and rainy seasons.

3.2.5.2. Water sample collection and microbial analysis during the dry and rainy seasons

The microbiological water quality analysis was conducted from May 17 to 31/2022, and August 2 to 17/2022, during the dry and rainy seasons, respectively. Totally, 440 water samples from water storage containers and 12 water samples from the point of collection and storage reservoir were collected during the dry and rainy seasons for *E. coli* analysis. Besides, physicochemical parameters such as pH, turbidity, and temperature were analyzed. Temperature and pH were measured using the Pocket pH Sensor, while turbidity was measured using a Photometer (Model 9300). *E. coli* was used for assessing the microbiological quality of water as it indicates recent fecal contamination [89,221]. Water sampling, handling, and processing were conducted according to World Health Organization (WHO) and American Public Health Association (APHA) guidelines on water handling and processing [222,223]. The microbiological water quality analysis was conducted at the Southern Region Health Bureau Public Health Laboratory, Hosanna Branch. The water samples collected from the sources and point of use were analyzed for *E. coli* using standard methods of membrane filtration technique [222–224]. A 200 ml water sample was collected using a sterile Whirl-Pak bag, which contains 5 drops of sodium thiosulfate to neutralize the effect of any chlorine present in the sampled water. All collected water samples were immediately stored in a cold box containing ice packs, and transported to the laboratory, and analyzed within 4 hours of collection.

A carefully measured 100 ml of water was filtered aseptically through a sterile membrane filter of 0.45 µm pore size. All the retained *E. coli* bacteria on the membrane filter was transferred to the Petri dish containing an absorbent pad, which was saturated with M-Lauryl Sulfate Broth. Then, the Petri dish was incubated for 4 hours at 30 ˚C followed by 14 hours at 44 ˚C. Finally, the bacterial growth on solid media in colony form was counted and described in standard methods cited by WHO and APHA [222,223]. *E. coli* is represented by yellow colonies and therefore counted and expressed in numbers of colony-forming units (CFU) per 100ml of the water sample.

3.2.5.3. Challenges to the provision of drinking water and its implication on childhood diarrhea

Qualitative data was collected on challenges to the provision of drinking water and its implication on childhood diarrhea. In order to gain insights into the challenges of providing drinking water, three focus group discussions (FGDs) were conducted in three kebeles. Each FGDs consisted of eight households that were representative of the target population. The households were selected purposely by considering sex, age, and interest to maintain diversity among the participants. In addition, six key informants were interviewed, including one local leader, one higher official on water supply, and three health extension workers from the selected kebeles. The key informants were selected purposely based on their firsthand knowledge of the challenges of providing drinking water and their ability to explain these challenges. The focus group discussions and key informant interviews were led by trained moderators using a discussion guide, which contains eight open-ended questions that allow participants to share their thoughts and opinions. These methods were used to investigate the difficulties of ensuring sufficient drinking water, the inadequacy of water supply, and their implications on childhood diarrhea. Some of the issues raised in the open-ended questions include water accessibility, adequacy of water supply, major problems associated with their primary water sources, community member's participation in the planning of the water supply project, government effort in the provision of adequate water, the main barriers to the provision of adequate water at the household level, water shortage and its implication on childhood diarrhea and their suggestion in improving the existing water supply system. Finally, results obtained from FGDs and KIIs were audio recorded for thematic analysis.

3.2.6. Study variables

3.2.6.1. Dependent variables

The dependent variables of the study were microbiological water quality and daily average per capita water consumption, which was measured in *E. coli* number per 100 ml of water (CFU/100ml) and liters (L/C/D), respectively. A binary code was created for the microbiological quality of stored drinking water to identify factors associated with fecal contamination of water.

No (1) indicates the absence of *E. coli* in drinking water (Not contaminated with *E. coli*), and Yes (2) indicates the presence of *E. coli* in drinking water (Contaminated with *E. coli*).

3.2.6.2. Independent variables

The potential explanatory variables predicting the two outcomes of the study were identified from the literature review. The independent variables that could predict the per capita water consumption variables include type of water sources, sex of household head, educational level of mothers and household head, household family size, monthly household income, number of under-five children, volume of water storage containers, number of water storage containers, duration of water storage, and rainwater harvesting and using. The explanatory variables that could predict contamination of drinking water with *E. coli* include type of water sources, monthly household income, duration of water storage, types of sanitation facilities, availability of handwashing facilities, covering of water storage containers, water withdrawal method from the water storage containers, frequency of cleaning water storage containers, mouth size of water storage containers, solid waste disposal practice, and educational level of mothers.

3.2.7. Data Analysis

Water quantity and microbiological water quality data were summarized using descriptive statistics such as percentage, range, standard deviation, and mean. Factors associated with the per capita water consumption were identified using a stepwise multiple linear regression analysis. A paired sample t-test was used to observe the difference in mean per capita water consumption between the dry and rainy seasons. The differences in mean per capita water consumption between households connected with piped water on and off-premises were also checked using an independent sample t-test. Binary and multivariable logistic regression was conducted to identify factors associated with microbial contamination of drinking water. The adjusted odds ratios (AOR) were used to interpret the result of the logistic regressions instead of crude odds ratios (OR) because they take into account the effects of other variables that may be associated with the outcome variable. A Wilcoxon signed-rank test was used to observe the seasonal variation of microbiological water quality at the point of use. A non-parametric Mann-Whitney U-test was also used to observe the differences in microbiological water quality between households connected with piped water on and off-premises. The multicollinearity among independent variables was checked using VIF values before undertaking the regression analysis. The fitness of the bivariate and multivariable logistic regression model was checked using the Hosmer-Lemeshow statistics and log-likelihood ratio *P*-value, respectively. All assumptions of stepwise multiple linear regression were also checked before starting the analysis. Data that failed to meet the assumption of multiple linear regressions was transformed into logarithmic to meet the assumption. Assumption also checked for t-test before starting the analysis. Generally, a *P*-value less than 0.05 was considered statistically significant. All quantitative data was analyzed using STATA 14 software. The qualitative data obtained from three focus group discussions and key informant interviews was summarized by developing themes. The data was audio-recorded, translated from Amharic to English, and then thematically analyzed following a six-step analysis process [225].

3.3. Results

3.3.1. Household Socio-economic and Water-related Factors

Of the total sample size (n=292), 288 households participated with a 98.6% response rate. Four households did not participate in the study due to loss to follow up. The majority of the heads of households (62.5%) and mothers (55.2%) had access to secondary school and above education level. The head of household is a person who is recognized by the members of the household as the one who provides the basic necessities of life and as the head of the household. The Protestant religion was the dominant religion in the study area. Of the total households, 77.8% of the households were Protestants (Table 3.1). The median monthly income of the household was 78.7 US dollars.

Table 3. 1. Household Socio-economic and Water-related Factors

Variables	Category	Number of participants (%)
Sex of household head	Female	23 (8)
	Male	265 (92)
Educational status of household head	< Secondary school	108 (37.5)
	Secondary school and above	180 (62.5)
Education level of Mothers	< Secondary school	129 (44.8)
	Secondary school and above	159 (55.2)
Household family size	2-4	95 (33)
	5-6	134 (46.5)
	≥7	59 (20.5)
Religion	Protestant	224 (77.8)
	Orthodox Christian	43 (14.9)
	Other religions	21 (7.3)
Average monthly HH income	< 61 USD	137 (47.6)
	61 – 150 USD	119 (41.3)
	> 150 USD	32 (11.1)
Observed water sources	Piped water on premises	144 (50.0)
	Piped water off premises	144 (50.0)
Sanitation facilities	Improved	155 (53.8)
	Unimproved	126 (43.8)
	No facility	7 (2.4)
Presence of soap near handwashing facilities	Yes	49 (17)
	No	138 (47.9)
	No handwashing facilities	101 (35.1)

The average exchange rate of 1 USD = 51.9425 ETB (Ethiopian Birr) in 2022.

3.3.2. Water consumption during the dry and rainy seasons

The study households were visited for 7 consecutive days during the dry and rainy seasons to measure the daily and seasonal variation of household water use. Household water use refers to the quantity of water used inside and outside the home, which includes water used for drinking, handwashing, cooking, washing clothes, cleaning, other domestic purposes, and excluding water used for agricultural purposes. The average per capita water consumption was 19.4 and 20.3 liters during the dry and rainy seasons, respectively. The average per capita water consumption was calculated by adding the daily water consumption values of the seven consecutive days and dividing the sum by the number of days and then by the number of individuals living in the households. Higher per capita water consumption was obtained during the rainy season compared to the dry season. The daily per capita water consumption was calculated to be less than 20 liters for 52.1% and 45.5% of the studied households during the dry and rainy seasons, respectively.

3.3.3. Physicochemical and bacteriological quality of water sources and point of use water during the dry and rainy seasons

All water samples collected from water storage reservoirs (n = 6) and the point of water collection (n = 6) during the dry and rainy seasons were negative for *E. coli* (Supplementary Table 3.1). This means that *E. coli* is absent or not detectable in the sampled water, which makes the water safe and healthy for human consumption. A total of 440 water samples were also collected from randomly selected households during the dry and rainy seasons and analyzed for the presence of *E. coli* in water. The result revealed that the prevalence of contamination of drinking water with *E. coli* was 43.2% (95% CI = 36.6% - 49.8%) and 34.5% (95% CI = 28.2% - 40.9%) during the dry and rainy seasons, respectively. The *E. coli* counts ranged from 0 to 310 CFU/100ml and 0 to 284 CFU/100ml during the dry and rainy seasons, respectively. The mean *E. coli* counts were 14.7 and 8.3 CFU/100ml during the dry and rainy seasons, respectively. The risk levels for drinking water contaminated with fecal coliform were categorized into low risk (<1), medium risk (1-10), high risk (11-100), and very high risk (>100).[221] The result indicated that 21.8% and 14.1% of the households stored water were categorized under high-risk and above level during the dry and rainy seasons, respectively (Supplementary Table 3.2). The pH value of the water collected from water storage reservoirs and the point of water collection ranged from 7.2 to 7.6 and 7.5 to 7.6 during the dry and rainy seasons, respectively. The mean pH value of stored water for dry (7.76) and rainy (7.53) seasons was found in the safe drinking water range (6.5-8.5). The study also found that the difference in pH, turbidity, and temperature of stored water between the dry and rainy seasons was statistically significant ($P < 0.001$). Additionally, there was a statistically significant seasonal variation in the temperature of water collected from the point of collection ($P < 0.05$). In contrast, there were no statistically significant seasonal variations in pH and turbidity of water collected from storage reservoirs and the point of collection.

3.3.4. Per capita water consumption and prevalence of microbial water contamination among households connected with piped water on and off premises during the dry and rainy seasons

The households connected with piped water on premises had better per capita water consumption in both seasons. The mean per capita water consumption for households connected with piped water on premises was 23.1 and 23.6 liters during the dry and rainy seasons, respectively. On the other hand, the mean per capita water consumption for households connected with piped water off premises was 15.8 and 17.0 liters during the dry and rainy seasons, respectively (Supplementary Table 3.3**)**. An independent sample test was also conducted to observe the difference in mean per capita water consumption between the two groups. The result indicated that households connected with piped water on-premises had a significantly higher mean per capita water consumption compared to those with piped water off-premises during both the dry and rainy seasons ($P < 0.001$).

The result also revealed that the prevalence of contamination of drinking water with *E. coli* was higher in households lacking piped water on premises than in households connected with piped water on premises during the dry and rainy seasons (Supplementary Table 3.4**)**. A non-parametric Mann-Whitney U-test was used to observe the difference in *E. coli* counts in drinking water between the two groups in both seasons. This method was used due to the non-normal distribution of the bacteriological water quality data. The Mann-Whitney U-test indicated that the *E. coli* counts in water for households connected with piped water off premises during the dry and rainy seasons were statistically significantly higher than the *E. coli* counts in water for households connected with piped water on premises during both seasons ($P < 0.001$).

3.3.5. Seasonal variability of per capita water consumption and microbial quality of stored water

A paired sample t-test was used to observe the seasonal variability of per capita water consumption for various water use purposes. The result revealed that the difference in mean per capita water consumption for all household activities between the dry (19.4 liters, 95% CI = 18.81 - 20.05) and rainy seasons (20.3 liters, 95% CI = 19.69 - 20.94) was statistically significant at a *P*-value less than 0.001. Likewise, the paired sample t-test showed that the difference in mean per capita water consumption for handwashing, washing clothes, and cooking between the dry and rainy seasons was statistically significant (Figure 3.1). However, the difference in mean per capita water consumption for drinking and for other domestic purposes between the dry and rainy seasons was not statistically significant. The seasonal variation in the bacteriological quality of household stored water was checked using a non-parametric Wilcoxon signed-rank test. This method was used due to the non-normal distribution of the bacteriological water quality data. A Wilcoxon signed-rank test indicated that the *E. coli* counts in water during the dry season were statistically significantly higher than in the rainy season at a *P*-value less than 0.001 (Figure 3.2).

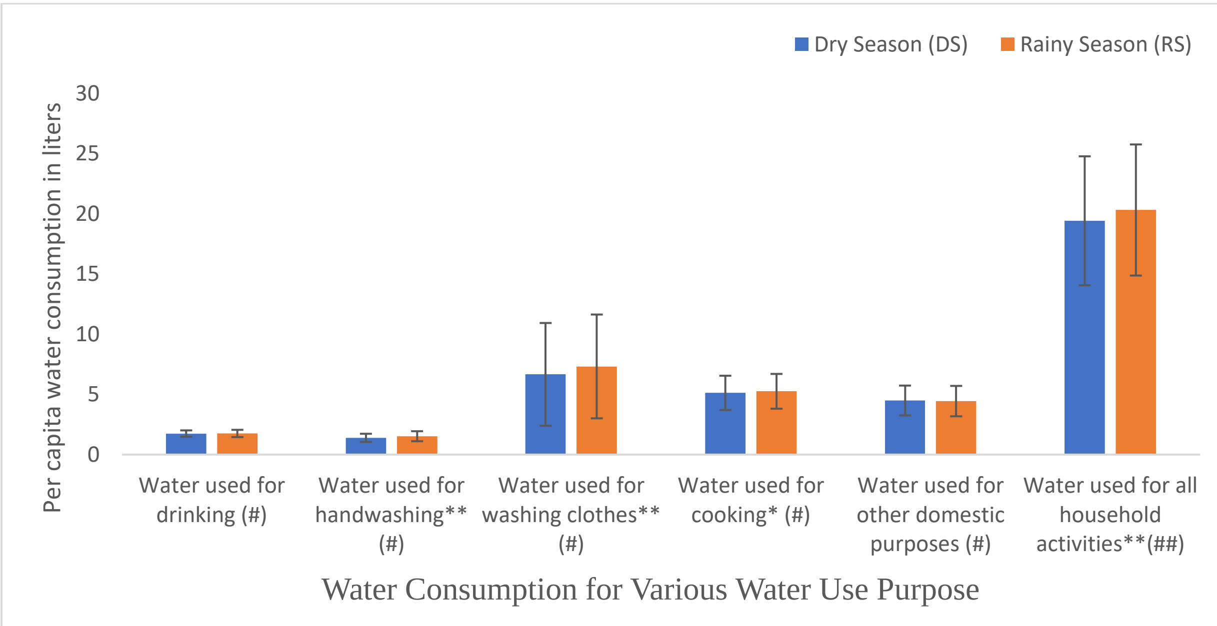

Figure 3.1. Seasonal variation in per capita water consumption for various water use purpose (Mean ± SD).

* – significant at *P*-value <0.01; ** – significant at *P*-value <0.001

(#) - Self-reported

(##) - Self-reported + Field measurement (Water flow rate in liters per minute) + Measuring the level of water changes in the water storage vessel using a tape meter

Water used for drinking: DS (95% CI = 1.72–1.78), RS (95% CI = 1.72–1.79), *P*-value (2- tailed), 0.3597

Water used for handwashing: DS (95% CI = 1.35-1.43); RS (95% CI =1.48-1.57), *P*-value (2- tailed), <0.001

Water used for washing clothes: DS (95% CI =6.17-7.16), RS (95% CI =6.83-7.83), *P*-value (2- tailed), <0.001

Water used for cooking: DS (95% CI =4.96-5.29), RS (95% CI =5.09-5.43), *P*-value (2- tailed), 0.0018

Water used for other dome. purposes: DS (95% CI =4.36-4.64), RS (95% CI =4.30-4.59), *P*-value (2- tailed), 0.1828

Water used for all HH activities: DS (95% CI =18.81–20.05), RS (95% CI =19.69–20.94), *P*-value (2- tailed), <0.001

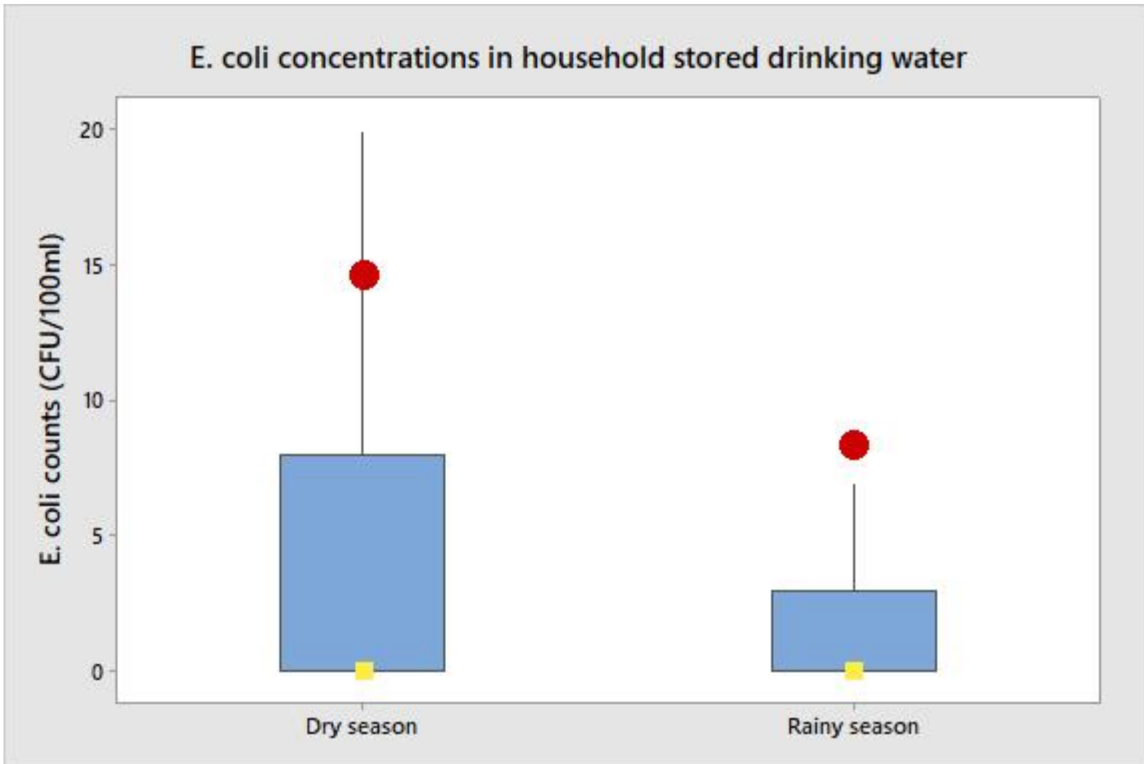

Figure 3.2. Seasonal variability of *E. coli* concentration in household stored drinking water (CFU/100ml). A blue graph represents *E. coli* loads, and a red circle represents the mean *E. coli* value. A yellow square represents the median value.

3.3.6. Factors associated with the microbial quality of stored water during the dry and rainy seasons

Eleven independent variables which could predict contamination of drinking water with *E. coli* during the dry and rainy seasons were identified. This includes types of water sources, duration of water storage, types of sanitation facility, availability of handwashing facilities, covering of water storage containers, water withdrawal method from the water storage containers, frequency of cleaning water storage containers, mouth size of water storage containers, solid waste disposal practice, monthly household income, and educational level of mothers. The bivariate analysis indicated that six variables, which include types of water sources, duration of water storage, availability of handwashing facilities, covering of water storage containers, water withdrawal method from the water storage containers, and mouth size of water storage containers were significantly associated with the presence of *E. coli* in drinking water during the dry season.

However, the multivariable logistic regression verified that piped water off premises (AOR = 4.50; 95% CI = 1.88- 10.75), storing water for more than three days (AOR = 2.78; 95% CI = 1.35- 5.72), uncovering of water storage containers (AOR = 2.41; 95% CI = 1.12- 5.18), and wide-mouthed water storage containers (AOR = 4.38; 95% CI = 1.56- 12.33) were significantly associated with the presence of *E. coli* in drinking water (Table 3.2).

Of those eleven variables considered in the bivariate analysis, five variables, which include the types of water sources, duration of water storage, covering of water storage containers, mouth size of water storage containers, and water withdrawal method from the water storage containers were significantly associated with the presence of *E. coli* in drinking water during the rainy season. On the other hand, the multivariable logistic regression showed that piped water off premises (AOR = 2.86; 95% CI = 1.24- 6.58), storing water for more than three days (AOR = 2.26; 95% CI = 1.09- 4.69), uncovering of water storage containers (AOR = 2.91; 95% CI = 1.34- 6.34), wide-mouthed water storage containers (AOR = 12.06; 95% CI = 3.05- 47.62) and mother's with less than secondary school education level (AOR = 2.17; 95% CI = 1.07- 4.41) were significantly associated with the presence of *E. coli* in drinking water (Table 3.3).

Table 3. 2**.** Factors associated with the bacteriological quality of stored drinking water during the dry season

Variables	Category	Contamination of water with *E. coli* (dry season)		OR (95% CI), *P*-value	AOR (95% CI), *P*-value
		Yes	No		
Water sources	Piped water on premises	28	82	1	1
	Piped water off premises	67	43	4.56(2.57- 8.11), <0.001***	4.50(1.88 - 10.75), 0.001**
Duration of water storage	≤ 3 days	26	72	1	1
	> 3 days	69	53	3.61(2.03 - 6.40), <0.001***	2.78(1.35 - 5.72), 0.006**
Mouth size of WSC	Narrow mouthed	9	45	1	1
	Wide and narrow	35	63	2.78(1.22 - 6.35), 0.015*	4.38(1.56 - 12.33), 0.005**
	Wide mouthed	51	17	15 (6.09 - 37.00), <0.001***	18.72(4.90 - 71.52), <0.001***
Water withdrawal method	Pouring	27	72	1	1
	Dipping	68	53	3.42(1.94 - 6.05), <0.001***	0.45(0.17 - 1.18), 0.103
Is the WSC covered?	No	71	68	2.48(1.39 - 4.44), 0.002**	2.41(1.12 - 5.18), 0.024*
	Yes	24	57	1	1
Frequency of cleaning WSC	More than once a week	38	49	1	1
	Weekly	28	59	0.61(0.33 - 1.14), 0.119	0.38(0.16 - 0.87), 0.022*
	Above weekly	29	17	2.20(1.06 - 4.58), 0.035*	0.76(0.27 - 2.12), 0.602
Sanitation facility	Unimproved	49	50	1.60(0.93 - 2.74), 0.088	0.68(0.32 - 1.46), 0.321
	Improved	46	75	1	1
Availability of HWF?	No	44	31	2.62(1.48 - 4.64), 0.001**	1.42(0.61- 3.33), 0.420
	Yes	51	94	1	1
Monthly HH income	Low	51	51	1	1
	Middle	34	57	0.60(0.34 - 1.06), 0.078	0.73(0.32 - 1.63), 0.438
	High	10	17	0.59(0.25 - 1.41), 0.233	0.80(0.25 - 2.54), 0.703

1 – Reference Category
OR – Crude odds ratio
AOR - Adjusted odds ratio
HWF - Handwashing facilities; WSC – Water storage containers
***** – significant at *P*-value < 0.05
** – significant at *P*-value < 0.01
*** – significant at *P*-value < 0.001
All variables with a *P*-value < 0.25 in the bivariate logistic regression analysis were included in the multivariable logistic regression analysis.

Table 3. 3. Factors associated with the bacteriological quality of stored drinking water during the rainy season

Variables	Category	Contamination of water with *E. coli* (rainy season)		OR (95% CI), *P*-value	AOR (95% CI), *P*-value
		Yes	No		
Water sources	Piped water on premises	23	87	1	1
	Piped water off premises	53	57	3.52 (1.94 - 6.36), <0.001***	2.86 (1.24 - 6.58), 0.013*
Duration of water storage	≤ 3 days	20	78	1	1
	> 3 days	56	66	3.31(1.80 - 6.07), <0.001***	2.26 (1.09 - 4.69), 0.029*
Mouth size of WSC	Narrow mouthed	8	46	1	1
	Wide and narrow	23	75	1.76 (0.73 - 4.27), 0.209	2.26 (0.77 - 6.60), 0.138
	Wide mouthed	45	23	11.25 (4.56 - 27.76), <0.001***	12.06 (3.05 - 47.62), <0.001***
Water withdrawal method	Pouring	18	81	1	1
	Dipping	58	63	4.14 (2.22 - 7.72), <0.001***	0.70 (0.26 - 1.90), 0.481
Is the WSC covered?	No	61	78	3.44 (1.79 - 6.61), <0.001***	2.91(1.34 - 6.34), 0.007**
	Yes	15	66	1	1
Frequency of cleaning WSC	More than once a week	27	60	1	1
	Weekly	27	60	1(0.52 - 1.90), 1.000	0.94 (0.42 - 2.09), 0.883
	Above weekly	22	24	2.04 (0.98- 4.25), 0.058	0.93 (0.35- 2.43), 0.876
Mother's education level	< Secondary school	40	57	1.70 (0.97- 2.97), 0.065	2.17 (1.07- 4.41), 0.032*
	≥ Secondary school	36	87	1	1
Availability of HWF?	No	32	43	1.71(0.96 - 3.05), 0.070	0.68(0.30 - 1.54), 0.358
	Yes	44	101	1	1

1 – Reference Category
OR – Crude odds ratio
AOR-Adjusted odds ratio
HWF - Handwashing facilities; WSC – Water storage containers
* – significant at *P*-value < 0.05
** – significant at *P*-value < 0.01
*** – significant at *P*-value < 0.001
All variables with a *P*-value < 0.25 in the bivariate logistic regression analysis were included in the multivariable logistic regression analysis.

3.3.7. Predictors of per capita water consumption during the dry and rainy seasons

A stepwise multiple linear regression model was used to identify predictors of the per capita water consumption. Around ten variables for the dry season and eleven variables for the rainy season were identified from the literature that could predict the per capita water consumption in each season. However, three variables that failed to meet the assumptions of linear regression were excluded from the analysis. This includes the number of under-five children, monthly household income, and sex of household head. The data on the volume of water storage vessels and family size was log-transformed to meet the assumptions of linear regressions. Then, a stepwise multiple linear regression was conducted with seven and eight independent variables for the dry and rainy seasons, respectively. Both the dry and rainy seasons models were significant at a *P*-value less than 0.001. The final model for the dry season included the types of water sources, family size, volume of water storage vessels, and number of water storage containers to predict per capita water consumption.

The dry season model indicated that piped water on premises (Coef. = 4.99, *P*-value < 0. 001), volume of water storage vessels (Coef. = 3.05, *P*-value < 0. 001), and number of water storage containers (Coef. = 0.44, *P*-value < 0. 05) were statistically significantly associated with increased per capita water consumption. However, family size was associated negatively with per capita water consumption (Coef. = -6.63, *P*-value < 0. 001). Similarly, the rainy season model also showed that piped water on premises (Coef. = 3.94, *P*-value < 0. 001), volume of water storage vessels (Coef. = 2.39, *P*-value < 0. 003), and number of water storage containers (Coef. = 0.78, *P*-value < 0. 001) were statistically significantly associated with increased per capita water consumption (Table 3.4). On the other hand, family size was associated negatively with per capita water consumption (Coef. = -7.00, *P*-value < 0. 001).

Table 3. 4. Stepwise multiple linear regression for identifying predictors of per capita water consumption during the dry and rainy seasons

Season	Variables	No. of Obs.	Coeff.	95% CI, *P*-value
Dry season	Piped water on premises	288	4.99	3.98 - 6.01, < 0.001***
	Family size (log)		-6.63	-7.91 - (-5.36), < 0.001***
	Volume of water storage vessels (log)		3.05	1.59 - 4.50, < 0.001***
	Number of water storage containers		0.44	0.06 - 0.81, 0.022*
Rainy season	Piped water on premises	288	3.94	2.84 - 5.05, < 0.001***
	Family size (log)		-7.00	-8.39 - (-5.61), < 0.001***
	Number of water storage containers		0.78	0.38 -1.19, < 0.001***
	Volume of water storage vessels (log)		2.39	0.81 - 3.97, 0.003**

* – significant at *P*-value < 0.05; ** – significant at *P*-value < 0.01; *** – significant at *P*-value < 0.001
In both seasons the Model *P*-value is significant at *P*-value < 0.001
Mother's education level, education status of the head of household, and duration of water storage did not significantly contribute to the dry season model were excluded from the analysis

Mother's education level, education status of the head of household, duration of water storage, and rainwater harvesting and using did not significantly contribute to the rainy season model were excluded from the analysis

3.3.8. Challenges to the provision of drinking water and its implication on childhood diarrhea

The study involved 24 households in three focus group discussions in the selected kebeles. All participants in the focus group discussion and key informant interviews believed that the provision of drinking water was insufficient, particularly in the peri-urban and informal settlement areas of the town. Due to inadequate water supply, a large number of people were compelled to use unsafe water, which increased health risks in the area. One FGD participant explained that;
"Access to piped water supply was very low in our area. While even the rural villages get enough water, people who live in the peri-urban areas of the town do not get enough water. Due to insufficient piped water supply in the area, we are forced to use unprotected springs and unsafe water. For this reason, the health of our children and ourselves are deteriorating." (Women, 35, Bobicho kebele)

The FGD result indicated that the major problems associated with the primary water sources were failure of public taps to provide water service at regular hours, lack of water from the main water sources, break-down of public taps, and slow repair. The result also revealed that private piped water coverage was low in the peri-urban informal settlement areas, and all participants believed that the reason is the area where they live is illegal. Most participants also indicated that community participation in planning and implementing water supply projects was poor. One key informant noted that;

"The community, myself included, is eager to engage in any efforts to enhance our water supply, even contributing financially if needed. We are ready to cooperate enthusiastically. However, our involvement has been limited due to the absence of a coordinating government body. Moreover, we are currently facing a water shortage.'' (Man, 48, Bobicho Kebele)

The results of the FGD indicated that the government's efforts to provide water were insufficient. One FGD participant noted that;

"The government's efforts to improve the existing water supply problems were insufficient. Additionally, the right to access water has been denied to us just because the place where we live is illegal.'' (Women, 27, Sech-Duna Kebele)

On the contrary to the above FGD participant, one key informant from Hosanna town water supply enterprise noted that: -

"Our office provides drinking water to all areas in the town, even in peri-urban and informal settlement areas. However, due to the water shortage, we are making it available in shifts. In general, we cannot say that the water supply is sufficient, but great efforts are being made to improve the water supply. Additionally, due to water scarcity, there are places where we have not been able to provide water even in shifts, especially the communities living in the peri-urban and informal settlement areas.'' (Higher official, HTWSE)

According to both FGD and KII participants, the inadequate provision of safe water has led to various water-related diseases, including diarrhea in the area. One FGD participant noted that;

"In our kebele, especially in the peripheral area where we live, the water supply has not been paid attention to, so it has had a great impact on our health. The lack of adequate water supply in our area has made it difficult for us to maintain our personal hygiene. For this reason, the number of people suffering from diarrhea and other water-related diseases in our kebele was very high.'' (Man,42, Bobicho Kebele)

In line with the above FGD participant, one key informant participant also noted that: -

"There are a lot of water supply problems in the kebele where I work. As my work is on children and mothers, I am seeing how the lack of adequate water is affecting health. The community had to travel long distances to obtain water and use unsafe water sources due to insufficient water supply. As a result, children are frequently affected by diarrhea." (Health extension worker, Jelo-Naremo Kebele)

All participants in the FGD and KII suggested that government bodies should take the initiative to involve community members in the planning and implementation of the water supply project. This could improve the provision of adequate and safe water for the community. Participants also suggested several measures to improve the existing water supply, such as repairing non-functional public taps quickly, building new public taps at a reasonable distance, and developing unimproved water sources.

3.4. Discussion

The findings showed that the seasonal variation in per capita water consumption was statistically significant. The per capita water consumption during the rainy season was statistically significantly higher than in the dry season. This is consistent with findings obtained from Sierra Leone and Ghana [21,54]. A higher per capita water consumption during the rainy season in the study area could be associated with the availability of alternative water sources such as rainwater. The average per capita water consumption during the dry (19.4 liters) and rainy seasons (20.3 liters) was lower than the findings in Benin, Ghana, and Sierra Leone [21,54,226]. This could be associated with the inadequacy of water supply, socioeconomic condition, culture, lifestyles, and climate condition of the study area. A statistically significant difference in mean per capita water consumption was also observed between the households connected with piped water on and off-premises during the dry and rainy seasons. In both seasons, households having piped water on premises had a better per capita water consumption compared to households lacking piped water on premises. Generally, the result revealed that the per capita water consumption for a large number of households in both seasons was below 20 liters per day, which failed to meet the minimum per capita water consumption Howard *et al.* (2020) recommends. Howard *et al.* (2020) recommend the minimum per capita water consumption compromising personal and domestic hygiene is 20 liters per day [46]. Lack of adequate water for domestic and personal hygiene could make households highly vulnerable to water-related diseases, including diarrhea.

This study attempted to determine the factors contributed to the amount of water people consume in both the dry and rainy seasons. A stepwise multiple linear regression identified piped water on premises, family size, number of water storage containers, and volume of water storage vessels were significant predictors of water consumption in both seasons. However, the importance of each factor varied depending on whether it was the dry or rainy season. Having piped water on premises has increased the per capita water consumption in both seasons. Households having piped water on premises had 5 and 4 times more per capita water consumption than households lacking piped water on premises during the dry and rainy seasons, respectively. Other studies also found that having piped water on premises was associated with better per capita water consumption [17,18]. The accessibility of water on premises might require less effort to collect large amounts of water and also encourage more water use, which might increase their per capita water consumption. The increase in the number and volume of water storage containers was also associated with an increased per capita water consumption in both seasons. A one unit increase in the volume of water storage vessels was associated with an average increase of 0.03 and 0.02 liters in per capita water consumption during the dry and rainy seasons, respectively. Likewise, a one unit increase in the number of water storage containers was associated with an average increase of 0.44 and 0.78 liters in per capita water consumption during the dry and rainy seasons, respectively. This could be due to an increase in the number and volume of water storage containers, which might increase the ability of households to store more water and simultaneously consume more water. This is consistent with the findings obtained from Ghana [54]. The household family size has an inverse relationship with the per capita water consumption in both seasons. Households with a larger family size had a lower per capita water consumption compared to a smaller family size. A one unit increase in family size was associated with an average decrease of 0.07 liters in per capita water consumption in both seasons. This finding is consistent with studies conducted in

Ghana, Iran, China, and the Middle East [54,86,227,228]. This is because water used for various domestic purposes such as cooking, house cleaning, yard cleaning is relatively independent of family sizes [54,86,227].

Although the water sample collected from the storage reservoir and point of water collection was free from contamination, household stored water was significantly contaminated with *E. coli* during the dry and rainy seasons. The prevalence of drinking water contamination with *E. coli* was 43.2% and 34.5% during the dry and rainy seasons, respectively. This microbial contamination of water might increase the risk of water-related diseases. The high prevalence of fecal contamination in this study could be due to poor water handling practices during collection, transport, and storage. Besides, inadequate access to piped water on premises, poor household water treatment practices, longer duration of water storage, and mouth sizes of water storage containers could also have effects on the level of microbial water contamination. On the other hand, the prevalence of fecal contamination of water in both the dry and rainy seasons was lower than other studies conducted in the Dessie Zuria district (66.0%), North Gonder Zone (72.6%), and Jimma Zone (80.0%) [216–218]. The disparity could be associated with the sources of water, where in this study, all study households relied on improved water sources while in the other studies relied on both improved and unimproved water sources. Besides, water handling practices, study setting, and sanitation might contribute to fecal contamination of water.

A statistically significant seasonal difference in microbial contamination of stored water was observed. The water contamination with *E. coli* at the point of use in the dry season was significantly higher than in the rainy season. This finding is in line with evidence obtained from South Africa, which showed higher levels of microbial contamination of stored water during the dry season than in the rainy season [72]. The study finding is also in contrast with evidence obtained from Addis Ababa, which found higher microbial contamination of stored water during the rainy season [20]. The high prevalence of fecal contamination of water during the dry season could be associated with poor hygienic practices and longer duration of water storage due to critical water shortages during the dry season than in the rainy season. Furthermore, households might use unsafe alternative water sources during water supply interruption and when they face water shortage, which is very common in the dry season. This could cross-contaminate the water storage containers and water collected from their water sources, thereby increasing the risk of microbial contamination of water in the household during the dry season. The prevalence of drinking water contamination with *E. coli* was higher in households connected with piped water off premises than in households connected with piped water on premises during the dry and rainy seasons. This finding is in line with evidence obtained from Vietnam and the systematic review [17,18]. This might be associated with households who lack piped water on premises were expected to collect water outside their compound, which could increase the risk of microbial contamination of water due to poor water handling during collection, transportation, and storage. The majority of households who lacked piped water on premises collect water using Jerry cans and transport it to home by carrying it on their head or backs. The findings also indicated that more than 94% of households store their water inside their home or kitchen. Storing water for an extended period of time combined with unsafe storage could increase the risk of microbial contamination, which is supported by different studies [216,229].

Various factors were associated with microbial contamination of stored water in the study area. The multivariate analysis indicated that the piped water off-premises, storing water for more than three days, uncovering of water storage containers, and the wide-mouthed water storage containers were significantly associated with the presence of *E. coli* in drinking water in both the dry and rainy seasons. Households with piped water off premises were 4.5 and 2.8 times more likely to have *E. coli* in their drinking water compared to households with piped water on premises during the dry and rainy seasons, respectively. Similarly, storing water for more than three days was 2.8 and 2 times more likely to increase the *E. coli* count in water compared to households who store water for a lower number of days during the dry and rainy seasons, respectively. The result is in line with findings obtained from Dessie Zuria District, which indicated that water stored for more than three days and uncovered water storage containers were significantly associated with the presence of fecal coliform in water [216]. The majority of households (75.5%) in the study area use either wide-mouthed or wide-and narrow-mouthed water storage containers for storing water, which could increase the risk of microbial contamination. This is because wide-mouthed water storage containers provide a large surface area for microbial attachment and are also more likely to be left open, which allows microbes to enter the water storage containers more easily. Besides, wide-mouthed water storage containers are typically larger in size and store water for a longer time, which could increase the risk of contamination. This is in line with the findings obtained from El Paso, Texas [229]. The study also indicated that mothers with less than a secondary school education level were another important predictor of contamination of household stored water in the rainy season. Mothers with less than a secondary school education level were 2 times more likely to have *E. coli* in their drinking water compared to mothers with secondary school and above education levels during the rainy season.

The study showed that the microbiological quality of stored water can be affected by per capita water consumption. The study found that the prevalence of microbial contamination of drinking water was high during the dry season when per capita water consumption was lower, and lower during the rainy season when per capita water consumption was higher. These results suggest that a lower per capita water consumption during the dry season might reduce hygienic practices, which could play a role in increasing the microbial contamination of drinking water. Conversely, increased per capita water use during the rainy season could improve hygienic practices, which may help lower the microbial contamination of drinking water. This is consistent with other findings, which revealed that reduced water availability can lead to poor hygienic practices [46,230,231]. Moreover, reduced availability of drinking water during the dry season might force households to use unsafe water, which contributes to an increase in microbial contamination of drinking water.

The town's drinking water provision was insufficient, particularly in the peri-urban and informal settlement areas. This was due to several factors, including poor investment in water infrastructure, lack of local community participation, unreliability of water sources, access inequality, breakdown in water distribution systems, and slow repair. The majority of the households in the selected study area were also lacking piped water on premises, which could be associated with the lack of land tenure rights and spatial factors. A review paper also indicated that economic, spatial, social, institutional, political, and informational factors were barriers to water infrastructure development in urban informal settlements in low-income and middle-income countries [8].

3.5. Conclusion

This study investigated the seasonal variation in household water use and microbiological water quality and their determinant factors. It also highlighted the challenges faced in providing adequate drinking water. The main conclusions are as follows:

- The findings revealed that the difference in per capita water consumption between the dry and rainy seasons was statistically significant. A higher per capita water consumption was observed during the rainy season. Despite an improvement in per capita water consumption during the rainy season, the per capita water consumption for many households in both seasons was below 20 liters. This might lead to poor personal and domestic hygiene that could increase the risk of water-related diseases.
- The findings also showed that the microbial contamination of water in the dry season was significantly higher than in the rainy season.
- The probability of *E. coli* contamination in households with piped water on premises is lower than in households with piped water off premises in both the dry and rainy seasons The findings also confirmed that households having piped water on premises had the highest per capita water consumption in both seasons. The per capita water consumption was positively correlated with piped water on premises, volume of water storage vessels, and number of water storage containers in both seasons, while family size was negatively correlated.
- The study recommends taking measures to enhance the quantity and microbiological quality of water to mitigate the risk of waterborne diseases. More investment in water infrastructures, including private and public taps, is also highly recommended to improve the quantity of water delivered to households. The findings also suggest seasonal monitoring of the safety of drinking water throughout all stages of water production, distribution, and use to ensure that the water is safe and healthy.

Chapter Four. The Nexus between Household Water Insecurity, Mother's Handwashing Practices, and Diarrheal Diseases among Under-five Children

Adopted from

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Chapter Four. The Nexus between Household Water Insecurity, Mother's Handwashing Practices, and Diarrheal Diseases among Under-five Children

4.1. Introduction

Diarrheal diseases are still a major cause of illness and death among children under the age of five in developing countries [173]. According to the World Health Organization (WHO), there are approximately 2.5 billion cases of diarrhea among children under the age of five worldwide each year, with most of these cases occurring in Southeast Asia and sub-Saharan Africa [142]. An updated analysis focusing on low- and middle-income countries verified that 60% of diarrheal deaths are caused by inadequate drinking water, sanitation, and poor hygiene (WASH) [175]. Recent evidence from a systematic review and meta-analysis in Ethiopia also verified that diarrheal diseases were a major contributor to under-five death in the country [115]. Handwashing with soap at five key times was the most cost-effective method to prevent childhood diarrhea [232]. Several studies have also demonstrated that washing hands with soap is crucial for interrupting pathogen transmission and preventing diarrhea [96,100].

However, insufficient domestic water supply can lead to poor hygiene practices [46,230]. Findings obtained from Burundi and Peru proved that handwashing frequency is affected by the amount of water available per person in households [104,231]. A study conducted in Debark town, Ethiopia, also found that the availability of water in the households, as well as the knowledge and attitude of mothers, significantly affects handwashing practices [105]. Inadequate access to water can also be associated with water insecurity, which could reduce hygienic practices and increase the risk of water-related diseases [46].

A study conducted in Ethiopia indicated that water insecurity was linked to an increase in the distance to the water source and a decrease in the quantity of water available in households [233]. It is a critical problem that is associated with a decrease in hygiene practices and an increase in the incidence of childhood diarrhea [234]. Evidence obtained from rural Ethiopia also indicated that an increase in water insecurity was associated with an increased occurrence of childhood diarrhea [114]. Water insecurity refers to the inability to access and benefit from water that is adequate, affordable, reliable, and safe water for maintaining a healthy life [109]. Inadequate water supply was also responsible for various water-related diseases in Hosanna town, particularly in the peri-urban and informal settlements. Peri-urban areas are located on the outskirts of the town and typically consist of legal settlements. However, in some cases, there may be illegal settlements on private land within these areas. These settlements often lack proper access to essential services like water and sanitation. Informal settlements, on the other hand, are situated in the transition zone between the urban periphery and rural areas. These settlements lack formal land tenure rights and are predominantly illegal. They suffer from inadequate infrastructure, including roads, electricity, and water supply [215]. Therefore, it is crucial to examine how water insecurity affects mother's handwashing practices and childhood diarrhea and their links in the study area.

Mothers play a critical role in their children's health, and improving their knowledge, attitude, and practices can improve children's health [235]. The role of handwashing with soap in preventing diarrheal diseases has been extensively studied worldwide. However, there is little information on the relationship between household water insecurity, mother's handwashing practices, and the prevalence of childhood diarrhea. Therefore, the objective of this study was to examine the association between household water insecurity (HWIS), mother's handwashing practices, and childhood diarrhea in the peri-urban and informal settlements of Hosanna town. The information obtained from this study could serve as baseline information for improving household water security, mother's handwashing practices, and child health in the study area.

4.2. Methods

4.2.1. Study area

The description of the study area is given in chapter 2, section 2.2.1 and in chapter 3, section 3.2.1

4.2.2. Study design

A community-based cross-sectional study was conducted from April 21/2022 to May 27/2022.

4.2.3. Sample size determination and sampling techniques

The sample size for this study was determined using a single proportion formula [236]. This formula aids in determining the minimum sample size necessary to attain the desired degree of precision. The following assumption was made: Absolute precision (d) = 5%; $Z_{1-\alpha/2}$ =1.96; P = 50%. Given that there were no prior studies on this particular topic and under this study setting in the country, 50% was used as the proportion of mothers with good handwashing practices. The formula for calculating the sample size is as follows:

$$n = \frac{(Z1 - a/2)^2 * P(1-p)}{d^2}$$

Where, n= Total sample size

$Z_{1-\alpha/2}$ = Critical value and a standard value for the corresponding level of confidence (At 95% CI =1.96)

P = Expected prevalence or based on previous research

q = 1-p

d = Margin of error or precision

The calculated sample size was 384, and adding 10% non-response, the total sample size for this study was estimated to be 424. The study was carried out in Hosanna town, specifically in three kebeles, namely Bobicho, Sech-Duna, and Jelo-Naremo kebeles. These kebeles were selected purposively because they have a significant number of peri-urban and informal settlements. Kebele is the lowest governmental administrative structure in Ethiopia. Mothers were allocated proportionally into these kebeles based on the size of each kebeles. Then, simple random sampling techniques were employed to select mothers participating in the study from the selected kebeles. The sampling frame was under-five children aged between 0 and 59 months.

4.2.4. Inclusion and exclusion criteria

The study included mothers/caregivers who had lived in the peri-urban and informal settlements of the selected kebeles for at least six months and had at least one child less than 60 months of age during the study period. On the other hand, mothers who had lived in the area for less than six months were excluded from the study. This is because the mothers who had lived in the area for less than six months were less likely to provide adequate information about the study as they were less familiar with the local environment and resources available. Additionally, they were more likely to have recently migrated to the area, which can make it difficult to track down and interview them. The exclusion of these mothers from the study ensured that the results were not biased by the fact that they were less likely to provide adequate information about the study.

4.2.5. Data collection tools, methods, and quality assurance

The data was gathered using a pretested structured questionnaire, the HWISE Scale, and an observational checklist. The questionnaire was first created in English and then translated into Amharic. The translated version was then translated back into English to ensure its accuracy. The pretesting was conducted on 5% of the sample size to check the quality of the questionnaire, and feedback obtained from the pretesting was incorporated into the questionnaire. Data was collected by trained health professionals, and the data collection was monitored strictly to ensure that it was being conducted in accordance with the established procedures. The study collected data on diarrhea occurrences from the infant's mother or caregiver with a recall period of two weeks. The study evaluated the mother's handwashing at two separate practices, which are handwashing with soap and water, and water only. Mothers were asked about their handwashing practice with soap and water, and water only before feeding a child, after defecation, before eating food, after cleaning the child's bottom, and before preparing food to assess their handwashing practices at five critical times (Cronbach's alpha 0.80). Mothers who washed their hands with soap at each critical time were given one point, while those who didn't were given zero points. Mothers who washed their hands with soap at three or more critical times were considered to have good handwashing practices, while those who washed their hands at less than three critical times were considered to have poor practices [190].

The study assessed the knowledge and attitude of mothers towards handwashing. The knowledge was evaluated based on the correct answers to 10 questions about handwashing (Cronbach's alpha 0.82). Then, a value of 1 was given for correct answers, and a value of 0 for incorrect or don't know responses. Households who scored above the mean knowledge score were considered as having good knowledge [237,238]. The attitude was assessed using seven questions on a Likert-type scale (Cronbach's alpha 0.75). This Likert scale has four items, which include strongly disagree, disagree, agree, and strongly agree in the questions. The responses were then divided into two categories, positive and negative attitudes. For positive attitudes, 1 point was given, while for negative attitudes, 0 points were given. Households that scored above the mean attitude score were considered to have a positive attitude, while households that scored below the mean attitude score were considered to have a negative attitude [237].

The household water insecurity was measured using the 12 items Household Water Insecurity Experience (HWISE) Scale (Cronbach's alpha 0.86). A four-week-recall period was used to measure a household's water insecurity. The study participants were asked to reflect on 12 items on how frequently they or any household members experienced problems with water in the last four weeks [239]. The twelve items include worry about inadequacy of water supply, interruption of water supply, inability to wash hands after activities, take a shower, and wash clothes due to water-related problems. The items also include change of schedules to use water, change of food items, drinking water inefficiency, anger about water situation, thirst for water during sleep, a complete lack of useable or drinkable water, and feeling shame due to water-related issues (Supplementary Table 4.2). HWISE Scale scores were calculated by summing responses to each item and with possible total scores of 0-36, where higher scores indicate greater water insecurity. A cut-point of 12 was considered for defining water-insecure households, and households with an HWISE Scale score of 12 or higher are considered water insecure. Then, the proportion of water insecure households was calculated by dividing the number of households with scores of 12 or higher by the total number of households.

4.2.6. Study variables

4.2.6.1. Dependent variables

The dependent variable of this study was the occurrence of childhood diarrhea with a recall period of two weeks (Yes or No), prevalence of household water insecurity, and handwashing practices at five critical times.

4.2.6.2. Independent variables

The independent variables predicting handwashing practices at five critical times and the occurrence of diarrhea were identified from the literature review. The factors that could predict handwashing practices at critical times include monthly HH income, mother's knowledge about handwashing, mother's attitude towards handwashing practices, water security status, maternal education, presence of handwashing facilities, availability of soap and water near HWF, maternal age, number of under-five children, marital status, mother's knowledge about handwashing practices at critical times, family size, and occupation of mothers. The factors that could predict diarrhea include diarrhea in the past 2 weeks in other household members, maternal age, monthly

HH income, number of under-five children, vaccination status of the child, duration of breastfeeding, maternal education, age of child in months, handwashing practices at 5 critical times, handwashing practices (good vs poor), water security status, sources of drinking water, sanitation facilities, solid waste disposal method, disposal of child's feces, covering of water storage container, types of drinking water storage containers, marital status, family size, occupation of mothers, breastfeeding status of the child, duration of water storage and the presence of feces in the compound.

4.2.7. Data analysis

The study's data was analyzed using descriptive statistics, bivariate, and multivariable logistic regression models. Bivariate logistic regression was used to identify factors associated with diarrhea and mother's handwashing practices. It was used to determine unadjusted associations between independent variables and the outcome variables. On the other hand, a multivariable logistic regression model was conducted to identify factors associated with diarrhea and mother's handwashing practices by controlling for potential confounding factors. Variables scoring 0.25 in the bivariate analysis, which are moderately associated with the outcome variables, were included in the multivariable logistic regression analysis. The variance inflation factor (VIF) was calculated to check the presence of multicollinearity among independent variables. Model fitness was checked by calculating the log-likelihood ratio *P*-value and using the Hosmer-Lemeshow statistics. A variable scoring a *P*-value less than 0.05 was considered statistically significant. All quantitative data was analyzed using STATA 14 software.

4.2.8. Operational definition of terms

Handwashing practices at five critical times: - It includes washing hands with soap before feeding a child, after defecation, before eating, after cleaning the child's bottom, and before preparing food.

Diarrhea: - It is defined as having at least three times or more loose or watery stools in 24 hours period [142].

Water sources: - It was categorized as either improved or unimproved based on WHO/UNICEF guidelines [25].

Sanitation facilities: - It was categorized as either improved or unimproved based on WHO/UNICEF guidelines [25].

Disposal of children's feces: - A child's stool was considered to be disposed of safely if a child uses toilet and puts/rinses feces in the toilet. Conversely, if feces were thrown into the garbage, left in an open area, or put/rinsed into a drain, it was considered unsafe [240].

4.3. Results

4.3.1. Socio-demographic characteristics of the study participants and child-related factors

A total of 424 mothers who had at least one under-five child with a 100% response rate participated in the study. More than one-third of mothers attended primary schools (38.7%), and 88.9% of mothers were married. Three-fourths of the mothers (75.3%) were found in the 25-34 age category, and only 9.7% of mothers were exclusively breastfeeding their children during the data collection time. The majority of the children (58.7%) were partially vaccinated, while the remaining (41.3%) were fully vaccinated. Fully vaccinated children were those who received all the vaccines recommended for their age groups according to the Ethiopian national immunization program for tuberculosis, Hepatitis B, Hemophilus influenza type b, Polio, diphtheria, pneumonia, rotavirus associated gastro-enteritis, tetanus, pertussis, and measles [241]. On the other hand, partially-vaccinated children were those who have received one or two vaccines but have not yet completed the full vaccination series. The mean monthly income of the households living in the peri-urban and informal settlements of the town was 3503.7 ETB (Ethiopian Birr), which is lower than the other parts of the town (5452 Ethiopian Birr) [242]. The mean monthly income of the households was also lower than the households living in other parts of Ethiopia, like Hawassa city and Wolkite town [243,244]. This is because a significant number of households living in the selected peri-urban and informal settlement areas were employed in low-skilled and low-paying jobs. Other socio-demographic and child-related factors are indicated in Table 4.1.

Table 4. 1. Socio-demographic characteristics of the study participants and child-related factors

Variables	Category	Frequency	Percentage
Household head sex	Male	376	88.7
	Female	48	11.3
Maternal Education	No formal education	59	13.9
	Primary school	164	38.7
	Secondary school	108	25.5
	Above secondary school	93	21.9
Marital status of mothers	Married	377	88.9
	Divorced	22	5.2
	Other marital status	25	5.9
Mother's occupation	House wife	218	51.4
	Government employee	72	17
	Self-employed	134	31.6
Maternal age	18 – 24	26	6.1
	25 – 34	319	75.3
	>35	79	18.6
Family size	≤ 5	256	60.4
	>5	168	39.6
Number of under-five children	1	215	50.7
	≥ 2	209	49.3
Average monthly income of the household	< 3201 Ethiopian Birr	249	58.7
	3201–7800 Ethiopian Birr	137	32.3
	> 7800 Ethiopian Birr	38	9
Religion	Protestant	318	75
	Orthodox Christian	68	16
	Apostolic	25	5.9
	Other religions	13	3.1
Sex of child	Male	223	52.6
	Female	201	47.4
Age of child in months	0 – 5	34	8
	6 – 11	87	20.5
	12 – 23	154	36.3
	24 – 35	86	20.3
	36 – 59	63	14.9
Currently breastfeeding status	None breastfeed	153	36.1
	Partial	230	54.2
	Exclusive	41	9.7
Vaccination status of the child	Partially vaccinated	249	58.7
	Fully vaccinated	175	41.3
Duration of breastfeeding	< 1 year	176	41.5
	≥ 1 year	248	58.5
Child started supplementary food	Yes	383	90.3
	No	41	9.7

4.3.2. Prevalence of diarrhea, household water insecurity, handwashing practices, and Environmental characteristics related to study participants

The prevalence of diarrhea among under-five children was 16% (95% CI: 12.5% - 19.5%), and 68.6% of households were water-insecure (95% CI: 64.2% -73.1%). More than half of the mothers (57.8%) had poor handwashing practices. Mothers who washed their hands with soap at three or more key moments were regarded as having good handwashing practices, while those who did so at fewer than three key moments were seen as having poor handwashing practices. The study also revealed that the average prevalence of handwashing with soap at five critical times was 35.1% (Figure 4.1). The majority of mothers (60.7%) washed their hands with water only. While a larger proportion of mothers use water only to wash their hands compared to those using soap, this practice is less effective in removing pathogens and reducing the risk of diarrhea. Conversely, only 4.2% of the mothers did not wash their hands at all. The majority of mothers, who accounted for 72.2% and 76.4%, had good knowledge about handwashing and positive attitudes towards handwashing practices, respectively. Mothers who scored 6 and above out of 10 knowledge score was considered as having good knowledge. Likewise, mothers who scored 4 and above out of seven attitude score was considered as having a positive attitude. Other environmental characteristics related to study participants are included in the Supplementary Table 4.1.

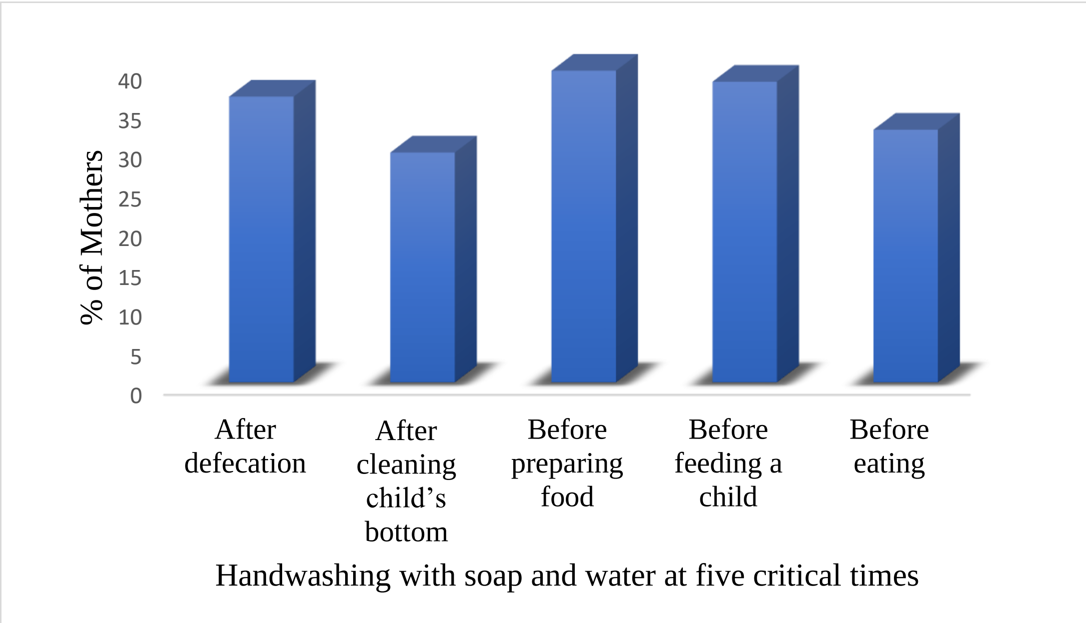

Figure 4.1. Prevalence of handwashing with soap and water at five critical times in Hosanna town

4.3.3. Factors associated with mother's hand washing practices at five critical times

Thirteen independent variables, which include monthly HH income, mother's knowledge about handwashing, mother's attitude towards handwashing practices, water security status, maternal education, presence of handwashing facilities, availability of soap and water near HWF, maternal age, number of under-five children, marital status, mother's knowledge about handwashing practices at critical times, family size, and occupation of mothers that could predict handwashing practices at five critical times were identified from the literature. Then, the bivariate logistic regression analysis was conducted to identify factors associated with good handwashing practices at those times. The analysis revealed that maternal education at the secondary school level, good knowledge of handwashing, positive attitudes towards handwashing, household water security, presence of handwashing facilities, presence of water and soap near handwashing facilities, and being aware of five critical times to wash hands were significantly associated with good handwashing practices.

However, the multivariable logistic regression analysis showed that only good knowledge of handwashing, positive attitudes towards handwashing, household water security, and the presence of handwashing facilities were significantly associated with good handwashing practices. Mothers who had good knowledge of handwashing were 4 times more likely to have good handwashing practices compared to households having poor knowledge. A positive attitude towards handwashing practices was 13.6 times more likely to increase good handwashing practices compared to a negative attitude. The multivariate analysis also showed that water-secure households were 4 times more likely to have good handwashing practices compared to water-insecure households (Table 4.2). Water security can also improve the attitude of mothers towards handwashing practices. Around 82.7% of water-secure households had a positive attitude towards handwashing practices, while only 73.5% of water-insecure households had a positive attitude towards handwashing practices. The bivariate analysis verified that water-secure households were found to be 1.7 times more likely to have a positive attitude towards handwashing practices compared to water-insecure households (*P*-value, < 0.05).

Table 4. 2. Factors associated with mother's handwashing practices at five critical times in Hosanna town

Variables	Category	Handwashing practice		OR (95% CI), *P*-value	AOR (95% CI), *P*-value
		Poor	Good		
Maternal Education	No formal education	41	18	1	1
	Primary school	96	68	1.61 (0.85- 3.05), 0.140	1.06 (0 .42- 2.72), 0.898
	Secondary school	55	53	2.19 (1.12- 4.29), 0.022*	1.27 (0.47- 3.45), 0.634
	Above secondary school	53	40	1.72 (0.86- 3.43), 0.124	0.96 (0.34- 2.68), 0.939
Knowledge of handwashing	Poor	109	9	1	1
	Good	136	170	15.14 (7.40-30.98), <0.001***	3.77 (1.48- 9.62), 0.006**
Attitude towards HW	Negative	95	5	1	1
	Positive	150	174	22.04 (8.74-55.61), <0.001***	13.56 (4.86- 37.86), <0.001***
Water security status	Water insecure HHs	197	94	1	1
	Water secure HHs	48	85	3.71 (2.41-5.71), <0.001***	3.94 (2.11- 7.34), <0.001***
Presence of handwashing facility	No	160	15	1	1
	Yes	84	164	20.83 (11.53-37.60), <0.001***	12.49 (6.30- 24.75), <0.001***
Presence of water and soap near HWF	No	234	134	1	1
	Yes	10	45	7.85 (3.84-16.10), <0.001***	1.82 (0.77-4.31), 0.173
Have you ever heard about HW at 5 critical times	No	140	51	1	1
	Yes	105	128	3.35 (2.22-5.05), <0.001***	1.51 (0.83-2.73), 0.178

1 – Reference Category; OR – Crude odds ratio; AOR - Adjusted odds ratio;
*****– significant at *P*-value < 0.05
******– significant at *P*-value < 0.01
*******– significant at *P*-value < 0.001
HWF – Handwashing Facilities; HW- Handwashing

4.3.4. Factors associated with diarrheal diseases among under-five children

Around twenty-seven explanatory variables predicting diarrhea were identified from the literature, which were considered in the bivariate analysis. These variables include factors like diarrhea in the past 2 weeks in other household members, maternal age, monthly HH income, number of under-five children, vaccination status of the child, duration of breastfeeding, maternal education, age of child in months, handwashing practices at five critical times, handwashing practices (good vs poor), water security status, sources of drinking water, sanitation facilities, solid waste disposal method, disposal of child's feces, covering of water storage container, types of drinking water storage containers, marital status, family size, occupation of mothers, breastfeeding status of the child, duration of water storage and the presence of feces in the compound.

The bivariate analysis showed that sixteen variables, which include maternal education above secondary school level and being self-employed, children aged 6 -11 months, poor handwashing practices, improved water sources accessible on premises, water insecure households, uncovered water storage containers, wide-mouthed water storage containers, sanitation facilities, unsafe child's stool disposal practices, duration of breastfeeding, and handwashing practices at five critical times were significantly associated with diarrheal diseases among under-five children. However, the multivariable logistic regression analysis indicated that only children at 6 -11 months of age, household water insecurity, uncovered water storage containers, wide-mouthed water storage containers, unsafe child's stool disposal practices, hands not washed with soap after defecation, before preparing food, and before feeding a child were significantly associated with the occurrence of diarrheal diseases.

Children at 6 -11 months of age were 13 times more likely to develop diarrheal diseases compared to children at 0-5 months of the age group. Children living in water-insecure households were also 4.3 times more likely to develop diarrheal diseases compared to children living in water-secure households. The result also indicated that children whose mothers didn't wash their hands with soap after defecation had 4 times higher odds of developing diarrheal diseases compared to children whose mothers didn't wash. Likewise, the odds of developing diarrheal diseases of children whose mothers didn't wash their hands with soap before preparing food and before feeding a child were 3.6 and 4.6 times higher than children whose mothers washed their hands with soap before preparing food and before feeding a child, respectively (Table 4.3).

Table 4. 3. Factors associated with diarrheal diseases among under-five children in Hosanna Town

Variables	Category	Diarrhea No	Diarrhea Yes	OR (95% CI), *P*-value	AOR (95% CI), *P*-value
Maternal Education	No-formal educ.	44	15	1	1
	Primary school	139	25	0.53 (0.26- 1.09), 0.084	0.57 (0.21-1.58), 0.280
	Secondary school	91	17	0.55 (0.25-1.20), 0.132	0.68 (0.22-2.14), 0.511
	Above sec. school	82	11	0.39 (0.17-0.93), 0.034*****	0.36 (0.07-1.90), 0.230
Mother's occupation	House wife	175	43	1	1
	Gov't employee	62	10	0.66 (0.31- 1.38), 0.269	1.01 (0.21-4.75), 0.991
	Self-employed	119	15	0.51 (0.27-0.97), 0.039*****	0.77 (0.35-1.66), 0.500
Family size	≤ 5	209	47	1	1
	>5	147	21	0.64 (0.36- 1.11), 0.110	0.60 (0.29-1.24), 0.167
Age of child in months	0 – 5	33	1	1	1
	6 – 11	64	23	11.86 (1.53-91.73),0.018*****	13.17 (1.46-118.40),0.021*
	12 – 23	126	28	7.33 (0.96- 55.90), 0.055	7.90 (0.83-75.56), 0.073
	24 – 35	76	10	4.34 (0.53- 35.31), 0.170	5.37 (0.49-59.08), 0.170
	36 – 59	57	6	3.47 (0.40- 30.12), 0.259	5.96 (0.52-68.85), 0.153
Handwashing practices	Poor	184	61	8.15 (3.63-18.30), <0.001*******	0.54 (0.04-6.93), 0.640
	Good	172	7	1	1
Main water sources	Unimproved WS	44	16	1	1
	IWS accessible off premises	216	41	0.52 (0.27- 1.01), 0.054	0.80 (0.30-2.11), 0.647
	IWS accessible on premises	96	11	0.32 (0.14- 0.73), 0.008******	1.03 (0.30-3.56), 0.959
Water security status	Water-insecure HHs	230	61	4.77 (2.12-10.75), <0.001*******	4.33 (1.48-12.67), 0.007******
	Water secure HHs	126	7	1	1
Covering of WSC	No	186	60	6.85 (3.19-14.75), <0.001*******	6.84 (2.84-16.49), <0.001*******
	Yes	170	8	1	1
Mouth size of water storage containers	Narrow	93	11	1	1
	Wide and narrow	203	39	1.62 (.80- 3.31), 0.182	1.61 (0.66-3.92), 0.291
	Wide	60	18	2.54 (1.12- 5.74), 0.026*****	3.08 (1.08-8.77), 0.035*****
Sanitation facilities	No facility	14	10	1	1
	Unimproved	171	33	0.27 (0.11-0.66), 0.004******	0.45 (0.13- 1.55), 0.207
	Improved	171	25	0.20 (0.08-0.51), 0.001******	0.44 (0.12-1.63), 0.223
Child's stool disposal pract.	Unsafe	169	46	2.31 (1.34-4.01), 0.003******	2.07 (1.05- 4.09), 0.036*****
	Safe	187	22	1	1
Duration of breastfeeding	< 1 year	140	36	1.74 (1.03-2.92), 0.038*****	1.39 (0.53- 3.63), 0.505
	≥ 1 year	216	32	1	1
HW with soap after defecation	No	209	61	6.13 (2.73-13.78), <0.001*******	4.12 (1.31-12.90), 0.015*****
	Yes	147	7	1	1
HWS after cleaning child's bottom	No	237	63	6.33 (2.48-16.15), <0.001*******	1.39 (0.20- 9.58), 0.741
	Yes	119	5	1	1
HWS before preparing food	No	194	62	8.63 (3.64-20.46), <0.001*******	3.64 (1.01-13.07), 0.047*****
	Yes	162	6	1	1
HWS before feeding a child	No	200	62	8.06 (3.40-19.12), <0.001*******	4.62 (1.24-17.21), 0.023*****
	Yes	156	6	1	1
HWS before eating food	No	229	59	3.64 (1.74-7.58), 0.001******	0.49 (0.11- 2.10), 0.338
	Yes	127	9	1	1

1 – Reference Category; OR – Crude odds ratio; AOR - Adjusted odds ratio; *****– significant at *P*-value < 0.05; ******– significant at *P*-value < 0.01; *******– significant at *P*-value < 0.001; HWS- Handwashing with soap; IWS - Improved Water Sources

4.4. Discussion

The study revealed that the prevalence of household water insecurity (68.6%) was very high in the study area, which is consistent with findings obtained from West Cameroon and Botswana. The findings revealed that the prevalence of water insecurity was 58% and 60% in West Cameron and Botswana, respectively [234,245]. The high prevalence of water insecurity in the study area could be associated with the inadequacy of water supply, use of unimproved water sources, and unreliability of the water sources. More than three-fourths (83.3%) of households reported that their main water sources have been interrupted at least once in the last four weeks. Furthermore, more than half of the households (53.8%) had to spend more than 30 minutes collecting water, which might lead to water scarcity and deterioration of water quality. This could further exacerbate water insecurity in the study area. This is in line with findings obtained from the rural South Gonder zone, Ethiopia, which revealed that the use of unprotected water sources and a longer time to fetch water was positively associated with water insecurity [233]. A more recent study conducted in Colombia also indicated that the use of non-piped water sources and water supply interruption was positively associated with water insecurity [246]. The high prevalence of water insecurity in the study area could affect human health by reducing hygienic practices and increasing the risk of various waterborne diseases.

Overall, the high prevalence of household water insecurity in the area indicates that households frequently experience insecurity in their water access. When more than half of households spend over 30 minutes collecting water, it highlights the burden of time and effort required for water procurement. Longer collection time can also impact daily life and well-being [106]. Thus, increased water collection time correlates with higher household water insecurity [233]. Furthermore, only one-fourth of households had access to improved water accessible on-premise, while three-fourths of households had either unimproved water or improved water sources accessible off-premises, which contributed to the increased prevalence of water insecurity. Storing water for more than three days is also commonly practiced by the majority of the study households (73.3%) in the area. While storage provides a buffer against water insecurity, prolonged storage can lead to water quality deterioration [216,247]. This could increase the risk of diarrheal diseases in the study area. The relationship between all these factors suggests the need for a holistic approach, which considers water infrastructure improvement, behavior, and policy to improve household water security, hand hygiene, and reduce waterborne diseases, including diarrhea.

The findings indicated that only 42.2% of the mothers had good handwashing practices (95% CI: 37.5% - 46.9%). This is consistent with findings obtained from Northwest Ethiopia (39.1%) [96], rural areas of the Gedeo zone (44.9%) [238], and Woldia town in northeastern Ethiopia (46.5%) [190]. The result is lower than other findings obtained from Debark town (52.2%) [105] and Kolladiba town, Northwest Ethiopia (51.2%) [248]. The discrepancies might be associated with the study setting, water insecurity status of the households, low handwashing promotion, socio-economic condition, and behavioral factors of the study area. The study also attempted to identify factors that influence good handwashing practices. The findings revealed that a mother's good handwashing practices were positively significantly associated with good knowledge of handwashing, positive attitudes towards handwashing, household water security, and the presence of handwashing facilities in the compound. This is consistent with findings obtained from Northwest Ethiopia, which revealed that good knowledge of handwashing and the availability of handwashing facilities was significantly associated with good handwashing practices [249]. Various other studies also showed that factors, which include good knowledge of handwashing [105], positive attitudes towards handwashing [105], and the presence of handwashing facilities [248] were positively associated with good handwashing practices. The findings also showed that water-secure mothers were more likely to have good handwashing practices compared to water-insecure mothers. This is in line with findings obtained from West Cameroon [234]. This is because water-secure mothers were more likely to have the motivation and adequate drinking water to practice good handwashing habits. The study revealed that the average prevalence of handwashing practices at five critical times was very low (35.1%). This might increase the risk of waterborne diseases that could be prevented by effective handwashing practices.

The two-week period prevalence of diarrhea among under-five children was 16% (95% CI: 12.5% - 19.5%). This is in line with findings obtained from Northwest Ethiopia (16.7%) [250], Debre Berhan town (16.4%) [251], Bereh District in Ethiopia (17.3%) [130], Serbo town in Southwest Ethiopia (14.9%) [252], and sub-Saharan Africa (16%) [253]. The prevalence is also higher than the findings obtained from Southern Ethiopia (13.6%) [126], rural India (9.5%) [254], semi-urban areas of Northeastern Ethiopia (11%) [255], Wolaita Sodo town (11%) [256], and rural Ethiopia

(11.2%) [257]. The higher prevalence of diarrhea in this study might be associated with poor sanitation and hygiene practices, high prevalence of water insecurity, study setting, behavioral and socio-economic factors of the area.

The findings indicated that being a child of 6 -11 months of age, uncovered water storage containers, wide-mouthed water storage containers, unsafe child's stool disposal practices, household water insecurity, hands not washed with soap after defecation, before feeding a child, and preparing food were significantly associated with increased diarrheal diseases. Children between the ages of 6 -11 months had a significantly higher risk of developing diarrheal diseases compared to children aged 0-5 months. This is in agreement with findings obtained from Jimma Geneti District and the slums of Addis Ababa, which revealed children of 6 -11 months of age were significantly associated with the occurrence of diarrheal diseases [99,134]. Various other studies also supported this finding [257,258]. The higher risk of developing diarrheal diseases in children between the ages of 6 -11 months could be associated with several factors. When children are between 6 -11 months old, they usually start to move from only drinking breast milk to eating other foods as well, which could expose them to a wide range of foods and increase the risk of consuming contaminated food or water, leading to the occurrence of diarrhea [99]. Besides, the immune system of infants aged 6 -11 months is not fully matured, which makes them susceptible to infections of diarrheal diseases [134].

Being children from water-insecure households was significantly associated with increased diarrheal diseases compared to children from water-secure households. This is because the lack of safe and adequate water can lead to reduced hygienic practices and also force households to use unsafe water sources, which in turn increases the risk of diarrheal diseases. This is in agreement with findings obtained from Bolivia [259] and West Cameroon [234]. Unsafe stool disposal practices have also increased the risk of diarrheal diseases among under-five children, which could be due to the presence of feces in the compound that creates a breeding ground for flies. Flies might carry disease causing microorganisms and contaminating food and water sources, which could increase the risk of diarrheal diseases [255]. This is consistent with findings obtained from India [260] and Western Ethiopia [258]. The finding also indicated that wide-mouthed water storage containers were significantly associated with increased diarrheal diseases, which is in line with findings obtained from Northwest Ethiopia [261]. Children who lived in households that didn't cover their water storage containers were more likely to develop diarrheal diseases than children who lived in households that covered their water storage containers, which is in line with findings obtained from Debre Berhan town [262] and Nekemte town in Western Ethiopia [263]. This is because uncovered water storage containers are more easily contaminated by flies carrying diseases causing microbes and other dirty materials, which can increase the transmission of diarrheal diseases [263].

There was a significant association between hands not washed with soap after defecation, before feeding a child and preparing food, and the occurrence of childhood diarrhea. This indicates that of those five critical times, only handwashing with soap after defecation, before preparing food, and before feeding a child can prevent the occurrence of diarrhea. This is in agreement with findings obtained from the slums of Addis Ababa, which revealed that washing hands with soap after defecation and before preparing food were the key practices in preventing diarrhea [99]. A study conducted in rural Bangladesh also found that washing hands before preparing food was an important practice in preventing the occurrence of diarrhea [264].

4.5. Conclusion

The study revealed that the prevalence of diarrhea and household water insecurity was very high in the study area. Household water insecurity was statistically significantly associated with increased diarrheal diseases among under-five children. The majority of the mothers had poor handwashing practices, and the average prevalence of handwashing practices at five critical times was also very low. Such poor practices of handwashing had contributed to the increased occurrence of diarrheal diseases in the study area. The study also identified that handwashing with soap before feeding a child, after defecation, and before preparing food were key practices in preventing the occurrence of diarrhea. Hence, the findings suggest interventions that aim to reduce water collection time by providing households with access to closer water sources, including private taps, which could help to improve household water security. Local authorities play a vital role in ensuring regular access to drinking water and soap for people living in the peri-urban and informal settlements, which could improve hand hygiene practices and reduce the risk of diarrheal diseases. Key actions local authorities should take include improving water infrastructure, making water affordable through subsidies, and promoting soap usage through public awareness campaigns and accessible distribution. Educating mothers about proper stool disposal practices, appropriate handling of water storage containers, and enhancing sanitation infrastructure further contribute to disease prevention.

Chapter Five. Incidence of Diarrhea and Associated Risk Factors Among Under-five Children

Adopted from

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Chapter Five. Incidence of Diarrhea and Associated Risk Factors Among Under-five Children

5.1. Background

Diarrheal diseases, which are closely linked to water, sanitation, and hygiene (WASH), continues to be a major health issue affecting children under the age of five globally [265]. It is the third most common cause of death under the age of five [266]. In Ethiopia, diarrheal disease is also a major contributor to the death of under-five children [115]. Frequent diarrheal episodes could be associated with malnutrition and delays in the development of children [267]. It is also connected to elevated mortality risks, growth failure, and the danger of recurrent infections [268]. Generally, the incidence of diarrhea has been reduced from 3.4 episodes per child per year in 1990 to 2.9 episodes per child per year in 2010 [170]. Despite the decline in diarrhea incidence rates, under-five children living in low- and middle-income countries remain at risk for frequent diarrhea episodes [268]. The incidence of diarrhea varies widely between countries and regions. In low- and middle-income countries in 2010, the annual incidence of diarrhea is estimated to be between 2.3 and 4 episodes per child per year [170].

Inadequate water supply, sanitation, and poor hygiene practices are responsible for 60% of diarrheal deaths in low- and middle-income countries [175]. Seasonal changes can also greatly affect both the quantity and quality of water, which may, in turn, impact the occurrence of diarrheal diseases [72]. Evidence shows that improvements in drinking water, sanitation facilities, and hygiene practices can significantly reduce the risk of diarrhea in less developed countries [193]. The health benefits of improved water sources are well-documented in the literature [155,156]. However, there is limited knowledge about the impact of off-premises water access on human health, including diarrhea, compared to on-premises water access. Additionally, existing studies provide mixed evidence on the health effects of on-premises versus off-premises water access. Some research indicates that on-premises water supplies reduces the risk of diarrhea [17,18,160,161], while other studies no significant effect [163,164]. The issue of water supply is a significant challenge in urban areas of developing countries, including Ethiopia, affecting millions of people [9].

Similar to other urban areas in Ethiopia, Hosanna town faces significant water supply challenges, especially in the peri-urban and informal settlements. While the specifics of these areas are covered elsewhere, it is important to note that most households in these areas rely on off-premises water sources [215]. This situation has implications for the incidence of childhood diarrhea. Therefore, it is crucial to investigate the relationship between off-premises water access and childhood diarrhea. Numerous studies have explored the prevalence and risk factors of diarrhea globally. However, there are limited longitudinal studies, particularly in Ethiopia, that have assessed the incidence and risk factors of diarrhea, making it challenging to develop and implement effective interventions. Therefore, this study aimed to measure the incidence of diarrhea and identify associated risk factors among under-five children in the peri-urban and informal settlements of Hosanna town. The findings could be instrumental in addressing childhood diarrhea in several ways. The findings could help develop targeted interventions to prevent diarrhea in the study area. It could also inform the development of national programs to prevent and control diarrhea in the country.

5.2. Methods

5.2.1. Study design and setting

The description of the study area is given in chapter 2, section 2.2.1 and in chapter 3, section 3.2.1. A longitudinal, prospective cohort study was conducted from January 3/2022 to January 2/2023. A one-year follow-up period was considered to measure diarrhea incidence and identify risk factors associated with diarrhea among under-five children. This study design could offer an opportunity to calculate the incidence rate and yield the most reliable data assessing risk factors for diarrhea [161].

5.2.2. Sample size determination and sampling

The sample size is determined using Epi-info version 7.2.3.1 software. A cohort study sample size calculation formula was used for calculating the sample size. The sample size is determined by taking into account the following statistical assumptions, which include risk ratio (1.56)[160]; percentage outcome in an unexposed group (37.5%)[197]; the ratio between unexposed and exposed groups (1:1); power of the study (90%) and alpha (0.05%). After accounting for a 15%

follow-up loss, the study's overall sample size is estimated to be 292. This indicates that 146 unexposed and 146 exposed households participated in the selected three kebeles. A simple random sampling method was used to select the cohort households from the selected three kebeles. The specifics of determining sample size and sampling methods are covered elsewhere [215].

5.2.3. Eligibility and enrollment criteria

Households in selected kebeles in the peri-urban and informal settlements who relied on piped or un-piped improved water sources located off-premises were considered as an exposed group. Meanwhile, households in the same or nearby areas with on-premises water sources, like house and yard connections, were considered as unexposed. The study focused on children aged less than 48 months at the beginning of the study, with the goal of including children under 60 months by the end of the study period. If a household had multiple children, one child was randomly selected to participate in the study. Additionally, households residing in the study area for at least six months were included in the study, while those with serious illness at the study's onset and less than six months of residency were excluded from the study.

5.2.4. Data collection methods and quality assurance

The data collection involved several methods, which included a pretested structured questionnaire, an observation spot-check method, and a questionnaire for recording diarrhea incidence. Water quantity and microbial water quality data were also collected. Detailed information on water consumption and microbiological water quality analysis during the dry and rainy seasons is discussed elsewhere [247]. Diarrhea data was gathered from the infant's mother or caregiver, using a two-week recall period. The mother or caregiver was asked if the infant had experienced any episode of diarrhea within the past two weeks. Diarrhea is defined as having three or more loose or watery stools within a 24-hour period [142]. A new episode of diarrhea can be defined as three diarrhea-free days to mark the beginning of a new episode [269,270]. Diarrhea incidence was calculated as the number of new diarrhea episodes divided by the total number of children per year observation [271]. A biweekly follow-up visit was conducted to collect data on the occurrence of diarrhea. The trained data collectors visited the cohort's households every two weeks over the course of the year (26 times) to collect information about diarrhea episodes.

A bi-monthly follow-up visit was also conducted to collect data on the hygiene practices of study participants. An observational spot-check method was conducted once a day in two months to collect information about hygiene practices in the participating households. The spot-check, a less intrusive, less time-consuming, more economical, and less reactive method, is becoming a promising alternative to structured observations [272]. Fourteen hygienic practices were identified from the literature to evaluate hygienic practices through a spot-check method. However, due to incomplete information about the cleanliness of dishes and the covering of food, the two variables were excluded from the analysis. The remaining twelve hygienic practices assessed through the spot-check method include the presence or absence of feces on the ground, large number of flies around the house, stagnant water around the house, garbage in the living area, and the presence or absence of a handwashing facility with soap in the toilet or near the toilet. The spot-check method also assessed various other variables, such as the cleanliness of the toilet, kitchen, and water storage containers, as well as the cleanliness of the mother's hands and child's hands. Additionally, it included the storage conditions of food and the covering of drinking water containers.

An observational spot-check method was conducted bi-monthly, and average results were calculated for each household for data analysis. Each good hygiene practice was awarded 1 point, while poor hygiene practices received 0 points. This generated a hygiene index score with a maximum of 12 points. Based on the distribution of these scores, a categorical variable was created to classify hygiene practices as poor, average, or good [272]. Households scoring 0-4 were classified as having poor hygienic practices, those scoring 4.1-6.9 as having average hygienic practices, and those scoring 7 and above as having good hygienic practices. Experienced and trained health professionals collected all the data. The data collection tools, adapted from various sources, were pretested on 8% of the study participants to ensure completeness and comprehensiveness. To reduce biases, both the study participants and data collectors were blinded to the research objectives and hypotheses during the data collection. Continuous follow-up was conducted throughout the data collection process, and all collected data was checked for consistency and errors.

5.2.5. Measurements of study variables

5.2.5.1. Dependent variable

The dependent variable was diarrhea incidence among under-five children. Diarrhea incidence was collected 26 times on a bi-weekly basis over the course of the year.

5.2.5.2. Explanatory variables

The incidence of diarrhea can be influenced by various factors. According to the literature, these explanatory variables include socio-demographic factors, child-related factors, as well as environmental and behavioral factors. Socio-demographic factors which could predict diarrhea include mothers/caregivers age, education level of mothers/caregivers, monthly income of the household, marital status of mothers/caregivers, family size, occupation of mothers/caregivers, religion, house ownership, and prior diarrheal status of other household members. Child-related factors predicting diarrhea include the number of under-five children in the family, vaccination status of the child, length of time spent breastfeeding, age of the child, and sex of the child.

Environmental and behavioral factors include washing hands with soap and water at critical times, sources of drinking water, types of sanitation facilities, having education on the causes, consequences, and treatment of diarrhea, solid waste disposal practice, disposal of child stool, length of water storage period, presence of feces within the compound, disposal of liquid waste, covering of water storage vessels, types of drinking water storage containers, breastfeeding mode, presence of handwashing facilities, availability of soap and water near handwashing facilities, method of drawing water from water storage vessels, frequency of cleaning water storage vessels, eating unheated food, and eating uncooked vegetables. Additionally, the microbiological quality of water at the point of use and per capita water consumption were considered as the explanatory variables to examine their associations with diarrhea during the dry and rainy seasons.

5.2.6. Data analysis

Descriptive statistics were used to summarize the study variables. Bivariate logistic regression models were applied to examine the relationship between microbiological water quality at the point of use and per capita water consumption with the incidence of diarrheal diseases during both the dry and rainy seasons. The incidence rate of diarrhea per child per year was calculated for both the exposed group (EG) and the unexposed group (UG). A risk ratio was computed to quantify the frequency of diarrhea incidence in the exposed group compared to the unexposed group. Both the crude and adjusted incidence rate ratio (IRR) were also calculated with a 95% confidence interval. Factors associated with diarrhea incidence were identified using the Generalized Estimating Equations (GEEs) model with the Poisson family and log link, adjusting for potential confounders [273]. Variance inflation factors (VIF) were calculated to check for multicollinearity among independent variables. Variables with a P-value less than 0.25 in the bivariate analysis were included in the multivariate regression models. A P-value below 0.05 was considered statistically significant. The formulas for calculating the risk ratio and diarrhea incidence rate for both the exposed group (EG) and unexposed group (UG) are provided below.

$$Incidence\ Rate\ (IR) = \frac{Number\ of\ new\ cases\ of\ diarrhea\ during\ 1\ year\ period}{Total\ number\ of\ child\ year\ at\ risk} \quad (1)$$

$$IR\ for\ EG = \frac{Number\ of\ new\ cases\ of\ diarrhea\ in\ exposed\ group\ during\ 1\ year\ period}{Total\ number\ of\ child\ year\ at\ risk\ in\ exposed\ group} \quad (2)$$

$$IR\ for\ UG = \frac{Number\ of\ new\ cases\ of\ diarrhea\ in\ unexposed\ group\ during\ 1\ year\ period}{\text{Total number of child year at risk in unexposed group}} \quad (3)$$

$$Risk\ Ratio = \frac{\text{Risk in the exposed group}}{\text{Risk in the unexposed group}} \quad (4)$$

5.2.7. Operational definition of terms

Diarrhea: - Diarrhea can be defined as having at least three times or more loose or watery stools in 24 hours period.

Episode: - A new episode of diarrhea can be defined as three diarrhea free days to mark the beginning of a new episode

Index child: - Under-five children between 0-60 months selected for the study.

Mothers/Caregivers: - A woman who is responsible for taking care of a child.

Appropriate disposal of liquid waste: - When liquid waste is directed to a sewer, septic tank, or pit.

Inappropriate disposal of liquid waste: -When liquid waste is dumped directly on to open ground or water body, or if a sink/drain is connected to an open drain or open ground.

Appropriate disposal of solid waste: - It pertains to waste managed by an official service provider, which is either incinerated or buried, stored in a container, or disposed of at a designed site in a manner that safeguards the environment and public health.

Inappropriate disposal of solid waste: When waste is discarded elsewhere in an open space, collected by an informal service provider, or discarded within a household yard or plot in a manner that affects the public health and environment.

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5.3. Results

5.3.1. Maternal and child-related factors and Environmental Factors Related to Study Participants at the baseline

A total of 292 under-five children were involved in this prospective cohort study. More than half of the mothers (55.8%) were found in the 25-34 age category. The mean age of the participating children at the baseline was 24.4 months. At the baseline, almost three-fourths of the children were in the 12-23 months age category (32.2%), with the next largest group being the 24-35 months age group (27.4%). More than half of the children (51.7%) were females, and the remaining children (48.3%) were males. Nearly two-thirds of the children were weaned (59.6%), and only 7.5% of children were exclusively breastfeeding during the baseline. More than 90% of the children have already started supplementary food during the baseline (Table 5.1). Almost 97.6% of the children have completed the full year follow-up period. A total of 288.38 child-years observations were made.

Table 5. 1. Maternal and Child-related Factors and Environmental Factors Related to Study Participants at baseline

Variables	Category	Frequency	Percentage
Mothers age	18 – 24	61	20.9
	25 – 34	163	55.8
	>35	68	23.3
Household family size	≤ 5	171	58.6
	>5	121	41.4
Number of under-five children	1	141	48.3
	≥ 2	151	51.7
Sex of indexed child	Male	141	48.3
	Female	151	51.7
Child's age in months	0 – 5	18	6.2
	6 – 11	42	14.4
	12 – 23	94	32.2
	24 – 35	80	27.4
	36 – 59	58	19.8
Breastfeeding mode	None breastfeed	174	59.6
	Partial	96	32.9
	Exclusive	22	7.5
Child vaccination status	Partially vaccinated	126	43.1
	Fully vaccinated	166	56.9
Duration of breastfeeding	< 1 year	118	40.4
	≥ 1 year	174	59.6
Child started supplementary food	No	22	7.5
	Yes	270	92.5
Mother's handwashing with water and soap at five critical times	No washing with soap	54	18.5
	Less often	123	42.1
	Often	70	24
	Very often	45	15.4
Water sources	Piped water located on-premises	146	50
	Piped water located off-premises	146	50
Type of sanitation facility	No facility	7	2.4
	Unimproved sanitation	128	43.8
	Improved sanitation	157	53.8

5.3.2. Diarrhea episodes

The result found that a total of 465 diarrhea episodes over 288.38 child-years observations. More than half of the children (55.1%) had at least one episode of diarrhea during the one-year follow-up period, and the remaining 44.9% of children never had any episode of diarrhea. The incidence of diarrhea was 1.61 episodes per child per year (95% CI, 1.47-1.77). A higher diarrhea episode was found among the exposed group compared to the unexposed (Figure 5.1). The result found that a total of 319 diarrhea episodes over 3748 child bi-weekly observations for the exposed group, while for the unexposed group, a total of 146 diarrhea episodes over 3750 child bi-weekly observations The incidence of diarrhea among households lacking piped water on premises (exposed group) was 2.2 episodes per child years observation (95% CI, 1.98-2.47), while households connected with piped water on premises (unexposed group) was 1.0 episodes per child years observation (95% CI, 0.85-1.19). The findings indicated a risk ratio of 2.2, meaning children in the exposed group were 2.2 times more likely to suffer from diarrhea compared to those in the unexposed group. Diarrhea incidence was collected 26 times on a bi-weekly basis over the course of the year. The data revealed the incidence of diarrhea fluctuates with each bi-weekly observation, peaking in the months of the dry season, particularly February, March, and May (Figure 5.2).

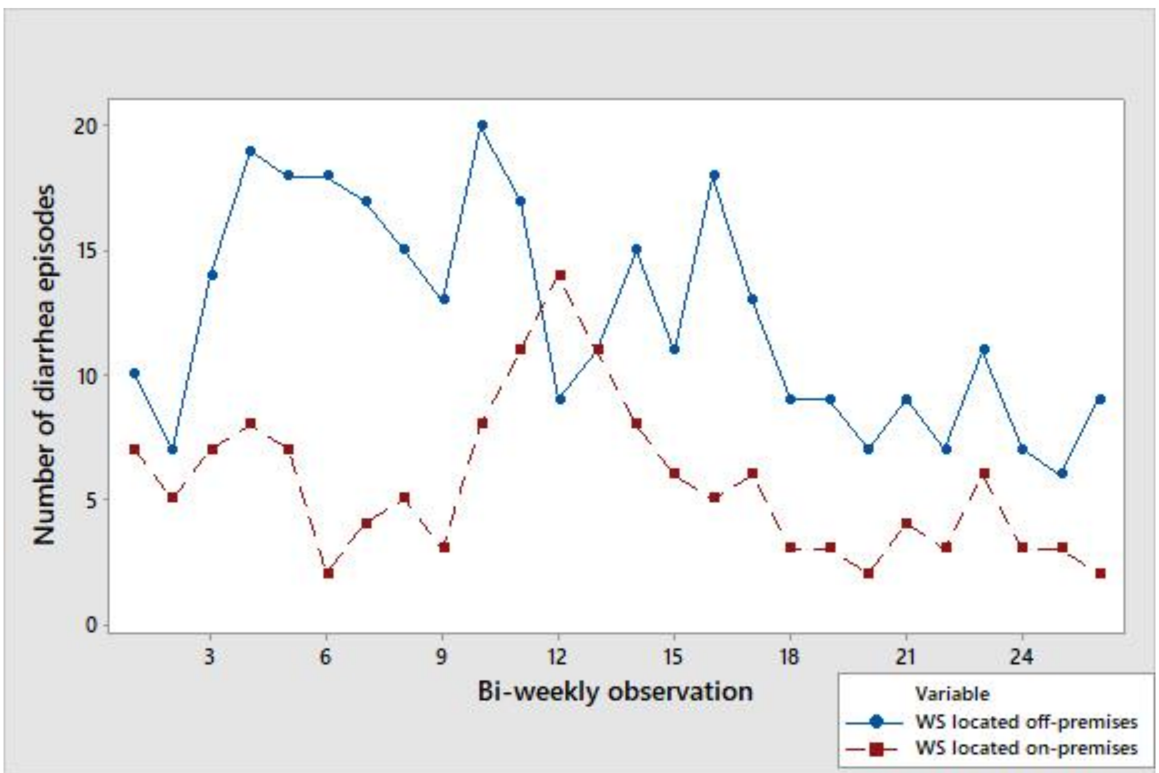

Figure 5.1. The number of diarrhea episodes among exposed (Piped water off-premises) and unexposed (Piped water on-premises) under-five children followed for one year in Hosanna town, central Ethiopia. WS- Water sources

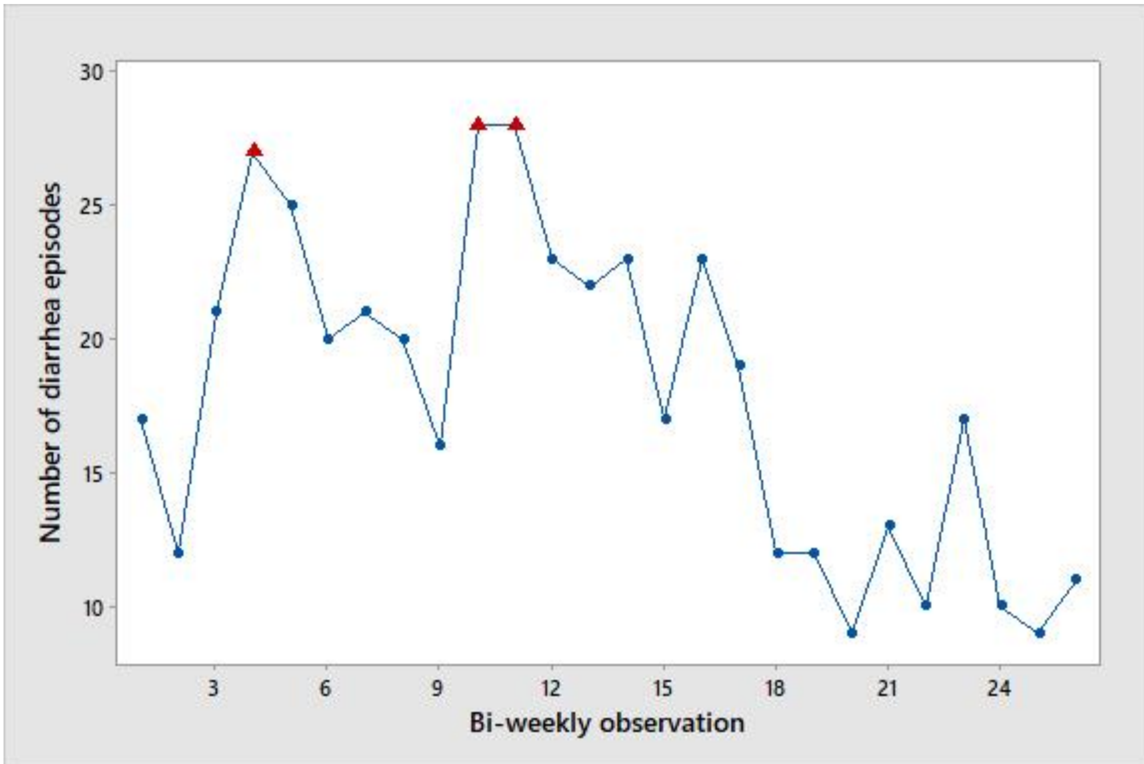

Figure 5.2. Incidence of diarrhea among under-five children in Hosanna town, central Ethiopia. The incidence data was collected 26 times on a bi-weekly basis over the course of the year from January 3/2022 to January 2/2023. The red triangle represents the peak diarrhea incidence.

5.3.3. Microbiological quality of stored water

Nearly 43.2% of stored water samples were contaminated with *E. coli* during the dry season, compared to 34.5% during the rainy season. The *E. coli* counts varied from 0 to 310 CFU/100ml in the dry season and from 0 to 284 CFU/100ml in the rainy season. Additionally, 18.6% of households stored water fell into the high-risk category during the dry season, while 12.3% did during the rainy season. Meanwhile, 3.2% and 1.8% of the households' stored water were categorized under very high-risk levels during the dry and rainy seasons, respectively. Detailed information about microbial water quality is included in Supplementary Table 3.1 and 3.2. When comparing the three study kebeles, Sech-Duna had the highest prevalence of *E. coli* contamination at 20%, followed by Bobicho at 15.5%, and Jelo-Naremo at 7.7% during the dry season. Similarly, in the rainy season, Sech-Duna had the highest contamination rate at 14.5%, followed by Bobicho kebele at 12.7% and Jelo-Naremo kebele at 7.3%.

5.3.4. Nexus of water quantity, microbial quality and diarrheal diseases in children under five.

A bivariate analysis was carried out to examine the associations between microbiological water quality and the occurrence of diarrheal diseases during the dry and rainy seasons. Additionally, the connection between per capita water consumption and the occurrence of diarrhea during these seasons was analyzed using bivariate logistic regression analysis. The data used for this analysis included diarrhea recorded during the dry and rainy seasons, coinciding with the periods of the water sampling and microbiological water quality analysis and water consumption measurement. The analysis found a significant link between consuming microbially contaminated water and an elevated risk of diarrhea during both the dry and rainy seasons. Consuming microbially contaminated water increased the risk of acquiring diarrhea by 4 times during the season (COR = 4.02, 95%CI = 1.51-10.71) and by 4.1 times during the rainy season (COR = 4.12, 95%CI = 1.20-14.15), compared to consuming uncontaminated water. Similarly, a lower per capita water consumption was significantly associated with an increased risk of diarrhea in the dry season. Consuming less than 20 liters of water per capita per day increased the risk of acquiring diarrhea by 2.5 times compared to those who consumed 20 liters or more of water per capita per day during the dry season (COR = 2.5, 95%CI = 1.06-5.88). However, the per capita water consumption is not significantly associated with the occurrence of diarrheal diseases during the rainy season (Table 5.2).

Table 5. 2. Bivariate logistic regression analysis of microbiological water quality at point of use and per capita water consumption with the occurrence of diarrheal diseases during the dry and rainy seasons in Hosanna town, central Ethiopia

Variables	Category	Diarrhea		COR (95% CI)	*P*-value
		Yes	No		
Number of *E. coli* in drinking water (CFU/100ml) during the dry season	0	8	117	1	1
	≥ 1	11	84	4.02 (1.51- 10.71)	0.005**
Number of *E. coli* in drinking water (CFU/100ml) during the rainy season	0	6	138	1	1
	≥ 1	5	71	4.12 (1.20 - 14.15)	0.025*
Per capita water consumption during the dry season	< 20L	15	135	2.5 (1.06 - 5.88)	0.036*
	≥ 20L	10	128	1	1
Per capita water consumption during the rainy season	< 20L	11	120	1.71 (0.67 - 4.38)	0.266
	≥ 20L	8	149	1	1

1 – Reference Category; COR- Crude odds ratio; L - Liters
*****– significant at *P*-value < 0.05; ******– significant at *P*-value < 0.01

5.3.5. Risk factors associated with the incidence of diarrheal diseases

Around 34 explanatory variables predicting diarrhea were considered in the bivariate analysis. The analysis indicated that type of water sources, age of child, education level of mothers/caregivers and household head, monthly income of the household, types of sanitation facilities, disposal of child stool, presence of handwashing facilities, availability of soap and water near handwashing facilities, washing hands with soap and water at critical times, length of water storage period, vaccination status of the child, length of time spent breastfeeding, eating unheated food, and hygiene practices were significantly associated with incidence of diarrhea. However, the multivariate analysis showed that piped water off-premises, unsafe disposal of child's stool, eating unheated food, and washing hands with soap less often or never were significantly associated with increased risk of childhood diarrhea (Table 5.3). The analysis also indicated that children between 24-35 and 36-49 months had a lower risk of diarrheal diseases compared to those aged 0-11 months. Better hygiene practices were also protective against childhood diarrhea.

Table 5. 3. Factors associated with the incidence of diarrheal diseases among children under the age of five in Hosanna town

Variables	Category	CIRR (95%CI)	*P*-value	AIRR (95%CI)	*P*-value
Age of index child	0 – 11	1	1	1	1
	12 – 23	0.70 (0.57-0.85)	< 0.001***	0.85 (0.65- 1.11)	0.241
	24 – 35	0.29 (0.22-0.38)	< 0.001***	0.51 (0.32- 0.80)	0.004**
	36 – 59	0.03 (0.01-0.08)	< 0.001***	0.13 (0.05- 0.34)	< 0.001***
Education level of mothers/caregivers	Below seco. school	1	1	1	1
	Secondary school	0.78 (0.62-.97)	0.029*	0.79 (0.61- 1.02)	0.071
	Above sec. school	0.71 (0.57-.89)	0.005**	0.95 (0.64- 1.42)	0.804
Education level of household head	Below seco. School	1	1	1	1
	Secondary school	0.81 (0.64-1.01)	0.070	0.97 (0.74- 1.27)	0.845
	Above sec. school	0.76 (0.62-0.94)	0.003**	0.96 (0.72- 1.28)	0.781
Occupation Mothers/caregivers	House wife	1	1	1	1
	Gov't/NGO employee	0.67 (0.52-0.85)	0.001**	0.87 (0.55- 1.37)	0.542
	Self-employed	0.88 (0.71-1.10)	0.260	0.88 (0.69- 1.12)	0.287
House ownership	Private house	1	1	1	1
	Private rental house	1.17 (0.97-1.41)	0.095	0.93 (0.75- 1.14)	0.470
Religion	Protestant	1	1	1	1
	Other religions	1.15 (0.93 - 1.42)	0.186	1.24 (0.98 -1.58)	0.079
Average monthly HH income	Low income (< 3201 ETB)	1	1	1	1
	Middle income (3201-7800 ETB)	0.63 (0.52-0.77)	< 0.001***	0.87 (0.67- 1.13)	0.292
	High income (> 7800 ETB)	0.59 (0.42-0.83)	0.002**	1.17 (0.75- 1.83)	0.498
Disposal of Liquid waste	Inappropriate	1.19 (0.91-1.56)	0.203	0.90 (0.65- 1.24)	0.509
	Appropriate	1	1	1	1
Disposal of solid waste	Inappropriate	1.20 (0.99-1.43)	0.062	0.96 (0.79- 1.17)	0.707
	Appropriate	1	1	1	1
Water sources	Piped water off premises	2.19 (1.80- 2.66)	< 0.001***	1.57 (1.22- 2.03)	< 0.001***
	Piped water on premises	1	1	1	1
Sanitation facility	No facility	1	1	1	1
	Unimproved	0.78 (0.47- 1.29)	0.325	0.86 (0.49- 1.52)	0.599
	Improved	0.64 (0.38- 1.05)	0.079	0.88 (0.49- 1.58)	0.665
Disposal of child's stool	Unsafe	4.78 (3.80- 6.01)	< 0.001***	1.47 (1.13-1.92)	0.004**
	Safe	1	1	1	1
Availability of HWF	No	1.58 (1.32- 1.90)	< 0.001***	0.88 (0.68-1.14)	0.326
	Yes	1	1	1	1
Availability of both water and soap-HWF	No	1.69 (1.26-2.27)	0.001**	1.12 (0.78-1.61)	0.550
	Yes	1	1	1	1
Handwashing with soap at 5 critical times	Less often/never	6.38 (4.66- 8.73)	< 0.001***	1.95 (1.37-2.80)	< 0.001***
	Very often/often	1	1	1	1
Length of water storage period	≤3 days	1	1	1	1
	> 3 days	1.31 (1.08-1.58)	0.005**	1.00 (0.80-1.24)	0.980
Water storage containers' mouth sizes	Narrow	1	1	1	1
	Wide and narrow	1.18 (0.92- 1.50)	0.186	1.23 (0.94- 1.68)	0.121
	Wide	1.58 (1.23- 2.02)	0.001**	1.33 (0.90- 1.96)	0.149
Method of drawing water from WSC	Dipping	1.15 (0.96-1.38)	0.140	0.86 (0.64-1.15)	0.317
	Pouring	1	1	1	1
Length of time spent breastfeeding	< 1 year	3.04 (2.50- 3.69)	< 0.001***	1.10 (0.83-1.44)	0.511
	≥ 1 year	1	1	1	1
Vaccination status	Partially vaccinated	3.26 (2.67- 3.98)	< 0.001***	1.05 (0.75-1.48)	0.763
	Fully vaccinated	1	1	1	1
Does index child eat unheated food	No	1	1	1	1
	Yes	2.37 (1.97- 2.86)	< 0.001***	1.43 (1.16-1.76)	0.001**
Hygiene practices	Poor	1	1	1	1
	Average	0.60 (0.50- 0.73)	< 0.001***	0.77 (0.63-0.96)	0.018*
	Good	0.08 (0.05- 0.13)	< 0.001***	0.26 (0.16-0.42)	< 0.001***

1 – Reference Category; CIRR – Crude incidence rate ratio; AIRR - Adjusted incidence rate ratio; *– significant at *P*-value < 0.05; **– significant at *P*-value < 0.01; ***– significant at *P*-value < 0.001; HWS- Handwashing Facility; HH-Household; WSC-water storage container; IC- Index child; ETB - Ethiopian Birr

5.4. Discussion

This study aimed to assess the incidence of diarrhea and identify factors contributing to its occurrence among children under-five. The result indicated an incidence rate of 1.6 episodes per child per year (95% CI, 1.47-1.77), which is higher than the 0.81 episodes reported in Vietnam [171]. This discrepancy may be linked to poor hygiene, sanitation, and inadequate water supply in the study area. Conversely, the incidence rate is lower than those reported in Afghanistan, rural Bangladesh, Turkey, and Guinea-Bissau, potentially due to differences in the study area, behavioral factors, socioeconomic, and environmental conditions [161,165,167,168]. The study also found that children with piped water off-premises experienced more frequent diarrhea episodes, with an incidence rate of 2.2 episodes per child per year (95% CI, 1.98-2.47), compared to 1.0 episodes per child per year (95% CI, 0.85-1.19) for those with piped water on their premises.

The study tried to explore the impact of seasonal changes in microbiological water quality and per capita water consumption on the incidence of diarrhea. The findings showed that consuming microbiologically contaminated water significantly increased the risk of diarrhea during both the dry and rainy seasons. This is because contaminated water could contain microbial pathogens that can cause diarrhea. This aligns with previous studies, which found a significant association between drinking water contaminated with *E. coli* and a higher risk of diarrhea [62,63,65,274]. While other studies have revealed no significant association between *E. coli* levels in water and diarrhea [67–70]. A lower per capita water consumption was also significantly associated with an increased risk of diarrhea during the dry season. This is because a lower per capita water consumption can reduce hygiene practices, which could contribute to an increase in diarrhea cases. However, no statistically significant association was found between the per capita water consumption and the occurrence of diarrheal diseases during the rainy season. These findings are consistent with findings obtained from Eastern Ethiopia, which revealed that consuming less than 20 liters of water per capita per day was significantly associated with an increased risk of diarrhea [274]. Various studies have also shown that higher water usage at home reduces the risk of diarrhea [46,47,49,50,52], while one study found no significant association between daily per capita water consumption and risk of diarrhea [54].

The study also attempted to determine the factors associated with the incidence of diarrheal diseases among under-five children. The study found that the risk of diarrhea was higher among children lacking piped water on-premises compared to children having piped water on-premises. Children who had piped water off premises had a 57% higher incidence of diarrhea than children who received piped water on premises (AIRR= 1.57, 95%CI = 1.22-2.03). Collecting water from sources outside the home decreases the amount of water available for household use, which can lead to reduced water consumption. This reduction may negatively impact hygiene practices and increase the risk of diarrhea. Moreover, fetching water from off-premises water sources heightens the likelihood of contamination by pathogens that cause diarrhea. This is consistent with other findings, which stated that on-premises water sources can significantly reduce the risk of diarrhea [17,18,160,161,275]. In contrast, several other studies showed that on-premises water supply has no significant effect on diarrhea [164,165]. The findings indicate that merely having water on premises does not offer full health benefits unless accompanied by improved sanitation and better water storage practices. Children eating unheated food were at higher risk of contracting diarrhea compared to children who did not eat unheated food (AIRR= 1.43, 95% CI = 1.16-1.76). This is consistent with findings obtained from Guinea-Bissau [161]. This is because unheated food might contain harmful pathogens that can cause infections in the intestine, including diarrhea.

Unsafe disposal of child stool was significantly associated with increased incidence of diarrheal diseases (AIRR= 1.47, 95%CI = 1.13-1.92). This is in line with findings obtained from India, Northwest Ethiopia, and Western Ethiopia [258,260,276]. Unsafe disposal, which includes open defecation and leaving stools in the open, can contaminate the water sources, food, and the environment could increase the transmission of pathogens and risk of diarrhea. In contrast, safe disposal of child stool is an effective method to prevent the spread of pathogens that cause diarrheal diseases [277]. The likelihood of diarrhea in children was substantially higher when handwashing at critical times with soap was done less frequently or never. Children whose mothers wash their hands with soap less frequently or never had 2 times more risk of contracting diarrhea compared to children whose mothers wash their hands very often or often (AIRR= 1.95, 95%CI = 1.37-2.80). This is in agreement with findings obtained from Bereh District Ethiopia and Western Ethiopia, which revealed that poor handwashing practices at critical times can increase the risk of diarrhea [127,130].

The findings verified that children aged 24-35 and 36-59 months were at a lower risk of contracting diarrhea than children aged 1-11 months. In line with this finding, research conducted in Ethiopia, India, and Kenya has shown that the risk of diarrhea decreases as children grow older [278–280]. Factors related to immunity and hygiene likely contribute to the observed differences in diarrhea risks among different children's age groups. This is because as children get older, their immune systems become robust [281]. They could also develop some immunity through exposure to various pathogens that might protect them from diarrhea-causing pathogens. Additionally, children in this age group are more likely to be aware of the importance of hygiene and to practice good hygiene practices, which could reduce exposure to diarrhea-causing microbes. Improved hygienic practices have been shown to protect against diarrheal diseases. Children from households with average hygiene practices experience a 23% reduction in diarrhea incidence compared to those from households with poor hygiene (AIRR= 0.77, 95%CI = 0.63-0.96). Likewise, children from households with good hygiene practices see a 74% reduction in diarrhea incidence compared to those from households with poor hygiene (AIRR= 0.26, 95%CI = 0.16-0.42). This aligns with multiple studies that have shown a link between better hygiene practices and a lower occurrence of diarrheal diseases [282,283].

5.5. Conclusion

Although diarrhea incidence is declining globally, children living in the selected peri-urban and informal settlement areas are highly vulnerable to frequent episodes of diarrhea, leading to substantial morbidity. The incidence of diarrhea episodes in children lacking piped water on-premises was significantly higher compared to children who had piped water on-premises. Unsafe disposal of child stool, eating unheated food, and poor handwashing practices at critical times contributed to the increased incidence of diarrheal diseases. Conversely, better hygienic practices were found to be protective against childhood diarrhea. The findings indicate that consuming water contaminated with *E. coli* significantly increased diarrhea during both dry and rainy seasons. Additionally, consuming less than 20 liters of water per capita per day during the dry season significantly raised the risk of diarrhea. However, there is no significant association between per capita water consumption and diarrhea during the rainy season. Therefore, the study highlights the importance of improving water infrastructure, including on-premises water access, in order to reduce the incidence of diarrhea. Improving microbial water quality at the point of use and increasing per capita water consumption could also help reduce the risk of diarrhea. Interventions to improve handwashing practices at critical times can lower the incidence of diarrhea and potentially save children's lives. Maintaining good hygienic practices in food preparation and consumption is also key to reducing the risk of diarrheal diseases.

Chapter Six. Synthesis

6.1. Synthesis

The study revealed that the reliability of the water sources was a major challenge, posing significant health risks in the study area. Only 8.9% of the study households had access to reliable water services that received water regularly from their main water sources during both the dry and rainy seasons. The majority (91.1%) relied on unreliable water sources. The primary reasons for unreliable water access were the inaccessibility of the water source at a given time and the unavailability of water when needed. This could profoundly impact household water availability and pose significant public health risks. Around 55.1% of households had improved sanitation, while 44.9% had unimproved sanitation facilities. Among improved sanitation facilities, 35.1% were basic sanitation facilities, and the remaining 20% were categorized as limited sanitation facilities. Basic sanitation involves using improved facilities that are exclusively for one household, while limited sanitation refers to using improved facilities that are shared among two or more households [25]. This finding shows a significant number of households in the selected area were lacking improved sanitation facilities, which could increase the spread of infectious diseases, including diarrhea.

In the study area, while two-thirds of the households (65%) had access to handwashing facilities, only 16.8% had basic handwashing facilities. Unfortunately, this falls short of the ambitious sustainable development goals (SDGs) target 6.2 of providing adequate and equitable sanitation and hygiene services for everyone by 2030 [25]. Without further effort, water-related infectious diseases may continue to pose risks to households, which could be prevented through effective handwashing practices in the area. The study also identified factors determining the availability of on-premises water access, improved sanitation, and handwashing facilities. A comprehensive understanding of the factors influencing access to these facilities is crucial for facilitating targeted interventions that address specific local needs and promote equitable access to WASH facilities in the study area. The study identified the income of households as a significant factor affecting access to piped water on-premises, improved sanitation, and handwashing facilities. The qualitative study also revealed that inadequate water services in the area were hindered by land tenure issues, low community involvement and residing in the town's outskirts. These findings highlighted that ensuring community participation, improving the income of households, and addressing households' financial constraints through various interventions, particularly in the peri-urban and informal settlements areas, could improve WASH facilities.

Off-premises water sources can affect both the quantity [17] and microbial quality of water delivered to households [177]. Seasonal changes can also significantly influence the availability and consumption [21] and the microbiological quality of water [20]. The study found a statistically significant difference in mean per capita water consumption for all household activities between the dry and rainy seasons. This is consistent with findings from research carried out in Sierra Leone and Ghana [21,54]. On average, daily per capita water consumption was 19.4 liters in the dry season and 20.3 liters in the rainy season, with higher consumption during the rainy season. This increase could be due to the availability of alternative water sources like rainwater. Although daily per capita water consumption increased during the rainy season, many households in both seasons consumed less than 20 liters per capita per day. This falls short of the minimum per capita water requirement (20 liters per day) compromising personal and domestic hygiene, making them vulnerable to diarrheal diseases [46].

The study identified that having piped water on-premises, family size, the number of water storage containers, and the capacity of these containers were significant factors influencing water usage during the dry and rainy seasons. Households with piped water on their premises, a higher number of water storage containers, and a larger volume of water storage vessels have significantly higher per capita water consumption in both seasons. This is likely because having more and larger water storage containers allows households to store and use more water [54]. Conversely, larger family sizes were associated with lower per capita water consumption in both seasons. This is because the amount of water used for domestic purposes like cooking, house cleaning, and yard cleaning does not significantly vary with family sizes [54,86,227].

The findings showed that the prevalence of *E. coli* contamination in drinking water was 43.2% during the dry season and 34.5% during the rainy season. The analysis indicated that *E. coli* levels were significantly higher during the dry season compared to the rainy season. This result aligns with findings from South Africa [72] but differs from those observed in Addis Ababa [20]. The high rate of fecal contamination during the dry season may be attributed to poor hygienic practices and extended water storage times caused by severe water shortages. Additionally, households might resort to unsafe alternative water sources when the water supply is interrupted and when they experience water shortages, which are frequent in the dry season. This can lead to cross-contamination of water storage containers and water collected, thereby heightening the risk of microbial contamination.

The result also indicated that *E. coli* contamination was more prevalent in households with piped water off-premises compared to those with piped water on-premises during both seasons. The analysis showed that *E. coli* counts were significantly higher in water from households with piped water off-premises compared to those with piped water on-premises during both seasons. This result aligns with findings from Vietnam [17]. This could be because households without piped water on premises need to collect water outside their compound, increasing the risk of microbial contamination due to poor handling during collection, transportation, and storage. Several other factors were also linked to microbial contamination of stored water in the study area. These include storing water for more than three days, leaving water storage containers uncovered, and using wide-mouthed water storage containers. All of these factors were significantly associated with the presence of *E. coli* in drinking water in both the dry and rainy seasons.

Inadequate water supply greatly impacts public health by increasing household water insecurity and leading to a range of adverse health outcomes. The study found that household water insecurity was highly prevalent at 68.6%, posing a significant public health risk in the study area. This high prevalence is linked to inadequate water supply, the use of unimproved water sources, and unreliable water sources. Water insecurity in the area can negatively affect human health by reducing hygiene practices and increasing the risk of diarrheal diseases. The study showed that only 42.2% of the mothers practiced good handwashing, a lower rate than other studies [105,248], possibly due to high water insecurity, low handwashing promotion, socio-economic conditions, and behavioral factors in the area. The study also identified factors influencing good handwashing practices, revealing that mothers with good handwashing practices had better knowledge and attitudes towards handwashing, and access to handwashing facilities. Household water security has also improved mother's handwashing practices, which is in line with findings from West Cameroon [234]. Water-secure mothers were more likely to practice good handwashing due to better motivation and sufficient drinking water. The two-week period prevalence of diarrhea among under-five children was 16%. Children from water-insecure households had significantly higher diarrhea compared to those from water-secure households, which is consistent with findings from Bolivia and West Cameroon [234,259]. This is due to the lack of safe and adequate water, which reduces hygiene practices and forces households to use unsafe water sources, increasing the risk of diarrheal diseases. Other factors significantly associated with diarrheal diseases included children aged 6 -11 months, uncovered water storage containers, wide-mouthed water storage containers, unsafe child's stool disposal practices, and not washing hands with soap after defecation, before preparing food and before feeding a child.

Though the global incidence of diarrhea is on the decline, it remains notably high in the study area. The study indicated an incidence rate of 1.6 episodes per child per year. Children with piped water off-premises experienced more diarrhea episodes compared to those with piped water on-premises. Households without piped water on premises had an incidence rate of 2.2 episodes per child per year, whereas those with piped water on premises had a rate of 1.0 episodes per child per year. This is in agreement with several studies [17,160,161] and yet contrasted with others that found no significant link between off-premises water access and the occurrence of diarrhea [163,164]. The study also examined the relationship between microbiological water quality, per capita water consumption, and risk of diarrhea during the dry and rainy seasons. The analysis utilized data on diarrhea recorded during these seasons, aligning with the times when microbiological water quality and water consumption were measured. The consumption of microbiologically contaminated water was significantly associated with an increased risk of diarrhea during both the dry and rainy seasons. This is consistent with findings from Addis Ababa, Jimma, Eastern Ethiopia and Bangladesh, which revealed the presence of *E. coli* in water is significantly associated with increased risk of diarrhea [62,63,65,274], while various studies found no association between *E. coli* levels in drinking water and diarrhea [67–70].

Lower per capita water consumption, which is less than 20 liters per day, was also significantly associated with a higher risk of diarrhea during the dry season. While it was also linked to an increased risk during the rainy season, this association was not statistically significant. This result is consistent with findings from Eastern Ethiopia, which revealed that consuming less than 20 liters of water per person per day is significantly linked to a higher risk of diarrhea [274]. Several studies have also demonstrated that increased water usage at home lowers the risk of diarrhea [46,47,49,50,52]. However, one study found no significant association between per capita water consumption and the risk of diarrhea [54]. These findings underscore the importance of improving water quantity and microbial water quality at home in reducing diarrheal diseases. The study showed that children aged 24-35 and 36-59 months had a notably lower risk of experiencing diarrhea compared to children aged 0-11 months. It also revealed that factors such as piped water off premises, unsafe disposal of child's stool, eating unheated food, and poor handwashing practices were also significantly associated with higher diarrhea incidence. Conversely, better hygiene practices were found to be protective against childhood diarrhea [282].

6.2. Conclusion

The study found that most households had unreliable drinking water sources. This unreliability was primarily due to the unavailability of water when needed and the inaccessibility of water sources. Household water insecurity was prevalent, and many mothers practiced poor handwashing. The study noted significant differences in per capita water consumption between the dry and rainy seasons, with higher consumption during the rainy season. Despite this increase, many households still consume less than 20 liters per capita per day in both seasons, potentially leading to poor hygiene and an increased risk of diarrheal diseases. It also confirmed that households with piped water on premises had the highest per capita water consumption and lower microbial contamination in both seasons. This underscores the impact of on-premises water access on water quality and the quantity of water available to households. The per capita water usage exhibited a positive correlation with piped water on premises, capacity, and number of water storage vessels in both seasons, while family size showed a negative correlation.

Despite a global decline in diarrhea prevalence and incidence, children living in the selected peri-urban and informal settlement areas remain highly susceptible to frequent diarrhea episodes, leading to substantial morbidity. The incidence of diarrhea is notably higher among under-five children without piped water on premises compared to those with piped water on premises The findings also revealed that the consumption of microbiologically contaminated water in both seasons and lower per capita water consumption during the dry season have significantly increased the risk of diarrhea. However, improved hygiene practices were found to protect against childhood diarrhea.

6.3. Recommendations

The study's findings suggest a holistic approach to address water-related issues and the risk of diarrhea in the study area. By enhancing WASH infrastructure and incorporating behavior change initiatives, it is possible to improve water security, promote good hygiene practices, reduce microbial contamination of water, and the risk of diarrhea. Furthermore, to ensure adequate access to WASH facilities in the study area, it is crucial to address socioeconomic factors by engaging households in various poverty reduction activities. The following recommendations are suggested to various stakeholders.

Hosanna Town Water Supply and Sewerage Enterprise

- Regular monitoring of microbiological water quality at the sources and point of use is highly recommended as it can help identify and address microbial water contamination problems. Additionally, the office should promote household water treatment and provide timely and effective responses to microbial water contamination problems to ensure safe drinking water in the peri-urban and informal settlement areas. The office should also develop strategies to manage water supply efficiently during both the dry and rainy seasons, ensuring that the availability of water and microbial water quality remains consistent throughout the year. Given the high level of microbial contamination of water and water shortages, especially during the dry season, special focus should be given to improving microbial water quality and the availability of water during this period. Additionally, households without piped water on their premises experienced the highest levels of microbial contamination and had a lower per capita water consumption in both seasons and an increased risk of diarrhea. Therefore, it is essential to prioritize enhancing microbial water quality and increasing water availability for those households to mitigate the risk of diarrhea.

- Prioritizing the expansion of new water infrastructures, which includes private and communal taps to areas that lack adequate water services, particularly in peri-urban and informal settlement areas. Additionally, investing in the upgrading or replacement of old water infrastructures, such as pipelines, treatment, and storage facilities, can enhance the safety and reliability of water supplies and improve household water security. The office also has to ensure that the existing water supply systems are well-maintained and provide reliable access to safe and adequate water.
- The office should encourage households to adopt rainwater harvesting as an additional water source, particularly during the rainy season, and offer guidance on the correct methods for collecting and storing rainwater. Ensuring the proper collection and storage of rainwater is crucial for safety.
- The office should establish a regular maintenance plan for water supply infrastructures in order to avert breakdowns and microbial contamination. Given the qualitative study that identified frequent public tap break-downs and slow repairs as major issues with primary water sources, timely repairs should be carried out to minimize any interruptions in the water supply.

Local Health Department

- The local health department should provide training for the community members on the importance of proper water handling and treatment practices, handwashing with soap at key moments, appropriate stool disposal practices, and handling of water storage containers, which could play a role in reducing microbial contamination and risk of diarrhea in the study area.
- The department should introduce specific financial aids to assist low-income households in covering the cost of building, maintaining, and utilizing improved sanitation and basic handwashing facilities, especially in the peri-urban and informal settlement areas.
- The department should implement regular monitoring of diarrhea cases, particularly among children under-five, and ensure rapid support and response to those households living in poor resource settings. The department should train local health extension workers to manage and respond to diarrhea cases efficiently. It should also equip local health centers with essential

materials, including oral rehydration solutions (ORS), antibiotics, and other necessary medical supplies, to efficiently address diarrhea cases, particularly among vulnerable children, and ensure that those in poor resource settings receive the support they need.

- The department should monitor seasonal changes in household water use and microbiological water quality and their impact on childhood diarrhea. Due to high microbial contamination and water shortages, particularly during the dry season, special attention should be given to enhancing microbial water quality and water availability during this time. This could help mitigate the risk of waterborne diseases, including diarrhea. Additionally, given the high levels of microbial water contamination and water shortages in households lacking piped water on premises, it is crucial to focus on improving both the microbial quality of water and its availability in these homes.

Hosanna Town Administration Head Office, Hadiya Zone, and Central Ethiopia Regional State

- Regional and Zonal departments, along with other concerned stakeholders, should design and implement WASH projects that specifically address the needs of low-income households, particularly in the peri-urban and informal settlements. This could include constructing communal water facilities at a reasonable distance, affordable sanitation facilities, and providing subsidies for soap and handwashing stations.
- These departments should also allocate sufficient funds for water infrastructure development and ensure that these resources are prioritized for the most urgent needs.

Ministry of Health

- The ministry should develop and implement comprehensive public health campaigns focusing on the causes, prevention, and treatment of diarrhea, the importance of handwashing with soap, safe child's feces disposal, and safe water handling and treatment. The department should also train local health professionals on the management of diarrhea.
- Increase support for household water treatment. The ministry should provide affordable or subsidized water treatment options for households to reduce microbial contamination and the risk of diarrhea, particularly in poor resource settings
- The ministry should implement regular monitoring of diarrhea cases, particularly among children under-five, and ensure rapid support and response to those households living in

poor resource settings. The department should also build the capacity of local health systems to manage and respond to diarrhea cases efficiently

- The ministry should track seasonal variations in household water use and microbiological water quality and its implications on childhood diarrhea. This involves monitoring changes in water sources and adequacy of water supply, water storage and treatment practices, and microbial contamination levels, which can help develop and promote seasonal preventive measures.
- The ministry should engage with policymakers to prioritize funding and resources for diarrhea prevention and treatment programs, particularly in poor resource settings.

Ministry of Water, Irrigation, and Energy

- The ministry should prioritize investments in expanding water infrastructures, including private taps in peri-urban and informal settlements where access is limited. Moreover, it should provide funding and assistance for small scale, community-led water initiatives to ensure a reliable water supply in poor resource settings.
- The ministry should subsidize water access for low-income households. This involves creating polices that provide financial support or subsidies to low-income households to improve access to piped water on premises, improved sanitation, and hand hygiene facilities. The ministry should also consider linking income-support programs with improvement in water and sanitation infrastructure for targeted assistance.
- The ministry should promote localized water treatment and testing. This involves implementing regular water quality testing in low-resource settings and providing immediate support for water treatment when microbial contamination is detected. This could be achieved by establishing local water testing centers equipped with portable or simple testing kits and involving community members in the testing process by educating them on the importance of water quality and how to use testing kits. This promotes ownership and encourages proactive participation in maintaining water safety.

6.4. Contribution of the study

Overall, the study offers a comprehensive understanding of diarrhea incidence and its risk factors, hygiene practices, seasonal variation in water quantity and microbiological water quality, and their implications on childhood diarrhea, helping to shape targeted interventions. It also guides policymakers and decision-makers on resource allocations, raises awareness, and lays the groundwork for future research work and improvement in water supply and child health. Specifically, the contribution of the study in various aspects is listed below: -

Guidance for policymakers and decisionmakers

- The study provides policymakers and local decision-makers with comprehensive data on diarrhea incidence and its risk factors, particularly in the peri-urban and informal settlements, enabling them to develop targeted interventions. By highlighting areas with poor access to drinking water, sanitation, and a higher risk of contracting diarrhea, the study can help in the allocation of resources to areas most in need, ensuring interventions are targeted and effective. The findings can also be used to advocate funding and resources from international donors, local governments, and non-governmental organizations for improving WASH facilities and practices and for reducing the risk of diarrhea in the study area.
- The daily per capita water consumption data from this study would be helpful for the future planning of water supply for the town and other urban areas across the country. Additionally, it will serve as baseline data nationally, providing evidence-based guidelines concerning water quantity requirements in the country.
- The study can offer evidence-based recommendations for local decision-makers and policymakers to design and implement effective interventions aimed at reducing the risk of diarrhea.

Contribution to scientific knowledge

- The study's longitudinal design highlights patterns in diarrhea incidence over time, allowing to determine causative relationships between risk factors and diarrhea. This approach can reveal previously unexplored or underestimated risk factors, opening up new research and intervention opportunities, particularly in Ethiopia, where such longitudinal studies are scarce.
- The study reveals new insights about how household water use and microbiological water quality change with seasons. These variations are a major public health issue and are crucial

for understanding the potential health risks associated with the quality and quantity of water consumed.

- The study also provides new insights into the relationship between lack of on-premises water access and water consumption and microbiological water quality at the household level. By understanding the impact of lack of on-premises water access on water consumption and microbiological water quality, policymakers can make more informed decisions about how to allocate resources to improve water access, particularly in low-resource settings.
- The research adds valuable knowledge to the field of microbiological water quality and the quantification of domestic water use, particularly in the context of seasonal variations. This information is beneficial for researchers and practitioners working on water-related issues.

Provide Baseline Data for Future Research

- The study's findings serve as a benchmark for comparing future research findings. This makes it possible for researchers to assess changes over time, evaluate the impact of interventions, and monitor progress in reducing the incidence of diarrhea.
- The study establishes a baseline for water consumption and microbiological water quality during the dry and rainy seasons that can be used for longitudinal studies. Future research can build on this data to track changes over time, assess the effectiveness of water management strategies, and evaluate the impact of interventions.
- The water consumption and microbial water quality data can serve as a reference point for comparing water consumption patterns and microbiological water quality across different areas in Ethiopia, contributing to broader studies on global water use trends.
- The study measured water consumption for various purposes, taking into account daily and seasonal variations over a 24-hour recall period. This approach would help develop standardized methods for measuring domestic water use, particularly in developing countries where water meters are not commonly available.

Awareness and Education

- The study's findings can be used to design educational campaigns both locally and nationally that raise awareness about proper stool disposal practices, safe water handling and storage, effective sanitation, and hygiene practices, which could play a role in reducing the risk of diarrhea. The study's result can also inform public health campaigns that focus on the most significant factors identified, enabling the creation of education initiatives that specifically address these factors and promote behaviors that reduce the incidence of diarrhea.

6.5. Future Prospect

The study's findings suggest several directions for future research. Specifically, future studies should employ molecular techniques to pinpoint the exact pathogens responsible for diarrhea, which will enhance our understanding of the causes of diarrheal disease and help develop specific treatment and prevention strategies for the study area. Future studies also have to investigate the temporal relationship between weather conditions of the area such as temperature, precipitation, and humidity, and incidence of diarrhea to understand how these weather conditions correlate with the risk of diarrhea over time. Conducting similar studies in various areas across the country can provide a more complete picture of water consumption patterns and needs, which guides policymakers in developing guidelines on water requirements in the country. The study also suggests water quantity quantification should consider fewer recall periods (less than 24 hours) for reliable water use estimation and also to include water consumed off premises in the analysis to have a full picture of water consumption.

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List of Original Articles

1. **Abiot Abera Aydamo**, Sirak Robele Gari, and Seid Tiku Mereta. Access to Drinking Water, Sanitation, and Hand Hygiene Facilities in the Peri-Urban and Informal Settlements of Hosanna Town, Southern Ethiopia. ***Environmental Health Insights***. 2023; 17, 1-14: https://doi.org/10.1177/11786302231193604

2. **Abiot Abera Aydamo**, Sirak Robele Gari, and Seid Tiku Mereta. Seasonal Variations in Household Water Use, Microbiological Water Quality, and Challenges to the Provision of Adequate Drinking Water: A Case of Peri-urban and Informal Settlements of Hosanna Town, Southern Ethiopia. ***Environmental Health Insights***. 2024;18, 1-15: https://doi.org/10.1177/11786302241238940

3. **Abiot Abera Aydamo**, Sirak Robele Gari, and Seid Tiku Mereta. The nexus between household water insecurity, mother's handwashing practices, and diarrheal diseases among under-five children. ***Journal of Water and Health***. 2024;22(8), 1357-1371: https://doi.org/10.2166/wh.2024.026

4. **Abiot Abera Aydamo**, Sirak Robele Garia, and Seid Tiku Mereta. Incidence of Diarrhea and Associated Risk Factors Among Under-five Children: A Prospective Cohort Study. **Under review in BMC Pediatrics Journal – Springer Nature.**

Annex I. Ethical Consideration

Ethical Consideration

The study was approved by National Research Ethics Review Committee, Ministry of Science and Higher Education (Ref.No.7/2-150/ M 259/35). Permission was obtained from the Hosanna town administration office and the selected three kebeles to visit the study area and select participating households. Written consent was also obtained from all participating households.

Annex II. Data collections tools

Part I. The questionnaire prepared for sampled households in Hosanna Town

This questionnaire intended to obtain data for research which would be helpful to address issues associated with childhood diarrhea in the study area. The overall objective of this study is to assess seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children in the peri-urban and informal settlements in Hosanna town. Therefore, your response is very vital for the success of the study because all the information that you provide determines the analysis and conclusion of the research. Hence, you are kindly requested to give your response by selecting your answer from the given alternative choice or describing your opinion. Please be informed that your responses will be kept confidential. The questionnaire was administered by trained data collectors and filled by the female head of the household.

Thank you so much for your cooperation!!

Instruction: Please put the right sign (√) or circle or write the appropriate information in the boxes or free spaces located in front of each question for the correct answer.

I. Socio-demographic factors

1. Address: Kebele ____ House no. ☐

2. Name of head of the Household ☐ Mother's Name ☐

3. Sex: Male ☐ Female ☐

4. Mother's age: __________________

5. Educational level of Mother:

1. No formal education ☐ 2. 1-8 grades complete ☐ 3. 9-12 grades complete ☐
4. Certificate, diploma ☐ 5. First degree and above ☐

6. Educational level of Father:

1. No formal education ☐ 2. 1-8 grades complete ☐ 3. 9-12 grades complete ☐
4. Certificate, diploma ☐ 5. First degree and above ☐

7. Marital status of mothers/caregivers

1. Single ☐ 2. Married ☐ 3. Divorced ☐ 4. Widowed ☐

8. Occupation of mothers/caregivers

1. Government employee ☐ 2. House wife ☐
3. Self-employed ☐ 4 Other (Specify) ____________

9. House ownership condition:

1. Kebele rental house ☐ 2. Private rental house ☐ 3. Private house ☐

10. Do you share your house with animals? 1. Yes ☐ 2. No ☐

11. Family size: ☐

12. Number of under-five children 1. one ☐ 2. Two ☐ 3. Three ☐ 4. Four ☐

13. Sex of index child (The sex of the child selected for the study)

1. Male ☐ 2. Female ☐

14. Age of index child (The age of the child selected for the study) ---date -------month-----year

15. Average monthly household income (in birr): ☐

16. Religion

1. Orthodox Christian ☐ 4. Catholic ☐
2. Protestant ☐ 5. Other (Specify) _____________
3. Muslim ☐

II. Drinking water sources

1. What is the main source of drinking water for members of your household in the rainy and dry seasons? (NB: There should be separate responses for the rainy and dry season)

1. Piped water into dwelling
2. Piped water to compound, yard or plot
3. Piped to neighbor
4. Public tap/standpipe
5. Borehole/ tube well
6. Protected dug well
7. Unprotected dug well
8. Protected spring
9. Unprotected spring
10. Rainwater collection
11. Bottled water
12. Surface water (river, dam, lake, pond, stream, canal, irrigation channels)
13. Other (specify) __________

2. What is the main source of water used by your household for other purposes, such as cooking and handwashing in the rainy and dry seasons? (NB: There should be separate responses for the rainy and dry season)

1. Piped water into dwelling
2. Piped water to compound, yard or plot
3. Piped to neighbor
4. Public tap/standpipe
5. Borehole/ tube well
6. Protected dug well
7. Unprotected dug well
8. Protected spring
9. Unprotected spring
10. Rainwater collection
11. Bottled water
12. Surface water (river, dam, lake, pond, stream, canal, irrigation channels)
13. Other (specify) _________

3. If your water source is outside your compound, please tell us the estimated distance to the water source in meters ________________ and time taken for the return trip to collect water in minutes __________.

4. Why do you choose to get water from the source mentioned in Q2?

1. Free access
2. Low cost
3. Reliable supply
4. Proximity
5. Good quality of water
6. Other (Specify) _____

5. Is water always available from your main water source?

1. Yes, water is always available
2. No, water is available most of the time
3. No, water is available some of the time
4. No, water is rarely available

6. If your answer is No in Q5, what was the (main) reason you were unable to access sufficient quantities of water when needed?

1. Water is not available from source
2. Water is too expensive
3. Source is not accessible
4. Other (specify) ___________________

7. What do you do during town water supply interruption?

1. Purchase water from piped water sources such as water vendor

2. Collect water from un-piped water sources such as spring
3. Other (Specify) ___________________

8. How many hours per day/number of days per week is water supplied on average? (Applies to piped supplies)

1. 24 hours per day
2. 18-24 hours per day
3. 12-17 hours per day
4. 6-11 hours per day
5. <6 hours per day
6. _______ days per weak
7. Don't know

9. In the past month, for how many days was water from the main source (Q1) unavailable when needed?

1. Number of days ___________
2. Don't know

10. Would you use alternative water sources when there is a shortage of water in your house?

1. Yes
2. No

11. When there is a shortage, what source will be the household's first choice?

1. Water vendor
2. Spring
3. Hand dug well
4. River
5. Other (Specify) __________________________

12. Is the water supplied from your main source had acceptable quality? If unacceptable, select the main reason.

1. Yes, acceptable
2. No, unacceptable taste
3. No, unacceptable color
4. No, unacceptable smell
5. No, contains materials
6. No, other (specify) __________
7. Don't know.

13. Describe the nature of your alternative water sources.

1. Only one source used all year round (01 Source)
2. Two sources used all year round (Source 01 + another)
3. Second source used only in dry season
4. More than two sources used all year round
5. More than two sources used in dry season

14. Do you face water shortage? 1. Yes 2. No

15.If your answer is yes in Q 14, which periods of a year do you face maximum water shortage?

1. Dry season
2. Rainy season
3. Always

16. If you don’t have water on-premises, what are the challenges to the provision of water at the household level?
    1. Economic factors of the households
    2. Economic factors of the government
    3. Institutional factors such as land tenure issues
    4. Spatial factors such as households may be located on the periphery of the city
    5. Political factors such as corruption
    6. Informational factors such as lack of data for decision-makers
    7. Social factors such as poor participation, discrimination, and exclusion from government policy development and implementation

III. Water collection, storage and treatment

1. How long does it take to go there, get water, and come back?
    1. Water on-premises
    2. < 15minutes
    3. 15 - 30minutes
    4. 30 – 60 minutes
    5. > 60 minutes
2. Who usually goes to this source to fetch the water for your household? *Probe:* Is this person under age 15 years? What sex? Circle the code that best describes this person.
    1. Adult woman (> 15 years)
    2. Adult man (> 15 years)
    3. Female child (under 15 years)
    4. Male child (under 15 years)
3. How many trips did that person make per week?
    1. Number of times _____________ 2. Don’t know
4. Methods used to transport water?
    1. Walking 2. Cart-hand-drawn 3. Cart-animal
    4. Vehicle 5. Other (Specify) ___________________
5. Total amount of water you collect a day in liters ________________
6. What type of container are you using for collecting water?
    1. Jerry can 2. Bucket 3 Clay-pot

4. Plastic bottles 5. Other (Specify) ____________________

7. Size of container used for carrying water to the house

1. < 5 liters 2. 5-10 liters 3. 11-15 liters 4. 16-20 liters

5. 21-25 liters 6. 26-30 liters 7. 31-35 liters 8. > 35 liters

8. Do you store water in the house? 1. Yes 2. No

9. If your answer is Yes in Q 8, what is the duration of the water stored in the home?

1. One day 2. Two days 3. Three Days

4. 4 -6 days 5. One-week 6. More than a week

10. Where do you store water?

1. Inside house 2. Outside house 3. In Kitchen

4. Overhead storage tank 5. Other (Specify) ____________________

11. How many storage containers are you using to store water currently?

1. Number of containers_____________ total volume in liters______________

12. What type of container do you use to store drinking water in the house?

1. Jerry can 2. Bucket 3. Barrel

4. Clay-pot 5. Overhead storage tank 6. Plastic bottles

7. Other (Specify) ____________________

13. How do you describe the mouth size of water storage containers? (This will be confirmed by observation; a wide-mouthed container with an opening of ≥ 6 centimeters, whereas a narrow-mouthed container with an opening of < 6 centimeters.)

1. Wide mouthed
2. Wide and narrow
3. Narrow mouthed

14. Does the storage container have a cover? 1. Yes 2. No

15.What is the mode of taking drinking water from storage containers?

1. Pouring 2. Dipping

16. If your answer is dipping in Q15, what type of vessels used for retrieving water from a water storage container?

1. Without handle 2. With and without handle 3. With handle

17. What is the volume/size of the storage vessel?

1. < 5 liters 2. 5-10 liters 3. 11-15 liters 4. 16-20 liters

5. 21-25 liters 6. 26-30 liters 7. 31-35 liters 8. > 35 liters

18. Does the vessel have a cover? 1. Yes 2. No

19. At present is the vessel covered? 1. Yes 2. No

20. How often do you clean the vessel used to draw water?

1. Daily
2. More than once a week
3. Weekly
4. More than once a month
5. Less than once a month
6. Every 6 months
7. Once a year
8. Rarely
9. Never
10. Don't know

21. Where do you place vessels used for retrieving water from a storage container?

1. Floor 2. Table/ chair 3. In cupboard

4. On vessel 5. Other (Specify) ___________________

22. How many times a week do you collect water?

1. Once per week 2. Twice per week 3. Three times per week

4. 4-5 times per week 5. Weekly 5. Every two weeks

23. How often do you clean your water storage container?

1. Daily
2. More than once a week
3. Weekly
4. More than once a month
5. Less than once a month
6. Every 6 months
7. Once a year
8. Rarely
9. Never
10. Don't know

24. Do you treat your water in any way to make it safer to drink?

1. Yes 2. No 3. Don't know

25. If your answer is Yes in Q24, what do you usually do to the water to make it safer to drink? Anything else?

1. Boil
2. Add bleach/chlorine
3. Add chemicals
4. Strain it through a cloth
5. Use a water filter (ceramic, sand, etc.)
6. Solar disinfection
7. Let it stand and settle
8. Other (specify) ______________________
9. Don't know

26. If you use chemical disinfectant, which one?

1. Water guard 2. Bishan gari 3. Other (specify) ________________

IV. Domestic Water Use

1. Please tell us the total amount of water used in liters excluding water used for agricultural purposes in a single day ________________
2. Please tell us the total amount of water used in liters excluding water used for agricultural purposes in a week ____________________
3. Please tell us the amount of water used in liters for the following domestic activities in a week.

a. Drinking ____________in liters

b. Cooking ____________in liters

c. Handwashing ______________ in liters

d. Water used for washing clothes inside home ____________in liters

e. Other domestic purposes ___________ in liters

f. All domestic uses excluding water used for agriculture __________in liters

4. Where do you frequently wash clothes?

1. At water source
2. Home
4. Laundry
5. Home and laundry

3. Home and at water source 6. Home, at water source, and laundry

5. Where did you wash your clothes last week?

1. At water source 4. Laundry
2. Home 5. Home and laundry
3. Home and at water source 6. Home, at water source, and laundry

V. Sanitation and Hygiene

1. Do you have access to latrine facility 1. Yes 2. No
2. **If your answer is yes in Q1, what kind of toilet facility do members of your household usually use?** *If "flush" or "pour flush" probe:* Where does it flush to? Flush or pour flush

   1. Flush to septic tank 7. Twin pit without slab
   2. Flush to pit latrine 8. Bucket
   3. Flush to don't know where 9. Container based sanitation
   4. Pit latrine with slab 10. No facilities or bush or field
   5. Pit latrine without slab/open pit 11. Other (specify) ______________
   6. Twin pit with slab
3. Do you share this facility with others who are not members of your household?

   1. Yes 2. No
4. Where is this toilet facility located?

   1. In own dwelling 2. In own yard / plot 3. Elsewhere
5. If shared, how many households in total use this toilet facility, including your own household?

   1. Number of households __________ 2. Don't know
6. If you do not have a latrine, what is your primary means of disposing of waste?

   1. Public toilet 3. Share with neighborhood
   2. Open defecation 4. Other (Specify) _______________
7. The last time your child (Index child) passed stools, what was done to dispose of the stools?

   1. Child used toilet/latrine 6. Left in the open
   2. Put/rinsed into toilet or latrine 7. Used as manure
   3. Put/rinsed into drain or ditch 8. Other (specify) ____________

4. Thrown into garbage
5. Buried
9. Don't Know

8. How do you dispose of household water used for cooking, laundry and bathing?
    1. Sink/drain connected to sewer
    2. Sink/drain connected to septic tank
    3. Sink/drain connected to pit
    4. Sink/drain connected to open drain or open ground
    5. Disposed directly to open ground or water body
    6. N/A (cooking, laundry and bathing is done away from the household)
    7. Don't know
9. Where does your septic tank discharge to?
    1. To a leach field, soak pit
    2. To a sewer
    3. To an open drain
    4. Other (specify) __________
    5. Don't know
10. How does your household usually dispose of garbage?
    1. Collected by formal service provider
    2. Collected by informal service provider
    3. Disposed of in designated waste disposal area
    4. Disposed of within household yard or plot
    5. Buried or burned
    6. Disposed of elsewhere
    7. Don't know
    8. Other (Specify) ____________________
11. Does your sanitation facility leak or overflow wastes at any time of year? Probe for problems during the rainy season or floods.
    1. No, never
    2. Yes, sometimes
    3. Yes, frequently
    4. Don't know
12. Has your pit latrine or septic tank ever been emptied?
    1. Yes 2. No
13. The last time it was emptied, where were the contents emptied to? Was it removed by a service provider?

Removed by service provider

1. To a treatment plant
2. Buried in a covered pit
3. To don't know where

Emptied by household

1. Buried in a covered pit
2. To uncovered pit, open ground, water body or elsewhere
3. Other (specify) ______________
4. Don't know

14. Can you please show me where members of your household most often wash their hands?

Fixed facility observed (sink/tap)

1. In dwelling
2. In yard/plot

Mobile object observed

1. Bucket/jug
2. No handwashing place in dwelling/yard/plot
3. No permission to see
4. Other reason (specify) ________________

15. Is water available at the place for handwashing?

1. Yes, it is available 2. No, it is not available

16. Is soap or detergent available near handwashing facility

1. Yes, it is available 2. No, it is not available

17. Do you have soap in the house? 1. Yes 2. No

18. How frequently do you wash your hands with water and soap at five key moments (Mothers/caregivers)?

1. No washing with soap 2. less often 3. Often
4. Very often 5. Uncertain

19. Is handwashing facility available near the toilet? 1. Yes 2. No

VI. Mother's handwashing practices, knowledge, attitudes and childhood diarrhea

Practices

When do you wash your hands? (Handwashing at critical times**)**

1. Do you wash your hands after defecation?

    1. Yes, with soap and water   2. Yes, with water only   3. Do not wash

2. Do you wash your hands after cleaning a child's anus who had defecated

    1. Yes, with soap and water   2. Yes, with water only   3. Do not wash

3. Do you wash your hands before preparing food

    1. Yes, with soap and water   2. Yes, with water only   3. Do not wash

4. Do you wash your hands before feeding a child

    1. Yes, with soap and water   2. Yes, with water only   3. Do not wash

5. Do you wash your hands before eating food

    1. Yes, with soap and water   2. Yes, with water only   3. Do not wash

6.Do you have a handwashing facility near the toilet facility? (It will be confirmed by observation)

    1. Yes   2. No

7.If your answer is Yes in Q6, which material are available in a handwashing facility? (It will be confirmed by observation)

    1. Water and soap   2. Water only   3. None

<u>Knowledge</u>

1. Have you ever heard about handwashing at five critical times?   1. Yes   2. No
2. Washing hands with soap and water after defecation, before preparing food, before feeding a child, before eating food, and after cleaning a child's anus who had defecated prevent childhood diarrhea? (Handwashing at critical times prevents childhood diarrhea)

    1.Yes   2. No

3. Long nails can harbor and easily transfer disease-causing microorganisms

    1.Yes   2. No   3. I don't know

4. Is clean water used for handwashing?

    1. Yes   2. No

5. How much time do you used to wash your hands?

1. < 10 sec. 2. < 19 sec. 3. 20-30 sec. 4. >30 sec.

6. Mothers have a significant role in the hand hygiene of their children

1.Yes 2. No 3.I don't know

7. Why do you wash your hands? (Reasons for washing hands)

1. Prevents diseases.
2. Appears good
3. Hygiene
4. Because everyone does
5. Other (Specify) ________________

8.Hands not washed properly can transfer disease-causing microorganisms

1.Yes 2. No 3.I don't know

9.How do you wash your hands? (Handwashing occasion)

1. Washing one hand 2. Washing both hand 3. Do not wash hands

10.Handwashing with water only can help prevent infectious diseases such as diarrhea.

1.Yes 2. No 3.I don't know

<u>Attitudes</u>

1.Washing hands with soap and water after defecation, before preparing food, before feeding a child, before eating food, and after cleaning a child's anus who had defecated prevents childhood diarrhea?

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

2.Washing hand with water only is enough to prevent childhood diarrhea.

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

3.A handwashing facility which contains water and soap need to be available near the toilet.

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

4.Nail cleanliness is significantly important to prevent infectious diseases such as diarrhea.

. 1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

5.Inadequate quantity of water in the households has a direct effect on the frequency of handwashing practices.

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3.Neutral

6. Having good knowledge of proper handwashing procedures helps for better handwashing practice.

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

7.Presence of a handwashing facility near the toilet is vital to prevent disease.

1. Strongly agree 4. Disagree
2. Agree 5. Strongly disagree
3. Neutral

VII. Childhood diarrhea and other child-related behavioral factors

1.Please tell us the name of your child? (Name of the child selected for the study or index child) _____________________

2.What is the birthday of index child? __________________________________

3.What was the duration of breastfeeding?

1.≤ 6 months 3. 12–23 months

2. <12 months 4. >24 months

4. What was the duration of exclusive breastfeeding?

1. < 6 months 2. ≥ 6 months

5.When did an index child starting supplementary food?

1.Before six months 2. After six months

6.What is the current feeding status of index child?

1.Exclusive 2. Partial 3. Food only

7. Vaccination status of the child

1. Not vaccinated 2. Fully vaccinated 3. Partially vaccinated

8. Has the index child experienced diarrhea within the past two weeks?

1. Yes B. No

9.Has any member of your household other than the index child had diarrhea in the past 2 weeks? 1. Yes 2. No

10.When your child experiences diarrhea, what is the first thing you do?

1. Go to health center 3. Do nothing

2. Treat/manage the illness at home 4. Other (Specify) __________

11.What are the causes of diarrhea?

1. Drinking of contaminated water 4. Over eating

2. Poor sanitation and hygiene 5. Don't know

3. Eating unheated food 6. Other (Specify) _________

12.Does the index child eat unheated food? 1. Yes 2. No

13.Does the index child eat uncooked vegetables? 1. Yes 2. No

14.Have you got any training/education on the causes, consequences, or treatment of diarrhea?

1. Yes 2. No

15.If your answer is yes in Q 14, who gave you the training/education?

1.Govt organization such as Health center & Hospital 3. Media (Radio and Television)

2. NGOs 4. Other (Specify) __________

Part II. Observational Checklist

Observational checklist for assessing WASH facilities and practices

s/n	Items to be observed	Remark		
1	Type of water sources			
2	Is the water storage container covered?	Yes	No	
3	Is the water storage container clean? (Inside)	Clean	Unclean	
4	Mouth size of water storage containers			Narrow-mouthed, wide-mouthed or both
5	Number and volume of water storage containers			
6	Presence of feces on the floor	Yes	No	
7	Method of taking water from water storage containers	Dipping	Pouring	
8	Presence of garbage in the compound	Yes	No	
9	Availability of fixed/mobile handwashing facility in the compound	Yes	No handwashing facility	
10	Availability of water at the place for handwashing	Yes	No	
11	Availability of soap or detergent at the place for handwashing	Yes	No	
12	Availability of fixed/mobile handwashing facility with soap and water in the toilet or near the toilet	Yes	No handwashing facility	

Part III. Focus Group Discussion

Name of the facilitators ____________________Number of the participants _______________

Specific name of the area _____________________ GPS location _______________________

Data _______________________________________

Start time ___________________ End time_____________________

The number and type of questions raised during the focus group discussions.

1. What do you think about the current access to water supplies in peri-urban and informal settlements of Hosanna town? What type of water source does the community use for domestic purposes? (Improved, unimproved water source) Who is providing the water services? How do you see the level of service? (Adequate or inadequate, why)

2. Do you feel the quantity of water you collect fulfills your daily water requirement? If not, which strategy are you using in fulfilling your water needs?

3. What are the major problems with your primary water sources?

4. Do your community members participate in the planning and implementation of the water supply project?

5. How do you see government effort in the provision of adequate and safe water for households? (Adequate or inadequate, why)

6. How do you see the piped house and yard water connection in your community? If these connections are insufficient, what are the main barriers to providing adequate water at the household level?

7. What experience do you have with water shortage, water quality, and its implications on child health? (i.e childhood diarrhea)

8. What is your suggestion to improve the existing water supply system so that you can fulfill your water needs and improve your child's health?

Part IV. Key Informant Interview

Addis Ababa University

Ethiopian Institutes of Water Resource

Department of Water and health

Name of Key Informant: ____

Interview Date: ____

Specific Area of Informant's Specialization: ________________________________

Questions

1. What do you think about the current access to water supplies in peri-urban and informal settlements of Hosanna town? Who is providing the water services? How do you see the level of service? (Adequate or inadequate, why)
2. What measures is your institution currently considering to address any existing gaps in water service provision (if they do exist!)? Are they adequate, if not why?
3. What is your opinion on community involvement in planning and implementing water supply projects in the peri-urban and informal settlements of the town? What are your thoughts on private sector participation in this process?
4. What proportion of households are connected with piped water on-premises in the town? If all are not connected, what are the main barriers to providing adequate water at the household level, particularly in the peri-urban and informal settlements of the town?
5. How would you describe the connection between insufficient household water supply and child health? (i.e., childhood diarrhea)
6. What challenges has your institution encountered in improving water supply systems, particularly in the peri-urban and informal settlement areas?
7. Which alternative mechanisms do you think are appropriate to improve the existing water supply system so that households get adequate and safe water and improve their child's health?

Part V. A checklist for an observational spot-check method

During an observational spot-check visit, the following information was collected.

S/n	Things to be observed	Remark	
1	Presence of feces on the ground	Present	Absent
2	Cleanliness of the toilet	Clean	Unclean
3	Handwashing facility with soap and water in the toilet or near the toilet	Present	Absent
4	Presence of large number of flies around the house	Present	Absent
5	Stagnant water around the house	Present	Absent
6	Garbage in the living area	Present	Absent
7	Cleanliness of mother's hands	Clean	Unclean
8	Cleanliness of child's hands	Clean	Unclean
9	Cover food	Yes	No
10	Storage conditions of food	Safe	Unsafe
11	Cleanliness of the kitchen.	Clean	Unclean
12	Cleanliness of dishes	Clean	Unclean
13	Cover drinking water containers	Yes	No
14	Cleanliness of water storage container (Inside)	Clean	Unclean

Part VI. Water sampling, transporting, and laboratory analysis procedures

Water sampling, transport, and laboratory analysis were conducted according to the WHO and AMPH water sampling procedures and analysis.

Part I: Water sampling using a sterile Whirl-Pak bag from a tap and standpipes for *E. coli* analysis

- Thoroughly wash your hands with soap and water prior to collecting the water sample
- Remove from the tap any attachments that may cause splashing
- Use a clean cloth to wipe the outlet to remove any dirt
- Sterilize the tap for a minute with an alcohol-soaked cotton-wool swab.
- Allow the water to run for 1-2 minutes
- Write the sample code on the sterile Whirl-Pak bag
- Open the sterile Whirl-Pak bag carefully to avoid touching the inside. The sterile Whirl-Pak bag should be labeled before starting the sample collection.
- Hold the bag by the edges and position it under the running tap
- Allow the water to flow directly into the bag without touching the inside of the bag
- Fill the bag with a 200 ml water sample and add 4-5 drops of sodium thiosulfate into a bag to neutralize the effect of any chlorine present in the sampled water
- A small airspace should be left to make shaking before analysis easier
- Once the bag is filled, carefully close the bag by twisting the top of the bag
- All water samples collected must be promptly placed in a cold box with ice packs and transported to the lab.

Part II. Water sampling using a sterile Whirl-Pak bag from reservoirs for *E. coli* analysis

- Thoroughly wash your hands with soap and water prior to collecting the water sample
- Write the sample code on the sterile Whirl-Pak bag
- Open the sterile Whirl-Pak bag carefully to avoid touching the inside. The sterile Whirl-Pak bag should be labeled before starting the sample collection.
- Use a sterile dipper or container to collect the water from the reservoir and then pour it into the sterile Whirl-Pak bag (a 200ml water sample).

- Then, add 4-5 drops of sodium thiosulfate into a bag to neutralize the effect of any chlorine present in the sampled water
- A small airspace should be left to make shaking before analysis easier
- Once the bag is filled, carefully close the bag by twisting the top of the bag
- All water samples collected must be promptly placed in a cold box with ice packs and transported to the lab.

Part III. Water sampling using a sterile Whirl-Pak bag from storage containers for *E. coli* analysis

- Thoroughly wash your hands with soap and water prior to collecting the water sample
- Disinfect the end and side of the covered water storage container outlet with an ignited alcohol-soaked cotton-wool swab or another disinfecting agent
- Write the sample code on the sterile Whirl-Pak bag
- Open the covering
- Allow the stored water to run for 1-2 minutes
- Open the sterile Whirl-Pak bag carefully to avoid touching the inside. The sterile Whirl-Pak bag should be labeled before starting the sample collection.
- Pour a 200ml of stored water into the bag. Avoid any direct contact between the bag and the stored water source to prevent contamination.
- Add 4-5 drops of sodium thiosulfate into a bag to neutralize the effect of any chlorine present in the sampled water
- A small airspace should be left to make shaking before analysis easier.
- Once the bag is filled, carefully close the bag by twisting the top of the bag
- All water samples collected must be promptly placed in a cold box with ice packs and transported to the lab.

Part IV: Transporting water sample to the laboratory

- Water samples should be placed in a lightproof insulated box containing melting ice or ice-packs with water to ensure rapid cooling
- All water samples collected must be promptly placed in a cold box with ice packs, transported to the lab, and analyzed within four hours of collection.

Part V: Laboratory Procedures for membrane filtration method

- Ensure that all equipment and materials are sterile
- Place the membrane filter on the support screen of the membrane holder
- Attach the funnel securely to the filtration unit
- Then, pour a 100 ml of water sample into the funnel
- Connect the hand vacuum pump to the filtration unit
- Use the pump to create a vacuum and commence the filtration
- Once the entire sample has been filtered, disconnect the vacuum pump and take the filter funnel off the rubber base. The membrane filter is now ready to be removed and placed in the petri dish containing growth medium.
- Open a sterile Petri dish and place a sterile absorbent pad in it.
- Add M-Lauryl Sulfate Broth medium to saturate the pad; remove excess broth.
- Carefully use a sterile forceps to remove the membrane filter from the holder
- Place the membrane filter into the Petri dish containing a sterile absorbent pad saturated with M-Lauryl Sulfate Broth. Make sure that no air bubbles are trapped between the absorbent pad and the filter, and gently press the membrane filter on to the growth medium to ensure good contact.
- Invert the agar petri dish, and incubate the plate for 4 hours at 30˚C followed by 14 hours at 44˚C for *Escherichia coli*
- *E. coli* appears as yellow colonies and is quantified in terms of colony-forming units per 100ml of the water sample.

Part VII. Questionnaire for collecting the daily water consumption during the dry and the rainy seasons

Tabel A. Questionnaire for collecting the daily per capita water consumption over a one-week period for households connected with piped water on premises during the dry and rainy seasons.

S/N	**Activity**	Water consumption in liters per day							Family size
		Day1	D2	D3	D4	D5	D 6	D7	
A. HHs- Piped water on-premises	The amount of water filled the water containers in liters on the previous day/24 Hr								
	Used water from storage containers								
	Unused water from storage containers								
	Directly used water in minutes/Hr from the tap.								
1	Water used for drinking								
2	Water used for handwashing								
3	Water used for washing clothes inside home								
4	Water used for cooking								
5	Water used for other domestic purposes (non-agricultural)								
	Total water used in liters on the previous day								

Tabel B. Questionnaire for collecting the daily per capita water consumption over a one-week period for households connected with piped water off premises during the dry and rainy seasons.

S/N	**Activity**	Water consumption in liters per day							Family size
		Day 1	D2	D3	D4	D5	D 6	D7	
B. HHs-Piped water off-premises	The total amount of water collected in liters for households use on the previous day/24 Hr.								
	Used water								
	Unused water								
1	Water used for drinking								
2	Water used for handwashing								
3	Water used for washing clothes inside home								
4	Water used for cooking								
5	Water used for other domestic purposes (non-agricultural)								
	Total water used in liters on the previous day								

Part VIII. Questionnaire for collecting diarrhea incidence on a biweekly basis over a one-year period.

Name of index child __________________Sex _______Mother's/caregiver's Name_________

1. Has the index child experienced diarrhea within the past two weeks?

   1.Yes 2. No

   If yes, what is the number of days with diarrhea ____________

   If it persisted for two or more days, how many consecutive days did it occur? _____________

   If the episodes were not consecutive, what was the number of days between them? _________

2. Has any member of your household other than the index child had diarrhea in the past 2 weeks? 1. Yes 2. No

Part IX. Sanitary Inspection Forms

I. Type of Facility: PIPED WATER			
1	General Information	Zone	
		Area	
2	Code Number		
3	Date of Visit		
4	Water samples taken? ______________	Sample Nos.	
	II Specific Diagnostic Information for Assessment (Identify the sample sites where risks were found)		
		Risk	
		Yes	No
1	Are there any leaking tap stands?		
2	Is there surface water accumulating around any tap stand?		
3	Is the area uphill from any tap stand eroded?		
4	Are there any pipes exposed near a tap stand?		
5	Is there human excreta within 10 meters of any tap stand?		
6	Is there a sewer within 30 meters of any tap stand?		
7	Has there been any disruption in the water supply at any tap stand in the past 10 days?		
8	Are there any signs of leaks in the main pipes in the Parish?		
9	Have there been any reports of pipe breaks from the community in the past week?		
10	Is the main pipe exposed at any location in the Parish?		
Total Score of Risks out of 10 ________ Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low III Results and Recommendations: The following key risk points were observed: (list nos. 1-10) Signature of Health Inspector/Assistant: Comments:			

Annex III. Participant Information Sheet (For longitudinal study)

Title of the research: The role of water quantity and microbiological quality on the incidence of diarrheal disease among under-five children in Hosanna town, Central Ethiopia.

Name of the researcher: Abiot Abera (PhD candidate in Water and Health)

Information provided for the study participants and their willingness to participate in the study

Hello! I am here to conduct research on childhood diarrhea and the problems associated with it. This study tries to assess seasonal variations in household water use, microbiological water quality, and their implications on the incidence of diarrheal disease among under-five children in the peri-urban and informal settlements in Hosanna town. Your home is selected randomly from other houses. Your participation in the research provides valuable information and helps me to understand the potential problems associated with water quantity, quality, and childhood diarrhea. The information you provide will help address these problems, ultimately enhancing child health in the study area. You can also benefit from the study by getting advice about diarrhea treatment if your child is diagnosed with diarrhea during the data collection period. You are guaranteed that your family will be free from any health risks, stress, or discomfort during the data collection process. Hence, your genuine response is very vital for the success of the study because all information that you provide determines the analysis and conclusion of the research. The study is longitudinal with a one-year follow-up period. Information on diarrhea will be collected from the infant's mother or caregiver with a two-week recall period for one year. Besides, water quantity and microbial water quality will be measured during the dry and rainy seasons. The information you provide will be confidential, and no information will be used in any way that exposes your identity. Your participation is voluntary, and you are free to withdraw from study at any time. All information mentioned in the information sheet will be explained to you to your satisfaction, and finally, if you have the willingness to participate in the study, you will be asked to sign a consent form. Thank you for taking the time to listen to the explanations of the information mentioned in the Participant information sheet and considering taking part in the study.

Annex IV. Participant Information Sheet (For cross sectional study)

Title of the research: The role of water quantity and microbiological quality on the incidence of diarrheal disease among under-five children in Hosanna town, Central Ethiopia.
Name of the researcher: Abiot Abera (PhD candidate in Water and Health)

Information provided for the study participants and their willingness to participate in the study

Hello! I am here to conduct research on childhood diarrhea and the problems associated with it. This study tries to assess the association between household water insecurity, mother's handwashing practices, and childhood diarrhea in the peri-urban and informal settlements of Hosanna town. Your home is selected randomly from other houses. Your home is selected randomly from other houses. Your participation in the research provides valuable information and helps me to understand the potential problems associated with water quantity, quality, and childhood diarrhea. The information you provide will help address these problems, ultimately enhancing child health in the study area. You can also benefit from the study by getting advice about diarrhea treatment if your child is diagnosed with diarrhea during the data collection period. You are guaranteed that your family will be free from any health risks, stress, or discomfort during the data collection process. Hence, your genuine response is very vital for the success of the study because all information that you provide determines the analysis and conclusion of the research. This study is cross-sectional, and I will gather all necessary data through a structured questionnaire and observations. The information you provide will be confidential, and no information will be used in any way that exposes your identity. Your participation is voluntary, and you are free to withdraw from study at any time. All information mentioned in the information sheet will be explained to you to your satisfaction, and finally, if you have the willingness to participate in the study, you will be asked to sign a consent form. Thank you for taking the time to listen to the explanations of the information mentioned in the Participant information sheet and considering taking part in the study.

Annex V. Study participants consent form

I ________________________________ give consent to my participation in the research.

Title of the research: The role of water quantity and microbiological quality on the incidence of diarrheal disease among under-five children in Hosanna town, Central Ethiopia.

In giving consent, I acknowledge that:-

1. I approve that I have read and understood the information mentioned in the information sheet of the above study
2. I have had opportunities to ask any questions about the research, and all my questions have been answered adequately.
3. I understand that the information I share will remain confidential, and no information will be used in any way that exposes my identity.
4. Given the details in the information sheet, I have chosen to join the study of my own free will, and I am not under any obligation to take part in this study.

All information mentioned in the information sheet has been explained to me to my satisfaction, and I agree to take part in the above study.

Signature ______________________ Kebele ________________________

Date: _________________________

Annex VI. Supplementary Materials for Chapter Three

Supplementary Table 3.1**.** Statistical summary of temperature, turbidity, pH, and *E. coli* in water sources and point of use water in Hosanna town

Variables	Dry season					Rainy season					
	Min	Max	Mean	SD	95% CI	Min	Max	Mean	SD	95% CI	*P* value (2-tailed)
Household stored water (n=440 for both seasons)											
No. of *E. coli* CFU/100ml	0	310	14.7	37.0	-	0	284	8.3	27.9		<0.001**
pH	6.3	8.8	7.8	0.4	7.71-7.81	6.2	8.6	7.5	0.4	7.48-7.58	<0.001**
Temp. (^{0}C)	15.2	23.5	19.0	1.8	18.75-19.24	15.1	20.3	17.3	1.3	17.15-17.50	<0.001**
Turb. (NTU)	0	22	1.2	3.3	-	0	28	4.4	4.0	-	<0.001**
Storage reservoir (n=6 for both seasons)											
No. of *E. coli* CFU/100ml	0	0	0	0	-	0	0	0	0	-	-
pH	7.2	7.6	7.4	0.2	6.91-7.93	7.5	7.6	7.5	0.1	7.40-7.63	0.4599
Temp. (^{0}C)	18.7	19.6	19.2	0.5	18.05-20.29	15.9	19.4	18.2	2.0	13.28-23.05	0.4901
Turb. (NTU)	0	0	0	0	-	0	2	1.33	1.2	-	0.5930
Point of water collection (n=6 for both seasons)											
No. of *E. coli* CFU/100ml	0	0	0	0		0	0	0	0	-	-
pH	7.2	7.6	7.5	0.3	6.74-8.19	7.2	7.5	7.3	0.2	6.92-7.77	0.4701
Temp. (^{0}C)	18.2	18.5	18.4	0.2	17.99-18.75	15.9	16.6	16.1	0.4	15.13-17.14	0.0107*
Turb. (NTU)	0	0	0	0	-	0	2	0.7	1.2	-	0.3173

** – significant at *P*-value < 0.001
* – significant at *P*-value < 0.05
The microbial water quality and turbidity of stored water, storage reservoirs, and point of collection were analyzed using the Wilcoxon signed-rank test.
Other physicochemical parameters were analyzed using the paired-t test
0 CFU/100ml means that there is no detectable *E. coli* in the water. The detection limit of the Photometer is 0 to 400 NTU. The water turbidity value is 0 when the Photometer cannot measure any scattering, and this can happen if the water is very clear**.**

Supplementary Table 3.2. Risk levels of fecal contamination of drinking water in Hosanna town

Variables	Dry season		Rainy season	
Risk level (*E. coli* no. (CFU/100ml))	Frequency	Percentage	Frequency	Percentage
Low risk (<1)	125	56.8	144	65.5
Medium risk (1-10)	47	21.4	45	20.4
High risk (11-100)	41	18.6	27	12.3
Very high risk (>100)	7	3.2	4	1.8

Supplementary Table 3.3. Statistical comparison of per capita water consumption between households connected with piped water on and off-premises in Hosanna town

Variables	Per capita water consumption during the dry season (L/C/D)			*P*-value (2- tailed), 95% CI	Per capita water consumption during the rainy season (L/C/D)			*P*-value (2- tailed), 95% CI
	N	Mean	SD	< 0.001*	N	Mean	SD	< 0.001*
HHs with piped water on premises	144	23.1	4.0	22.42 - 23.74	144	23.6	4.4	22.92 - 24.36
HHs with piped water off premises	144	15.8	3.8	15.14 - 16.41	144	17.0	4.2	16.30 - 17.67

* – significant at *P*-value < 0.001

Supplementary Table 3.4. Statistical comparison of bacteriological contamination of water among households connected with piped water on and off-premises in Hosanna town

Variables	Water contaminated *with E. coli* (Dry season)		Z-value, P-value	Water contaminated with *E. coli* (Rainy season)		Z-value, P-value
	Yes (%)	No (%)		Yes (%)	No (%)	
HHs connected with piped water on premises (n=220 for both seasons)	28 (25.5)	82 (74.5)	5.908, <0.001*	23 (20.9)	87 (79.1)	4.485, <0.001*
HHs connected with piped water off premises (n=220 for both seasons)	67 (60.9)	43 (39.1)		53 (48.2)	57 (51.8)	

* – significant at *P*-value < 0.001

Annex VII. Supplementary Materials for Chapter Four

Supplementary Table 4.1. Prevalence of diarrhea, household water insecurity, handwashing practices, and environmental characteristics related to study participants

Variables	Category	Frequency	Percentage
Diarrhea in the past 2 weeks (Under-five children)	No	356	84
	Yes	68	16
Diarrhea in the past 2 weeks in other household members	No	391	92.2
	Yes	33	7.8
Water security status	Water insecure households	291	68.6
	Water secure households	133	31.4
Handwashing with soap at five critical times	Poor	245	57.8
	Good	179	42.2
Average prevalence of Handwashing at five critical times	Soap and water	149	35.1
	Water only	257	60.7
	Don't wash hands	18	4.2
Knowledge of handwashing	Poor	118	27.8
	Good	306	72.2
Attitude towards handwashing practices	Negative	100	23.6
	Positive	324	76.4
Main water sources	Unimproved water sources	60	14.2
	Improved water accessible off premises	257	60.6
	Improved water accessible on premises	107	25.2
Time taken to fetch water for return trip in minutes	<30	196	46.2
	≥30	228	53.8
Sanitation facilities	No facility	24	5.7
	Unimproved	204	48.1
	Improved	196	46.2
Presence of handwashing facility	No	175	41.4
	Yes	248	58.6
Presence of water and soap near HWF	No	368	87
	Yes	55	13
Child's stool disposal practices	Unsafe	215	50.7
	Safe	209	49.3
Feces observed in the compound	No	299	70.5
	Yes	125	29.5
Solid waste management	Inappropriate	246	58
	Appropriate	178	42
Covering of water storage containers	No	246	58
	Yes	178	42
Duration of water storage	≤3 days	113	26.7
	> 3 days	311	73.3

HWF – Handwashing Facilities

Supplementary Table 4.2**.** Household Water Insecurity Experiences (HWISE) Scale for measuring water insecurity in Hosanna town, central Ethiopia.

S/n	Label for each item	Item
1	Worry about inadequacy of water supply	How often in the past month (last 4 weeks) have you or someone in your household been worried about not having enough water to meet all your household needs?
2	Interruption of water supply	How often in the past month has your main water source been interrupted or limited (i.e. due to low water pressure, less water than expected, or a river dried up?)
3	Inability to wash clothes	How often in the past 4 weeks have you been unable to wash clothes due to water-related issues?
4	Change of schedules to use water	How often have you or someone in your household had to change their plans or schedules in the past four weeks due to water-related issues? (These issues may have affected activities such as caring for others, doing household chores, agricultural work, income-generating activities, etc.)
5	Change of food items	How often in the past 4 weeks have you or someone in your household had to change their food due to water-related issues? (e.g. lack of water for washing foods, cooking, and so on)
6	Inability to wash hands	How often in the past 4 weeks have you or someone in your household had to skip washing hands after dirty activities such as defecating or changing diapers, cleaning animal dung due to water-related issues?
7	Inability to take shower	How often in the past 4 weeks have you or someone in your household had to skip washing their body due to water-related issues? (e.g. insufficient water, dirty water, or unsafe water)
8	Drinking water inefficiency	In the past 4 weeks, how often have you or someone in your household had to drink less water than desired due to water-related issues?
9	Anger about water situation	In the past 4 weeks, how often have you or someone in your household felt anger or frustrated about your water situation?
10	Thirst for water during sleep	How often in the past month have you or someone in your household gone to sleep thirsty due to lack of drinking water?
11	A complete lack of useable or drinkable water	How often in the past month have you or someone in your household been unable to access useable or drinkable water?
12	Feeling shame	How often in the past month have you or someone in your household felt ashamed, excluded, or stigmatized due to water-related issues?

HWISE Scale scores are calculated by adding up the responses to each question. There are four response categories: never (0 times) is scored as 0, rarely (1-2 times) is scored as 1, sometimes (3-10 times) is scored as 2, and often and always (more than 10 times) are both scored as 3. The HWISE Scale was adapted from Young *et al.*[239].

Annex VIII. Water storage containers of different type and size equivalent chart

1. Jerricans

5 Liters

5 Liters

5 Liters

10 Liters

10 Liters

20 Liters

20 Liters

25 Liters

2. Buckets

10 Liters

20 Liters

40 Liters

40 Liters

Basins

30 Liters

30 Liters

30 Liters

4. Drums

40 Liters

80 Liters

80 Liters

140 Liters

300 Liters

300 Liters

350 Liters

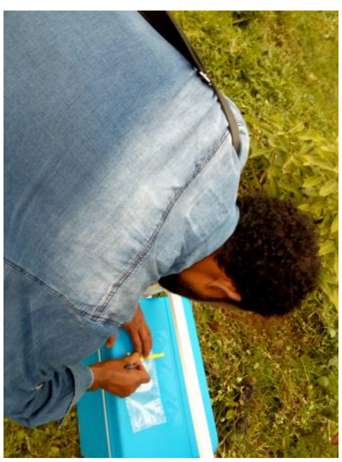
Annex IX. Selected Photos of FGDs, water sampling, storage, transportation, and laboratory analysis

Selected photos of water sampling from the selected households (1)

Selected photos of water sampling from the selected households (2)

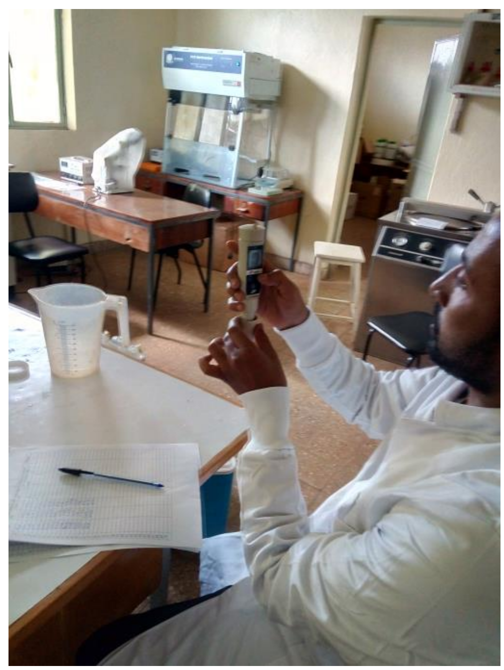
Selected photos of water sampling from the reservoirs



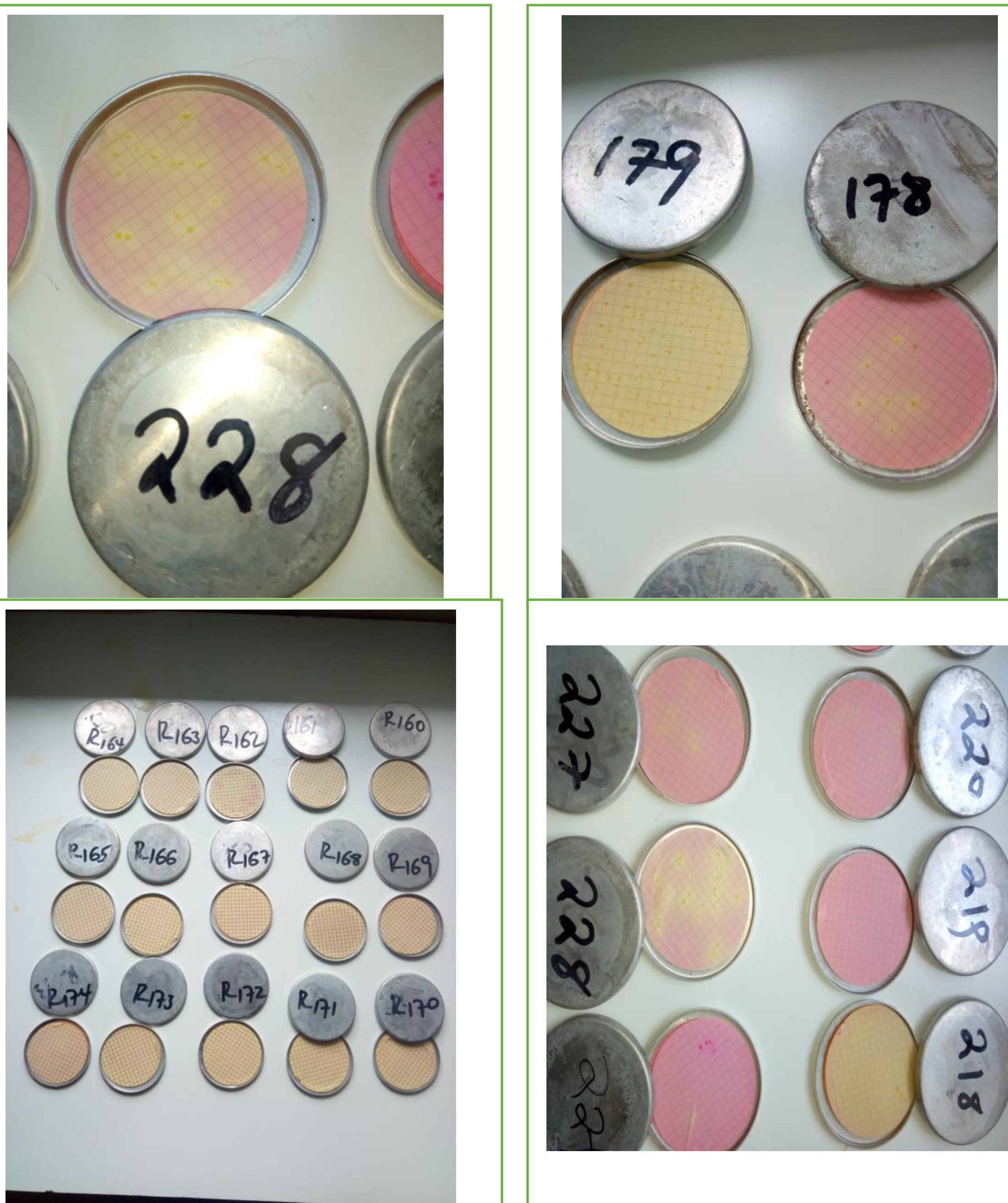
Selected photos of laboratory analysis (1)

Selected photos of laboratory analysis (2)

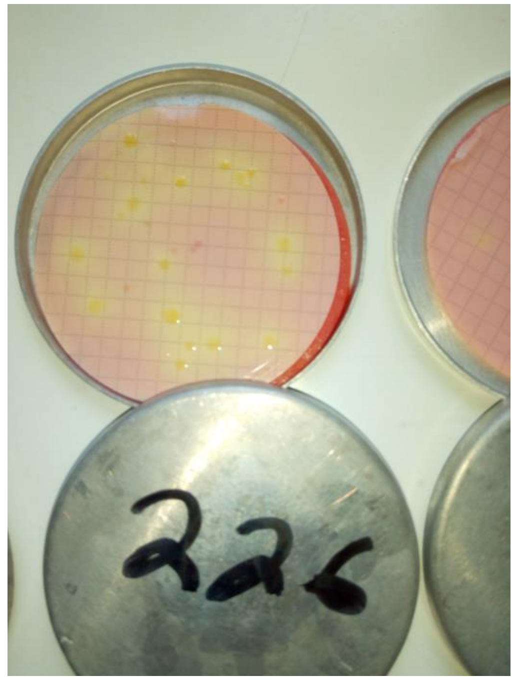


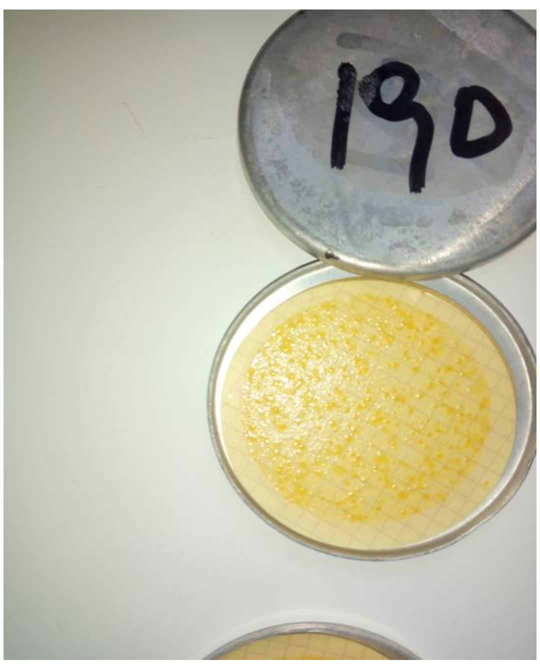
Selected photos of FGDs participants and laboratory equipment and materials

Selected photos of laboratory results (1)



Selected photos of laboratory results (2)





Annex X. List of Published Articles

Article I

Access to Drinking Water, Sanitation, and Hand Hygiene Facilities in the Peri-Urban and Informal Settlements of Hosanna Town, Southern Ethiopia

Environmental Health Insights
Volume 17: 1–14

DOI: 10.1177/11786302231193604
Sage

Abiot Abera Aydamo[1,2], Sirak Robele Gari[1] and Seid Tiku Mereta[3]

[1]Ethiopian Institute of Water Resources (EiWR), Addis Ababa University, Addis Ababa, Ethiopia. [2]Department of Environmental Sciences, Wachemo University, Hosanna, Ethiopia. [3]Department of Environmental Health and Technology, Jimma University, Jimma, Ethiopia.

ABSTRACT: Access to water, sanitation, and hygiene (WASH) facilities and practices have been extensively studied in urban and rural areas. However, there is a paucity of information on the coverage of water, sanitation, and hygiene facilities in the peri-urban and informal settlement areas, which could potentially exacerbate the spread of water, sanitation, and hygiene-related diseases. Therefore, this study was designed to examine access to drinking water, sanitation, and hand hygiene facilities and their determinant factors in the peri-urban and informal settlements of Hosanna town. A community-based cross-sectional study involving 292 households was conducted in 3 kebeles of Hosanna town. The primary data was collected using a pretested structured questionnaire and an observational checklist. Bivariate and multivariable logistic regressions were used to analyze the data. All the households (100%) had access to piped water on and off-premises, but the reliability of the water sources was a big challenge. Findings revealed that only 35.1% and 16.8% of the households had basic sanitation and basic handwashing facilities, respectively. Households with a middle income were identified as a determinant factor for the presence of piped water on premises (AOR = 2.23; 95% CI = 1.24-4.00), improved sanitation (AOR = 2.17; 95% CI = 1.17-4.03) and handwashing facilities (AOR = 4.36; 95% CI = 1.98-9.62). Piped water on premises was also another strong predictor of the availability of improved sanitation (AOR = 3.34; 95% CI = 1.99-5.62) and handwashing facilities (AOR = 8.18; 95% CI = 4.08-16.42). The majority of the studied households living in the selected peri-urban and informal settlements had access to unreliable drinking water sources. The study also revealed that households had poor access to basic sanitation and basic handwashing facilities. Hence, the findings call for solid government interventions to improve the reliability of the drinking water sources, basic sanitation coverage, and availability of basic handwashing facilities.

KEYWORDS: Drinking water, hand hygiene, Hosanna town, informal settlements, peri-urban, sanitation

RECEIVED: May 11, 2023. **ACCEPTED:** July 24 2023.

TYPE: Original Research

FUNDING: The author(s) received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Abiot Abera Aydamo, Ethiopian Institute of Water Resources (EiWR), Addis Ababa University, Addis Ababa 1176, Ethiopia.
Email: abioabera@gmail.com

Article II

Seasonal Variations in Household Water Use, Microbiological Water Quality, and Challenges to the Provision of Adequate Drinking Water: A Case of Peri-urban and Informal Settlements of Hosanna Town, Southern Ethiopia

Environmental Health Insights
Volume 18: 1–15

DOI: 10.1177/11786302241238940
Sage

Abiot Abera Aydamo[1,2], Sirak Robele Gari[1] and Seid Tiku Mereta[3]

[1]Ethiopian Institute of Water Resources (EiWR), Addis Ababa University, Addis Ababa, Ethiopia. [2]Department of Environmental Sciences, Wachemo University, Hosanna, Ethiopia. [3]Department of Environmental Health and Technology, Jimma University, Jimma, Ethiopia.

ABSTRACT: Several studies have been conducted on household water use and microbial water quality globally. However, studies that considered seasonal variability of household water use and microbial water quality were limited. Therefore, this study investigated the seasonal variability of household water use, microbiological water quality, and challenges to the provision of adequate water in the peri-urban and informal settlements of Hosanna town, Southern Ethiopia. A longitudinal study was conducted on 288 households. The data was gathered using a pretested structured questionnaire, laboratory-analysis, interviews, storage-container inventories, focus group discussions, key-informant interviews, and an observational checklist. The data was analyzed using stepwise-multiple linear regression, bivariate and multivariable logistic regression, thematic-analysis, t-tests, and non-parametric-tests. Households were visited for 7 consecutive days during the dry and rainy seasons to account for changes in daily and seasonal variation of water use. 440 stored water and 12 source samples were analyzed for *E. coli* presence during dry and rainy seasons. The prevalence of stored water contamination with *E. coli* was 43.2% and 34.5% during the dry and rainy seasons, respectively. The per capita water consumption was 19.4 and 20.3l during the dry and rainy seasons, respectively. Piped water on-premises, small family size, volume, and number of water storage containers were significant predictors of per capita water consumption in both seasons. Piped water off-premises, storing water for more than 3days, uncovered, and wide-mouthed water storage containers were significantly associated with the presence of *E. coli* in water in both seasons. Seasonal variability of household water use and microbiological water quality was statistically significant, which is a significant public health concern and needs intervention to enhance water quantity and quality to mitigate the risk of waterborne diseases. Findings also suggest seasonal monitoring of the safety of drinking water to ensure that the water is safe and healthy.

KEYWORDS: *E. coli*, Hosanna town, household water use, informal settlements, microbiological water quality, per capita water consumption, peri-urban, seasonal variability, Southern Ethiopia, water quantity

RECEIVED: September 11, 2023. **ACCEPTED:** February 26, 2024.

TYPE: Original Research

FUNDING: The author(s) received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Abiot Abera Aydamo, Ethiopian Institute of Water Resources (EiWR), Addis Ababa University, Addis Ababa 1176, Ethiopia. Email: abioabera@gmail.com

Journal of Water & Health

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The nexus between household water insecurity, mother's handwashing practices, and diarrheal diseases among under-five children

Abiot Abera Aydamo[a,b,*], Sirak Robele Gari[a] and Seid Tiku Mereta[c]

[a] Water and Health, Ethiopian Institute of Water Resources (EIWR), Addis Ababa University, P.O. Box: 1176, Addis Ababa, Ethiopia
[b] Department of Environmental Sciences, Wachemo University, P.O. Box: 667, Hosanna, Ethiopia
[c] Department of Environmental Health and Technology, Jimma University, P.O. Box: 1995, Jimma, Ethiopia
*Corresponding author. E-mail: abioabera@gmail.com; abiot.abera@aau.edu.et

AAA, 0009-0001-0092-177X

ABSTRACT

This study aimed to examine the association between household water insecurity (HWIS), mother's handwashing practices, and childhood diarrhea in the peri-urban and informal settlements of Hosanna town. A community-based cross-sectional study involving 424 mothers was carried out in Hosanna town, and the data were collected using a pretested structured questionnaire, HWISE Scale, and an observational checklist. Bivariate and multivariable logistic regression models were used to analyze the data. The study revealed that the prevalence of HWIS and diarrhea among under-five children was 68.6% and 16%, respectively. Only 42.2% of the mothers had good handwashing practices. Good knowledge of handwashing, positive attitudes toward handwashing, household water security (HWS), and the presence of handwashing facilities were significantly associated with good handwashing practices. Children aged 6–11 months, HWIS, uncovered and wide-mouthed water storage containers, unsafe child's stool disposal practices, and hands not washed with soap after defecation, before preparing food, and feeding a child were significantly associated with the occurrence of diarrhea. The prevalence of diarrhea and HWIS was very high. The majority of the mothers had poor handwashing practices. Therefore, findings suggest interventions to improve HWS and mother's handwashing practices, which could reduce the risk of diarrheal diseases.

Key words: diarrheal disease, Hosanna town, household water insecurity, informal settlements, mother's handwashing practices, under-five children

HIGHLIGHTS

- HWIS was significantly associated with increased diarrheal diseases and reduced hygienic practices.
- Despite progress in WASH coverage, the prevalence of diarrhea and HWIS remain high.
- Handwashing with soap before feeding a child, after defecation, and preparing food were key practices in preventing diarrhea.
- Intervention to improve HWS and promoting mother's handwashing practices could reduce the risk of diarrhea.

Annex XI. Data Collection Tools (Amharic Versions)

መጠይቁ በሆሳዕና ከተማ ላሉት ናሙና ቤተሰቦች (ለጥናቱ ለተመረጡ ቤተሰቦች) ተዘጋጅቷል

ይህ መጠይቅ የተዘጋጀዉ ጥናቱ በሚደረግበት አካባቢ ከልጅነት ተቅማጥ ጋር የተዛመዱ ችግሮችን ለመፍታት የሚረዳ መረጃ ለመሰብሰብ ነው፡፡ የዚህ ጥናት አጠቃላይ ዓላማ በሆሳዕና ከተማ፤ ከፊል ከተማና መደበኛ ባልሆኑ ሰፈሮች ዉስጥ ለሚኖሩ ከአምስት ዓመት በታች በሆኑ ሕፃናት ላይ የሚከሰት የተቅማጥ በሽታ ላይ የውሃ ብዛት፤የውሃ ረቂቅ ተህዋሲያን ጥራት እና ተጓዳኝ ምክንያቶች ሚና ምን እንደሆነ ማጥናት ነው፡፡ ስለሆነም እርስዎ የሚሰጡት መረጃ የጥናቱን ትንታኔ እና መደምደሚያ ስለሚወስን የእርስዎ ምላሽ ለጥናቱ ስኬት በጣም አስፈላጊ ነው፡፡ ስለሆነም ከቀረበሎት አማራጭ መልስ የሆነዉን በመምረጥ ወይም በተቀመጡት ክፍት አስተያየት መስጫ ቦታዎች ላይ ምላሽዎን እንዲሰጡ በትህትና ተጠይቀዋል፡፡ እባኮዎ ምላሽዎ በሚስጥር እንደሚጠበቅሎተ እንዲያውቁ እፈልጋለሁ፡፡ መጠይቁ በሰለጠኑ የመረጃ አሰባሳቢዎች የሚሰበሰብ ሲሆን በቤተሰቡ ሴት ኃላፊ ይሞላል፡፡

ስለ ትብብራችሁ በጣም አመሰግናለሁ!!

መመሪያ;-እባክዎን ይህን ምልክት በመጠቀም (√) ወይም በማክበብ ወይም ትክክለኛውን መልስ ከእያንዳንዱ ጥያቄ ፊት ለፊት ባሉ ሣጥኖች ወይም ነፃ ቦታዎች ላይ ይፃፉ፡፡

ክፍል I: ማህበራዊ-ስነ-ህዝብ ጉዳዮችን በተመለከተ

1. አድራሻ፡ ቀበሌ --------------------------- የቤት ቁጥር ☐ ☐
2. የቤተሰቡ ኃላፊ ስም ☐
3. ፆታ፡ ወንድ ☐ ☐
4. የእማዎራ ዕድሜ፡ ☐
5. የእማዎራ የትምህርት ደረጃ
   1. መደበኛ ትምህርት ያልተማሩ ☐ 2. ከ 1 – 8 ክፍል ያጠናቀቁ ☐
   3. ከ 9 – 12 ክፍል ያጠናቀቁ ☐ 4. የምስክር ወረቀት፣ ዲፕሎማ ያላቸዉ ☐
   5. የመጀመሪያ ዲግሪ ፣ ሁለተኛ ዲግሪ እና ከዚያ በላይ ያላቸዉ ☐
6. የአባዎራ የትምህርት ደረጃ
   1. መደበኛ ትምህርት ያልተማሩ ☐ 2. ከ 1 – 8 ክፍል ያጠናቀቁ ☐
   3. ከ 9 – 12 ክፍል ያጠናቀቁ ☐ 4. የምስክር ወረቀት፣ ዲፕሎማ ያላቸዉ ☐
   5. የመጀመሪያ ዲግሪ ፣ ሁለተኛ ዲግሪ እና ከዚያ በላይ ያላቸዉ ☐

7. የእናቶች / ተንከባካቢዎች የጋብቻ ሁኔታ
   1. ያላገባች ☐ 2. ባለትዳር ☐
   3. ከባሏዋ የተፋታች ☐ 4. ባሏ የሞተባት ☐

8. የእናቶች / ተንከባካቢዎች የስራ ሁኔታ
   1. የመንግስት ሠራተኛ ☐ 2. የቤት እመቤት ☐
   3. በግል የሚተዳደሩ ☐ 4. ሌላ ካለ (ይግለጹ) ___________

9. የቤት ባለቤትነት ሁኔታ

1. የቀበሌ ኪራይ ቤት ☐ 2. የግል ኪራይ ቤት ☐ 3. የግል ቤት ☐

10. የመኖሪያ ቤትዎን ከእንስሳት ጋር ይጋራሉ እንዴ? 1. አዎ እጋራለሁ ☐ 2. አይ አልጋራም ☐

11. የቤተሰብ ብዛት ☐

12. ከአምስት ዓመት በታች የሆኑ ሕፃናት ብዛት

1. አንድ ☐ 2. ሁለት ☐ 3. ሦስት ☐ 4. አራት ☐

13. ለጥናቱ የተመረጠው ልጅ ፆታ 1. ወንድ ☐ 2. ሴት ☐

14. ለጥናቱ የተመረጠው ልጅ ዕድሜ ------ቀን ------------- ወር --------ዓመተ ምህረት

15. አማካይ ወርሃዊ የቤተሰብ ገቢ በብር ☐

16. ሐይማኖት

1. ኦርቶዶክስ ክርስቲያን ☐
2. ፕሮቴስታንት ☐
3. ሙስሊም ☐
4. ካቶሊክ ☐
5. ሌላ ካለ (ይግለጹ) -----------------------------

<u>ክፍል II የመጠጥ ውሃ ምንጮችን በተመለከተ</u>

1. በዝናብ እና ደረቅ ወቅት ለቤተሰብዎ አባላት ዋና የመጠጥ ውሃ ምንጭ ምንድነው? (ማሳሰቢያ: - ለዝናባማ እና ደረቅ ወቅት የተለዩ ምላሾች ሊኖሩ ይገባል)

1. የቧንቧ ውሃ በመኖሪያ ቤት ዉስጥ
2. የቧንቧ ውሃ በአጥር ጊቢ ወይም መኖሪያ ጊቢ ዉስጥ
3. የጎረቤት ቧንቧ
4. የህዝብ ቧንቧ
5. ጥልቅ የዉሃ ጉድጓድ
6. የተጠበቀ/የጎለበተ የእጅ ዉሃ ጉድጓድ
7. ያልተጠበቀ/ያልጎለበተ የእጅ ዉሃ ጉድጓድ
8. የተጠበቀ/የጎለበተ ምንጭ ዉሃ
9. ያልተጠበቀ/ያልጎለበተ ምንጭ ዉሃ
10. የዝናብ ውሃ መሰብሰብ
11. የታሸገ ውሃ
12. የገፀ ምድር ውሃ(ወንዝ፣ግድብ ፣ ሐይቅ ፣ ኩሬ ፣ ጅረት ፣ ቦይ ፣ የመስኖ ሰርጦች)
13. ሌላ ካለ (ይግለጹ) ___________

2. ቤተሰቦዎ በዝናብ እና ደረቅ ወቅት ምግብ ለማብሰል እና እጅ ለመታጠብ ዓላማዎች የሚጠቀሙበት ዋና የውሃ ምንጭ ምንድነው? (ማሳሰቢያ: - ለዝናብ እና ለደረቅ ወቅት የተለዩ ምላሾች ሊኖሩ ይገባል)

1. የቧንቧ ውሃ በመኖሪያ ቤት ዉስጥ
2. የቧንቧ ውሃ በአጥር ጊቢ ወይም መኖሪያ ጊቢ ዉስጥ
3. የጎረቤት ቧንቧ
4. የህዝብ ቧንቧ
10. የዝናብ ውሃ መሰብሰብ
11. የታሸገ ውሃ
12. የገፀ ምድር ውሃ (ወንዝ፣ግድብ፣ ሐይቅ ፣ ኩሬ ፣ ጅረት ፣ ቦይ ፣

5. ጥልቅ የዉሃ ጉድጓድ

6. የተጠበቀ/የጎለበተ የእጅ ዉሃ ጉድጓድ

7. ያልተጠበቀ/ያልጎለበተ የእጅ ዉሃ ጉድጓድ

8. የተጠበቀ/የጎለበተ ምንጭ ዉሃ

9. ያልተጠበቀ/ያልጎለበተ ምንጭ ዉሃ

የመስኖ ሰርጦች)

13. ሌላ ካለ (ይግለጹ) ___________

3. የውሃ ምንጭዎ ከግቢዎ ውጭ ከሆነ እባክዎን ግምታዊ ርቀቱን በሜትር ይንገሩን ____________________ እና ደርሶ መልስ ውሃ ለመሰብሰብ የወሰደዉ ጊዜ በደቂቃ ______________________________

4. በጥያቄ 2 ላይ ከተጠቀሰው ምንጭ ውሃ ለማምጣት ለምን ወሰኑ?

1. ነፃ ስለ ሆነ 2. ዝቅተኛ ዋጋ ስላለዉ 3. አቅርቦቱ አስተማማኝ ስለሆነ

4. ቅርበት ስላለዉ 5. ጥሩ የውሃ ጥራት ስላለዉ 6. ሌላ ካለ (ይግለጹ) ______

5. ቤተሰቦዎ ምን ዓይነት የቧንቧ ዉሃ መስመር ይጠቀማሉ? (የቧንቧ ውሃ ተጠቃሚዎችን ብቻ ይመለከታል)

1. በመንግስት የሚተዳደር ትልቅ የቧንቧ መስመር

2. በህብረተሰቡ የሚተዳደር አነስተኛ የቧንቧ መስመር

3. በቤተሰቦቹ የሚተዳደሩ አነስተኛ የቧንቧ መስመር

6. ውሃ በዋናው የውሃ ምንጭዎ ሁል ጊዜ ይገኛል?

1. አዎ፣ ውሃ ሁል ጊዜ ይገኛል

2. አይ ፣ ውሃ ብዙ ጊዜ ይገኛል

3. አይ ፣ ውሃ የተወሰነ ጊዜ ይገኛል

4. አይ ፣ ውሃ እምብዛም አይገኝም

7. በጥያቄ 6 ላይ መልስዎ አይ ከሆነ ፣ አስፈላጊ በሚሆንበት ጊዜ በቂ የውሃ መጠን ማግኘት ያልቻሉበት (ዋናው) ምክንያት ምንድነው?

1. ውሃ ከምንጩ አይገኝም

2. ውሃ በጣም ውድ ስለሆነ

3. የዉሃ ምንጩ ተደራሽ አይደለም

4. ሌላ ካለ (ይግለጹ) _______________________

8. በቀን ለስንት ሰዓት/ በሳምንት ለስንት ቀን በአማካይ ውሃ ያገኛሉ? (ለቧንቧ ዉሃ ተጠቃሚዎች)

1. በቀን 24 ሰዓታት 5. በቀን <6 ሰዓታት

2. በቀን 18-24 ሰዓታት 6. በሳመንት ___________ቀን

3. በቀን 12-17 ሰዓታት 6. አላዉቅም

4. በቀን 6-11 ሰዓታት

9. ባለፈው ወር ዉሃ ሲያስፈልጎዎ ከዋናው ምንጭ (ጥያቄ 1) ለስንት ቀናት ማግኘት አልቻሉም?

1. የቀናት ብዛት ------------------------ 2. አላዉቅም/አላስታዉስም

10. በቤትዎ ውስጥ የውሃ እጥረት በሚኖርበት ጊዜ አማራጭ የውሃ ምንጮችን ይጠቀማሉ?

1. አዎ 2. አልጠቀምም

11. እጥረት በሚኖርበት ጊዜ የቤተሰበዎ የመጀመሪያ ምርጫ ምን ምንጭ ነዉ?

1. ውሃ የሚሸጡ አካላት 2. ምንጭ 3. እጅ ዉሃ ጉድጓድ

4. ወንዝ 5. ሌላ ካለ (ይግለጹ) ___________________________

12. ከዋና ምንጭዎ የሚቀርበው ውሃ ብዙውን ጊዜ ተቀባይነት አለው? ተቀባይነት ከሌለው ዋናውን ምክንያት ይምረጡ ፡፡

1. አዎ ተቀባይነት አለው 5. የለዉም፤ የማይፈለጉ ቁሳቁሶችን ይዟል

2. የለዉም፤ተቀባይነት የሌለው ጣዕም አለዉ 6. የለዉም፤ሌላ ካለ (ይግለጹ)__________

3. የለዉም፤ተቀባይነት የሌለው ቀለም አለዉ 7. አላዉቅም

4. የለዉም፤ ተቀባይነት የሌለው ሽታ አለዉ

13. አማራጭ የውሃ ምንጭዎን ምንነት ይግለጹ ፡፡

1. ዓመቱን በሙሉ ጥቅም ላይ የዋለው አንድ ምንጭ ብቻ ነው (01 ምንጭ)

2. ዓመቱን ሙሉ ጥቅም ላይ የዋሉ ሁለት ምንጮች ናቸዉ (ምንጭ 01 እና ሌላ አንድ ምንጭ)

3. በደረቅ ወቅት ብቻ ጥቅም ላይ የዋለ ሁለተኛው ምንጭ ነዉ

4. ዓመቱን በሙሉ ከሁለት በላይ ምንጮች እጠቀማለሁ

5. በደረቅ ወቅት ጥቅም ላይ የዋሉ ከሁለት ምንጮች በላይ ናቸዉ

14. የውሃ እጥረት አጋጥሞት ያቃል? 1. አዎ 2. አጋጥሞኝ አያዉቅም

15. በጥያቄ 14 ላይ መልስዎ አዎ ከሆነ በዓመት ውስጥ የትኞቹ ወቅቶች ላይ ከፍተኛ የውሃ እጥረት ያጋጥምዎታል?

1. ደረቅ ወቅት 2. ዝናብ ወቅት 3. ሁልጊዜ

16. በግቢው/ቤቶ ውስጥ ውሃ ከሌልዎት፤ በግቢው/ቤቶ ውስጥ የውሃ አቅርቦት እንዳይኖር ያደረጉት ችግሮች ምንድን ናቸዉ?

1. የቤተሰብ ኢኮኖሚያዊ ችግር
2. የመንግስት ኢኮኖሚያዊ ችግር
3. ተቋማዊ ሁኔታዎች ለምሳሌ የመሬት ይዞታ ጉዳዮች
4. የመኖሪያ ቤቶች ሁኔታ ለምሳሌ ቤታችን በከተማው ዳርቻ ላይ ስለሚገኝ
5. ፖለቲካዊ ምክንያቶች ለምሳሌ ሙስና
6. የመረጃ ምክንያቶች ለምሳሌ ለውሳኔ ሰጪዎች መረጃ እጥረት መኖሩ
7. ማህበራዊ ምክንያቶች ለምሳሌ ደካማ የህብረተሰብ ተሳትፎ፣ አድልዎ እና ከመንግስት ፖሊሲ ልማት እና ትግበራ መገለል የመሳሰሉት

<u>ክፍል III የውሃ መሰብሰብ ፣ ማከማቸት እና ማከም ሁኔታ</u>

1. ወደ ዉሃ ምንጭ ለመሄድ ፣ ውሃ ለማግኘት/ለመቅዳት እና ለመመለስ ምን ያህል ጊዜ ይወስዳል?

1. ዉሃዉ በቤት/ግቢው ውስጥ ነዉ ያለዉ

2. <15 ደቂቃ

3. 15– 30 ደቂቃ

4. 30– 60 ደቂቃ

5. > 60 ደቂቃ

2. ከዚህ ምንጭ አብዛኛውን ጊዜ ለቤተሰብዎ ውሃ የሚቀዳዉ ማን ነው? **የማወጣጫ ጥያቄ**-ይህ ሰው ዕድሜው ከ 15 ዓመት በታች ነው? ጾታዉ ምንድነው? ይህንን ሰው በተሻለ ሁኔታ የሚገልጸውን ኮድ ያክብቡ።

1. ጎልማሳ ሴት (ከ 15 ዓመት በላይ)
2. ጎልማሳ ወንድ (ከ 15 ዓመት በላይ)
3. ሴት ልጅ (ከ 15 ዓመት በታች)
4. ወንድ ልጅ (ከ 15 ዓመት በታች)

3. ባለፈው ሳምንት ያሰው ስንት ጉዞ አድርጓል? 1. ______ጊዜ   2. አላዉቅም/አላስታዉስም

4. ውሃ ለማጓጓዝ የተገለገሉበት ዘዴዎች የትኞቹ ናቸዉ?

1. በእግር በመጓዝ   2. በእጅ ጋሪ   3. በእንስሳተ ጋሪ

4. በተሽከርካሪ   5. ሌላ ካለ (ይግለጹ) ______________________

5. በቀን የሚቀዱት/የሚሰበስቡት ጠቅላላ ውሃ በሊትር __________________

6. ዋናው የውሃ ምንጭ ከቤትዎ ምን ያህል ይርቃል?

1. ዉሃዉ በቤት/ግቢው ውስጥ ነዉ ያለዉ
2. በ 1000 ሜትር ውስጥ
3. ከ 1000 ሜትር በላይ

7. ውሃ ለመሰብሰብ ምን ዓይነት ኮንቴይነር/የዉሃ ማከማቻ ዕቃ እየተጠቀሙ ነው?

1. ጀሪካን   2. ባልዲ   3 የሸክላ-ማሰሮ

4. የፕላስቲክ ጠርሙሶች   5. ሌላ ካለ (ይግለጹ) _______________________

8. ውሃ ወደ ቤት ለማጓጓዝ የሚገለገሉበት ኮንቴይነር መጠን ምን ያህል ነዉ?

1. ከ 5 ሊትር በታች   2. 5-10 ሊትር   3. 11-15 ሊትር   4. 16-20 ሊትር

5. 21-25 ሊትር   6. 26-30 ሊትር   7. 31-35 ሊትር   8. ከ 35 ሊትር በታች

9. በቤቶዎ ውስጥ ውሃ ያከማቻሉ?   1. አዎ   2. አላከማችም

10. መልስዎ በጥያቄ 9 ላይ አዎ ከሆነ፤ በቤቶ ውስጥ ለምን ያህል ጊዜ ዉሃ ያከማቻሉ?

1. አንድ ቀን   2. ሁለት ቀን   3. ሦስት ቀን

4.4 -6 ቀናት   5. አንድ ሳምንት   6. ከአንድ ሳምንት በላይ

11. ውሃ የት ነው የሚያከማቹት/የሚያስቀምጡት?

1. ቤት ውስጥ   2. ከቤት ውጭ   3. በኩሽና ውስጥ

4. በጣራ ላይ ባለ የዉሃ ማከማቻ ታንክር ዉስጥ   5. ሌላ ካለ (ይግለጹ) _________

12. በአሁኑ ጊዜ ውሃ ለማጠራቀም ስንት ዉሃ ማከማቻ ዕቃዎች/ኮንቴይነሮች እየተጠቀሙ ነው?

1. የኮንቴይነሮች ብዛት ______________ መጠን በሊትር _______________

13. በቤት ውስጥ የመጠጥ ውሃ ለማከማቸት ምን ዓይነት ኮንቴይነር ይጠቀማሉ?

1. ጀሪካን   2. ባልዲ   3. በርሜል   4. የሸክላ-ማሰሮ

5. በጣራ ላይ ባለ የዉሃ ማከማቻ ታንክር ዉስጥ   6. የፕላስቲክ ጠርሙሶች

7. ሌላ ካለ (ይግለጹ) ______________________

14. ውሃ የሚያጠራቅሙበት ኮንቴይነሮች አፍን እንዴት ይገልፁታል? (ይህ በመስክ ጉብኝት ወቅት በእይት ይረጋገጣል)

1. ሰፊ አፍ ያለዉ 2. ሰፊ እና ጠባብ አፍ ያለዉ 3. ጠባብ አፍ ያለዉ

15. ዉሃ የሚያጠራቅሙበት ኮንቴይነር ክዳን አለው እንዴ? 1. አዎ 2. የለዉም

16. የመጠጥ ውሃ ከማጠራቀሚያ ውስጥ የሚወስድበት ሁኔታ እንዴትነው?

1. በማፍሰስ 2. ዉሃ መቅጃዉን በማጥለቅ

17. መልስዎ በጥያቄ 16 ላይ ዉሃ መቅጃዉን በማጥለቅ ከሆነ ከውኃ ማጠራቀሚያ ውስጥ ውሃ ለመቅዳት ምን ዓይነት መቅጃዎች ይጠቀማሉ?

1. እጀታ የሌለዉ መቅጃ 2. እጀታ ያለዉ እና የሌለዉ መቅጃ 3. እጀታ ያለዉ መቅጃ

18. ዉሃ የሚያጠራቅሙበት ዕቃ ወይም ኮንቴይነር መጠኑ ምንያህል ነው?

1. ከ 5 ሊትር በታች 2. 5-10 ሊትር 3. 11-15 ሊትር 4. 16-20 ሊትር

5. 21-25 ሊትር 6. 26-30 ሊትር 7. 31-35 ሊትር 8. ከ 35 ሊትር በላይ

19. የዉሃ ማጠራቀሚያ እቃው/ኮንቴይነሩ ክዳን አለው? 1. አዎ 2. የለዉም

20. በአሁኑ ጊዜ የዉሃ ማጠራቀሚያ እቃው ተከድኗል እንዴ? 1. አዎ 2. አልተከደነም

21. ውሃ ለመቅዳተ የሚጠቀሙበትን ዕቃ በምን ያህል ጊዜ ያፀዳሉ?

1. በየቀኑ 6. በየ 6 ወሩ

2. በሳምንት ከአንድ ጊዜ በላይ 7. በዓመት አንድ ጊዜ

3. በየሳምንቱ 8. አልፎ አልፎ

4. በወር ከአንድ ጊዜ በላይ 9. በጭራሽ አይታጠብም

5. በወር ከአንድ ጊዜ ያነሰ 10. አፅድቼ አላውቅም

22. ከዉሃ ማጠራቀሚያ ኮንቴይነር ውስጥ ውሃ ለመቅዳት የሚገለግሉበትን ዕቃ የት ያስቀምጡታል?

1. ወለል ላይ 2. ጠረጴዛ / ወንበር ላይ 3. ቁም ሳጥን ላይ

4. የዉሃ ማጠራቀሚያ ኮንቴይነር ዉስጥ/ ላይ 5. ሌላ ካለ (ይግለጹ) ____________

23. በሳምንት ስንት ጊዜ ውሃ ይቀዳሉ?

1. በሳምንት አንድ ጊዜ 2. በሳምንት ሁለት ጊዜ 3. በሳምንት ሦስት ጊዜ

4. በሳምንት ከ 4-5 ጊዜ 5. በየሳምንቱ 5. በየሁለት ሳምንቱ

24. የውሃ ማጠራቀሚያ ዕቃዎን በምን ያህል ጊዜ ያጸዳሉ?

1. በየቀኑ 6. በየ 6 ወሩ

2. በሳምንት ከአንድ ጊዜ በላይ 7. በዓመት አንድ ጊዜ

3. በየሳምንቱ 8. አልፎ አልፎ

4. በወር ከአንድ ጊዜ በላይ 9. በጭራሽ አይታጠብም

5. በወር ከአንድ ጊዜ ያነሰ 10. አፅድቼ አላውቅም

25. ውሃዎን ለመጠጥ ደህንነቱ የተጠበቀ ለማድረግ የተለያዩ መንገዶችን በመጠቀም ያክሙታል/ያጣሩታል እንዴ?

1. አዎ 2. ምንም አላደርግም

26. መልስዎ በጥያቄ 25 ላይ አዎ ከሆነ ለመጠጥ ደህንነቱ የተጠበቀ እንዲሆን ብዙውን ጊዜ ውኃውን ምን ያደርጋሉ?

1. አፈላዋለሁ
2. ክሎሪን እጨመርበታለሁ
3. ጨርቅ በመጠቀም አጣራዋለሁ
4. የውሃ ማጣሪያ እጠቀማለሁ (ሴራሚክ ፤ አሸዋ ፤ ወዘተ)
5. የፀሐይ ብርሃንን በመጠቀም አጣራዋለሁ
6. እንዲዘቅጥ አደርገዋለሁ
7. ሌላ ካለ (ይግለጹ) ________________________

ክፍል አራት፡ የቤት ውስጥ ውሃ አጠቃቀም

1. እባክዎን በአንድ ቀን ውስጥ ለግብርና ዓላማ የሚውለውን ውሃ ሳይጨምር በሊትር ጥቅም ላይ የሚውለውን አጠቃላይ የውሃ መጠን ይንገሩን __________________
2. እባክዎን በሳምንት ውስጥ ለሚከተሉት የቤት ውስጥ እንቅስቃሴዎች በሊተር ጥቅም ላይ የሚውለውን የውሃ መጠን ይንገሩን ፡፡
   ሀ. ለመጠጥ የዋለ ______________ ሊትር
   ለ. ምግብ ለማብሰል የዋለ ______________ሊትር
   ሐ. ለእጅ መታጠብ የዋለ ________________ ሊትር
   መ. ልብብስ ለማጠብ የዋለ______________ ሊትር
   ረ. ለቀሪ ለተለያዩ ተግባራት በቤት ዉስጥ የዋለ ዉሃ በሊትር ከግብርና በስተቀር_____________ሊትር

4. በቤት ውስጥ የሚሰሩ ቧንቧዎች ብዛት ስንት ነው? ______________________

5. በቤት ውስጥ የሚሰራ የሻወር ቁጥር ስንት ነው? ______________________

6. ልብሶትን በተደጋጋሚ የሚያጥቡት የት ነው?

1. በውሃ ምንጭ ቦታ　　4. የልብስ ማጠቢያ ቤት(ላዉንደሪ)
2. ቤት　　5. ቤት እና የልብስ ማጠቢያ ቤት
3. ቤት እና በውሃ ምንጭ ቦታ　　6. ቤት፣በውሃ ምንጭ ቦታ እና የልብስ ማጠቢያ ቤት

7. ባለፈው ሳምንት ልብስዎን የት አጠቡ?

1. በውሃ ምንጭ ቦታ　　4. የልብስ ማጠቢያ ቤት (ላዉንደሪ)
2. ቤት ዉስጥ　　5. ቤት እና የልብስ ማጠቢያ ቤት
3. ቤት እና በውሃ ምንጭ ቦታ　　6. ቤት፣በውሃ ምንጭ ቦታ እና የልብስ ማጠቢያ ቤት

ክፍል 5: የአካባቢ ጽዳትና የግል ንፅህናን በተመለከተ

1. የመፀዳጃ ቤት መገልገያ ቦታ አለዎት　　1. አዎ　　2. የለኝም

2. መልስዎ በጥያቄ **1** ላይ ***አዎ*** ከሆነ ፣ የቤተሰብዎ አባላት አብዛኛውን ጊዜ የሚጠቀሙት ምን ዓይነት የመፀዳጃ ቤት ነው? ዉሃ ማቆሪያ ያለዉ እና ዉሃ የሚለቅ መፀዳጃ ቤት ከሆነ፤ ***የማወጣጫ ጥያቄ***፤ ፍሳሹ ወዴት ይፈሳል?

1. ወደ ፍሳሽ ቆሻሻ ማጠራቀሚያ ይፈሳል　　8. ባልዲ
2. ወደ ጉድጓድ መፀዳጃ ቤት ይፈሳል　　9. በኮንቴይነር ላይ የተመሠረተ የንፅህና አጠባበቅ
3. ወዴት እንደሚፈስ ዕዉቀቱ የለኝም
4. ክዳን ያለዉ የጉድጓድ መጸዳጃ ቤት　　10. የመፀዳጃ ቤት የለም ወይም

5. ከዳን የሌለዉ የጉድጓድ መጸዳጃ ቤት/ ክፍት ጉድጓድ ቁጥቋጦ ወይም ክፍትመሬት

6. ከዳን ያለዉ መንትያ የጉድጓድ መጸዳጃ ቤት ላይ መፀዳዳት

7. ከዳን የሌለዉ መንትያ የጉድጓድ መጸዳጃ ቤት 11. ሌላ ካለ (ይግለጹ) ________

3. ይህንን የመፀዳጃ ቤት የቤተሰብዎ አባላት ካልሆኑ ሌሎች አካላት ጋር ይጋራሉ እንዴ?

1. አዎ 2. አይ አልጋራም

4. ከላይ የጠቀሰዉ መፀዳጃ ቤት የት ይገኛል?

1. በራሴ መኖሪያ ቤት ዉስጥ 2. በራሴ ግቢ ዉስጥ 3. ሌላ ቦታ

5. መፀዳጃ ቤቱን በጋራ የሚጠቀሙ ከሆነ፤ የራስዎን ቤተሰብ ጨምሮ በአጠቃላይ ይህንን የመፀዳጃ ቤት ክፍል የሚጠቀሙት ስንት ቤተሰቦች ናቸው?

1. የቤተሰብ ብዛት _______________ 2. አላዉቅም

6. መጸዳጃ ቤት ከሌልዎ የሚጸፀዳዱት የት ነው?

1. የህዝብ መጸዳጃ ቤት

2. ልቅ በሆነ መልኩ በተገኙት ክፍት ቦታዎች ላይ

3. ጎረቤት ባሉ መፀዳጃ ቤት በመጋራት

4. ሌላ ካለ (ይግለጹ) ________________

7. ልጅዎ ለመጨረሻ ጊዜ (ለጥናቱ የተመረጠው ልጅ) ሲፀዳዳ የወጣዉ ሰገራ በምን መንገድ ተወገደ?

1. ልጅ መጸዳጃ ቤት ተጠቀሟል 6. በክፍት ቦታ ላይ ተጥሏል

2. ሰገራዉ በመጸዳጃ ቤት ውስጥ ተወግዷል 7. እንደ ፍግ ተጠቅመንበታል

3. በፍሳሽ ማስወገጃ ወይም ቦይ ውስጥ ተወግዷል 8. ሌላ ካለ (ይግለጹ) _____________

4. በቆሻሻ ዉስጥ ተጥሏል 9. አላውቅም

5. አፈር ዉስጥ ተቀበሯል

8. ምግብ ለማብሰያ፣ለማጠቢያ እና ለመታጠቢያ የተጠቀሙበትን የቤት ውስጥ ፍሳሽ እንዴት ያስወግዳሉ?

1. የቆሻሻ ፍሳሽ በሚተላለፍበት ቱቦ ጋር በማገናኘት

2. የቆሻሻ ማጠራቀሚያ ሴፕቲክ ታንክ ጋር በማገናኘት

3. ፍሳሹ በጉድጓድ ዉስጥ እንዲፈስ/እንዲንጣፈፍ በማድረግ

4. ፍሳሹን በቀጥታ ከክፍት የዉሃ መዉረጃ እና ክፍት መሬት ጋር በማገናኘት እንዲፈስ በማድረግ

5. በቀጥታ ወደ ክፍት መሬት ወይም የውሃ አካል ላይ በማፍሰስ

6. ምግብ ማብሰል፣ልብስ ማጠብ እና መታጠብ በቤት ዉሰጥ አይተገበርም

7. አላዉቅም

9. በፍሳሽ ቆሻሻ ማጠራቀሚያ/ሴፕቲክ ታንክ ዉስጥ ያለዉ ፍሳሽ ወዴት ይወገዳል?

1. ወደ ልቅ መሬት እና ጉድጓድ ዉስጥ እንዲፈስ/እንዲንጣፈፍ በማድረግ

2. ወደ ፍሳሽ ማስወገጃ ቦይ ዉስጥ

3. ወደ ክፍት የፍሳሽ ማስወገጃ ቦይ ዉስጥ

4. ሌላ ካለ (ይግለጹ) ___________

5. አላውቅም

10. ቤተሰብዎ አብዛኛውን ጊዜ ደረቅ ቆሻሻን እንዴት ያስወግዳሉ?

1. መደበኛ አገልግሎት ሰጪ በሆኑ አካላት ይሰበሰባል

2. መደበኛ ባልሆነ አገልግሎት ሰጪዎች ይሰበሰባል

3. መደበኛ/የተዘጋጀ የቆሻሻ ማስወገጃ ቦታ ላይ ማስወገድ

4. በቤተሰብ ቅጥር ግቢ ውስጥ ማስወገድ

5. አፈር ዉስጥ መቅበር ወይም ማቃጠል

6. ወደ ሌላ ቦታ በመዉሰድ ማስወገድ

7. አላውቅም

8. ሌላ ካለ(ይግለጹ) ________________________

11. የመፀዳጃ ቤቶ በዓመት ውስጥ በማንኛውም ጊዜ ከስር የማፍሰስ ወይም ሞልቶ ፈሶ ያዉቃል እንዴ? **የማወጣጫ ጥያቄ**፤ በዝናብ ጊዜ ወይም በጎርፍ ወቅት:-

1. በጭራሽ አያቅም 3. አዎ ፣ ብዙ ጊዜ

2. አዎ ፣ አንዳንድ ጊዜ 4. አላውቅም

12. የጉድጓድ መጸዳጃ ቤትዎ ወይም የፍሳሽ ማስወገጃ ገንዳዎ ዉስጥ ያለዉ ፍሳሽ ተወግዶ ያውቃል?

1. አዎ ያዉቃል 2. አያዉቅም

13. ለመጨረሻ ጊዜ በመጸዳጃ ቤትዎ ያለዉን ፍሳሽ ሲያስወግዱ፤ፍሳሹ የት ነዉ የተወገደዉ? የተወገደዉ የፍሳሽ አገልግሎት በሚሰጡ አካላት ነዉ እንዴ?

በአገልግሎት ሰጪዎች ተወግዷል

1. ወደ ፍሳሽ ማጣሪያ ጣቢያ በመዉሰድ

2. ሽፋን ባለዉ ጉድጓድ ውስጥ በመቅበር

3. የት እንደወሰዱት መረጃዉ የለኝም

ቤተሰቡ አስወግዶታል

4. ሽፋን ባለዉ ጉድጓድ ውስጥ በመቅበር

5. ፍሳሹን ክፍት ጉድጓድ ዉስጥ፣ክፍት መሬት ላይ፣የውሃ አካል ላይ ወይንም ሌላ ቦታዎች ላይ በማስወገድ

6. ሌላ ካለ (ይግለጹ) _______________

7. አላውቅም

14. እባክዎን የቤተሰብዎ አባላት ብዙውን ጊዜ እጃቸውን የሚታጠቡበትን ቦታ ሊያሳዩኝ ይችላሉ?

ቋሚ የእጅ መታጠቢያ መኖሩ ተረጋግጧል (መታጠቢያ ሲንክ/ ቧንቧ)

1. በመኖርያ ቤት ውስጥ

2. በግቢ ውስጥ

የተንቀሳቃሽ የእጅ መታጠቢያ መኖሩ ተረጋግጧል

3. ባልዲ / ጎድጓዳ ሳህን

4. በመኖሪያ ቤት / ጊቢ ውስጥ የእጅ መታጠቢያ የለም

5. ለማየት ፈቃድ አልተሰጠም

6. ሌላ ምክንያት ካለ (ይጥቀሱ) _________________

15. በእጅ መታጠቢያ ስፍራ ውሃ አለ እንዴ?

1. አዎ አለ 2. አይ የለም

16. የእጅ መታጠቢያ ቦታ አጠገብ ሳሙና ወይም ማጽጃ ይገኛል እንዴ?

1. አዎ አለ 2. አይ የለም

17. በቤት ውስጥ ሳሙና አለዎት? 1. አዎ አለ 2. አይ የለም

18. እጅዎን በውኃ እና በሳሙና ምን ያህል ጊዜ ይታጠባሉ?

1. በሳሙና አልታጠብም 2. በጣም ጥቂት ጊዜ

3. ብዙ ጊዜ 4. በጣም ብዙ ጊዜ

19. በመጸዳጃ ቤቶዎ አቅራቢያ የእጅ መታጠቢያ ቦታ/ዕቃ ይገኛል እንዴ?

1. አዎ አለ 2. አይ የለም

<u>ክፍል VI: - የእናቶች የእጅ መታጠብ ልምድ፣ዕዉቀት፣አመለካከት እና የልጅነት ተቅማጥ ሁኔታ</u>

<u>የእጅ መታጠብ ልምድ ሁኔታ</u>

እጅዎን መቼ ይታጠባሉ? (በአምስት አሰስፈላጊ ጊዜያት እጅን መታጠብ)

1. ከመፀዳዳት በኋላ እጅዎን ይታጠባሉ? 1. አዎ ፣ በሳሙና እና በውሃ 2. አዎ ፣ በውሀ ብቻ 3. አልታጠብም

2. ልጆት እንዲፀዳዳና ሰገራዉም እንዲወገድ ካዳረጉ በኋላ እጅዎን ይታጠባሉ?

1. አዎ ፣ በሳሙና እና በውሃ 2. አዎ ፣ በውሀ ብቻ 3. አልታጠብም

3. ምግብ ከማዘጋጀትዎ በፊት እጅዎን ይታጠባሉ? 1. አዎ፣በሳሙና እና በውሃ . አዎ፣ በውሀ ብቻ 3. አልታጠብም

4. ልጅን ከመመገብዎ በፊት እጅዎን ይታጠባሉ? 1. አዎ፣በሳሙና እና በውሃ 2. አዎ፣በውሀ ብቻ 3. አልታጠብም

5. ምግብ ከሙብላትዎ በፊት እጅዎን ይታጠባሉ? 1. አዎ፣በሳሙና እና በውሃ 2. አዎ፣በውሀ ብቻ 3. አልታጠብም

6. በመፀዳጃ ቤቱ አቅራቢያ የእጅ መታጠቢያ ቦታ ወይም ዕቃ አለዎት እንዴ? (በምልከታ ይረጋገጣል) 1. አዎ 2. የለም

7. መልስዎ በጥያቄ 6 ላይ አዎ ከሆነ በእጃ መታጠቢያ ቦታ አቅራቢያ የትኞቹ ቁሳቁሶች ይገኛሉ? (በምልከታ ይረጋገጣል)

1. ሳሙና እና በውሃ 2. ውሀ ብቻ 3. ምንም የለም

<u>የእጅ አስተጣጠብ ዕዉቀትን በተመለከተ</u>

1. በአምስት ወሳኝ ጊዜያት እጅን መታጠብ እንዳለቦት ሰምተዉ የውቃሉ? 1. አዎ 2. አይ አልሰማሁም
2. ከመፀዳዳት በኋላ ፣ ምግብ ከማዘጋጀትዎ በፊት ፣ ልጅ ከመመገብዎ በፊት ፣ ምግብ ከሙብላትዎ በፊት እንዲሁም ልጆት እነዲፀዳዳና ሰገራዉም እንዲወገድ ካዳረጉ በኋላ እጅን በሳሙና እና ዉሃ መታጠብ የልጅነት ተቅማጥን ይከላከላል? (በአምስት አስፈላጊ ጊዜያት እጅን በሳሙና እና ዉሃ መታጠብ የልጅነት ተቅማጥን ይከላከላል)

1. አዎ ይከላከላል 2. አይከላከልም

3. ረጅም ጥፍሮች በሽታ አምጪ ተህዋሲያንን ሊይዙ እና በቀላሉ ሊያስተላልፋ ይችላሉ፡፡ 1. አዎ 2. አይ፤አይችሉም

4. እጅን ለመታጠብ ንፁህ ውሃ ነዉ የሚጠቀሙት? 1. አዎ 2. አይደለም

5. እጅዎን ለመታጠብ ምን ያህል ጊዜ ይወስድቦት ነበር?

1.ከ 10 ሰከንድ በታች 2. ከ 19 ሰከንድ በታች 3. ከ 20-30 ሰከንድ 4. ከ 30 ሰከንድ በላይ

6. እናቶች በልጆቻቸው እጅ ንፅህና ላይ ጉልህ ሚና አላቸው። 1. አዎ 2. አይ፤የላቸዉም

7.እጅዎን ለምን ይታጠባሉ?(እጅን ለመታጠብዎ ምክንያቶቹ ምንድን ናቸዉ) 1.በሽታን ይከላከላል 2.ጥሩ ሆኖ ስለሚታይ

3. ለንፅህና 4. ሁሉም ሰው ሲታጠብ ስላየሁ እኔም እታጠባለሁ 5. ሌላ ካለ (ይግለጹ) _____________

8. በደንብ ያልታጠቡ እጆች በሽታ አምጪ ተህዋሲያንን ሊያስተላልፉ ይችላሉ። 1. አዎ 2. አይ፤አይችሉም

9. እጅዎን እንዴት ይታጠባሉ? (እጅን የሚታጠቡበት ሑኔታ)

1. አንድ እጇን ነዉ የምታጠበዉ 2. ሁለቱንም እጇን ነዉ የምታጠበዉ 3. እጇን አልታጠብም

10. እጅን በውሃ ብቻ መታጠብ እንደ ተቅማጥ ያሉ ተላላፊ በሽታዎችን ለመከላከል ይረዳል.፡፡ 1. አዎ 2. አይ፤አይችሉም

<u>**የእጅ አስተጣጠብ አመለካከትን በተመለከተ**</u>

i. ከመፀዳዳት በኋላ ፣ ምግብ ከማዘጋጀትዎ በፊት ፣ ልጅ ከመመገብዎ በፊት ፣ ምግብ ከሙብላትዎ በፊት እንዲሁም ልጆት እንዲፀዳዳና ሰገራዉም እንዲወገድ ካዳረጉ በኋላ እጅን በሳሙና እና ዉሃ መታጠብ የልጅነት ተቅማጥን ይከላከላል?

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

2. የሕፃናትን ተቅማጥ ለመከላከል እጅን በውኃ መታጠብ ብቻ በቂ ነው ፡፡

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

3. ውሃ እና ሳሙና የያዘ የእጅ መታጠቢያ ቦታ/ዕቃ በመፀዳጃ ቤቱ አጠገብ ማኖር አስፈላጊ ነዉ፡፡

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

4. እንደ ተቅማጥ ያሉ ተላላፊ በሽታዎችን ለመከላከል የጥፍር ንፅህና በጣም አስፈላጊ ነው.

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

5. በቤት ዉስጥ በቂ ያልሆነ የውሃ መጠን በእጅ መታጠብ ልምዶች ላይ ቀጥተኛ ተጽዕኖ አለው፡፡

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

6. ስለ ትክክለኛ የእጅ መታጠብ ሂደቶች ጥሩ እውቀት ማግኘት የተሻለ የእጅ መታጠብ ተግባር እንዲኖር ይረዳል።

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

7. የመፀዳጃ ቤት አጠገብ የእጅ መታጠቢያ ማሰስቀመጥ/ማዘጋጀት በሽታን ለመከላከል በጣም አስፈላጊ ነው፡፡

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

8. እንደ ተቅማጥ ያሉ ተላላፊ በሽታዎችን ለመከላከል የጥፍር ንፅህና በጣም አስፈላጊ ነው፡፡

1. በጣም እስማማለሁ 2. እስማማለሁ 3. ገለልተኛ ነኝ 4. አልስማማም 5. በጣም አልስማማም

<u>**ክፍል VII-ከልጅነት ተቅማጥ እና ሌሎች ከልጆች ጋር የተዛመዱ የባህሪ ሁኔታዎችን በተመለከተ**</u>

1. እባክዎን የልጅዎን ስም ይንገሩን? (ጥናቱ ላይ እንዲሳተፍ የተመረጠው ልጅ ስም) _______________________

2. ለጥናቱ የተመረጠው ልጅ ልደት ቀን መቼ ነው? _____________________________________

3. ልጅን ለምን ያህል ጊዜ ነበር ጡት ያጠቡት?

1. ለ 6 ወራት እና ከዚህ በታች 3. 12-23 ወራት

2. ከ 12 ወራት በታች 4. ከ 24 ወራት በላይ

4. ያለምንም ምግብ ተጨማሪ ጡቶትን ብቻ ያጠቡት ለምን ያህል ጊዜ ነበር?

1. ከ 6 ወራት በታች 2. ለ 6 ወራት እና ከዚያ በላይ

5. ለጥናቱ የተመረጠው ልጅ ተጨማሪ ምግብን መቼ ጀመረ?

1. ከስድስት ወር በፊት 1. ከስድስት ወር በኃላ

6. ለጥናቱ የተመረጠው ልጅ አሁን ያለው የአመጋገብ ሁኔታ ምንይመስላል?

1. የእናት ጡት ብቻ 2. የእናት ጡት እና ምግብ 3. ምግብ ብቻ

7. የልጆት ክትባት ሁኔታ ምን ይመስላል?

1. ምንም ክትባት አልወሰደም 2. ሙሉ በሙሉ ተከትቧል 3. በከፊል ተከትቧል

8. የልጁ የተመጣጠነ ምግብ እጦት ሁኔታ እንዴት ነዉ? __________________ (መረጃዉ ከሆሳና ከተማ አስተዳደር ጤና ጸ/ቤት ይሰበሰባል)

9. ባለፉት ሁለት ሳምንታት ለጥናቱ የተመረጠው ልጁ ተቅማጥ ነበረው?

1. አዎ 2. አልነበረዉም

10. ባለፉት 2 ሳምንታት ውስጥ ለጥናቱ ከተመረጠዉ ልጅ ዉጪ ሌላ የቤተሰብዎ አባል ተቅማጥ ነበረው? 1. አዎ 2. አልነበረዉም

11. ልጅዎ ተቅማጥ ሲያስቀምጠዉ መጀመሪያ የሚያደርጉት ነገር ምንድን ነው?

1.ወደ ጤና ጣቢያ ይዤዉ እሄዳለሁ 3. ምንም አላደርግም

2. ሕመሙን በቤት ውስጥ በተለያየ መንገዶች እቆጣጠረዋለሁ 4. ሌላ ካለ (ይግለጹ) _____

12. የተቅማጥ መንስኤ ምንድነው?

1. የተበከለ ውሃ በመጠጣት 4. ከአቅም በላይ በመብላት

2. በቂ ያለሆነ የአካባቢ ጽዳትና እና ንፅህና 5. አላውቅም

3. ያልሞቀ ምግብ በመመገብ 6. ሌላ ካለ (ይግለጹ) ___________

13. ለጥናቱ የተመረጠው ልጅ ያልሞቀ ምግብ ይመገባል እንዴ?

1. አዎ 2. አይመገብም

14. ለጥናቱ የተመረጠው ልጅ ያልበሰለ አትክልት ይመገባል እንዴ?

1. አዎ 2. አይመገብም

15. ከዚህ በፊት ስለ ተቅማጥ አያያዝ ወይም ህክምና ስልጠና/ትምህርት አግኝተዋል?

1. አዎ፤ አግኝቻያለሁ 2. አይ፤ አላገኘሁም

16. መልሶዎ በጥያቄ 15 ላይ አዎ ከሆነ፣ ስልጠናውን/ትምህርቱን ማን ሰጦዎት?

1. የመንግስት ድርጅት ለምሳሌ ጤና ጣቢያ እና ሆስፒታል 3. ሚዲያ (ሬዲዮና ቴሌቪዥን)

2. መንግሥታዊ ያልሆኑ ድርጅቶች 4. ሌላ ካለ (ይግለጹ) _______

የቡድን ውይይት

የቡድን ውይይቱ ከእናቶች ወይም ከህፃናት አሳዳጊዎች ጋር ይካሄዳል ፡፡

የአወያየዩ ስም ________________________ የተሳታፊዎች ብዛት __________________

ዉይይቱ የተካሄደበት ቦታ ልዩ ስም ___________________ የጂፒኤስ መገኛ _______________

ዉይይቱ የተካሄደበት ቀን ____

የመነሻ ጊዜ ______________________ የማብቂያ ጊዜ________________________

በቡድን ውይይት ወቅት የሚነሳው የጥያቄ ብዛት እና ዓይነት፡-

1. በሆሳዕና ከተማ፤ ከፊል ከተማ እና መደበኛ ባልሆኑ ሰፋሮች ውስጥ አሁን ያለው የውሃ አቅርቦት ተደራሽነት ደረጃ ላይ የእርስዎ አስተያየት ምንድነው? የትኞቹ የውሃ ምንጮች በህብረተሰቡ ለቤት ውስጥ ጥቅም ላይ ይውላል? (የውሃ ምንጭ ዓይነት) የውሃ አገልግሎቱን የሚሰጠው ማነው? የዉሃ አገልግሎት ደረጃዉን እንዴት ያዩታል? (በቂ ወይም በቂ ያልሆነ)
2. የሚሰበሰቡት/የሚቀዱት የውሃ ብዛት የዕለት ተዕለት የውሃ ፍላጎትዎን ያሟላ ነበር? አያሟላም ከሆነ መልሶዎ፤ የውሃ ፍላጎቶን ለማሟላት የትኛውን ስትራቴጂ እየተጠቀሙ ነው?
3. ከዋና የውሃ ምንጮዎ ጋር የተገናኙ ዋና ዋና ችግሮች ምንድናቸው?
4. የማህበረሰብ አባላት በውኃ አቅርቦት ፕሮጀክት እቅድ እና ትግበራ ላይ ይሳተፋሉ?
5. ለቤተሰቦዎ በቂና ንፁህ ውሃ በማቅረብ ረገድ የመንግስት ጥረት እንዴት ያዩታል? (በቂ ወይም በቂ ያልሆነ)
6. በማህበረሰብዎ ውስጥ የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ ያለዉን አቅርቦት እንዴት ያዩታል? በቂ አይደለም ካሉ፤ በቤተሰብ ደረጃ በቂ ውሃ እንዳይኖር ወይም የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ እንዳይኖር ያደረጉ ዋና መሰናክሎች ምንድናቸው?
7. የውሃ እጥረት እና ጥራት በልጆች ጤና ላይ ያለው አንድምታ ወይም ተፅህኖ ምን ይመስላል? (የልጅነት ተቅማጥ ላይ የሚያሳድረዉ ተፅህኖ)
8. የውሃ ፍላጎቶዎን ለማሟላት እና የልጅዎን ጤና ለማሻሻል እንዲቻል አሁን ያለውን የውሃ አቅርቦት ስርዓት እንዲሻሻል ምን አስተያየት አለዎት?

የዋና ወይም የቁልፍ መረጃ ሰጪ ቃለ መጠይቅ

የቁልፍ መረጃ ሰጪ ስም _____________________ቃለመጠይቁ የተደረገበት ቀን ___________

የቁልፍ መረጃ ሰጪ ሙያ ______________________

ጥያቄዎቹ

1. በሆሳዕና ከተማ፤ ከፊል ከተማ እና መደበኛ ባልሆኑ ሰፋሮች ውስጥ አሁን ያለው የውሃ አቅርቦት ተደራሽነት ደረጃ ላይ የእርስዎ አስተያየት ምንድነው? የውሃ አገልግሎቱን የሚሰጠው ማነው? የዉሃ አገልግሎት ደረጃዉን እንዴት ያዩታል? (በቂ ወይም በቂ ያልሆነ)
2. የውሃ አቅርቦት ክፍተቶችን ለመቅረፍ በአሁኑ ጊዜ በተቋማችሁ ምን ዓይነት የመፍትሄ አማራጮች እየተወሰዱ ነው (ክፍተቱ ካለ!)? እየተወሰዱ ያሉት የመፍትሄ አማራጮች በቂ ናቸው ብለዉ ያስባሉ፤ ካልሆነ ለምን?
3. በሆሳዕና ከተማ፤ ከፊል ከተማ እና መደበኛ በልሆኑ ሰፈሮች ዉስጥ የውሃ አቅርቦት ፕሮጀክት እቅድ እና አተገባበር ላይ የህብረተሰቡን ተሳትፎ እንዴት ያዩታል? በግል ዘርፉ ተሳትፎ ላይ የእርስዎ አስተያየት ምንድነው?
4. በከተማዉ ዉስጥ በፐረሰንት ምን ያህል ቤተሰቦች የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ አላቸዉ? ሁሉም ቤተሰቦች ከሌላቸዉ፤ የቧንቧ ዉሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ እንዳይኖራቸዉ እና በቂ ውሃ እንዳያገኙ ያደረጉ ዋና መሰናክሎች ምንድናቸው በተለይ ከፊል ከተማ እና መደበኛ ባልሆኑ ሰፈሮች ዉስጥ?
5. በቤተሰብ ደረጃ በቂ የውሃ አቅርቦት በመጠንና ጥራት እና የልጆች ጤና ጋር ያለውን ግንኙነት እንዴት ይገልጹታል? (ለምሳሌ ከልጅነት ተቅማጥ ጋር በማገናኘት)

6. ተቋሞዎት የውሃ አቅርቦት ስርዓቶችን በማሻሻል ዉስጥ ምን ተግዳሮቶች ገጠሞት በተለይም ከፊል ከተማ እና መደበኛ ባልሆኑ አካባቢዎች ውስጥ?
7. በአካባቢዉ የሚኖሩ ቤተሰቦች በቂና ንፁህ ውሃ እንዲያገኙ እና የልጃቸዉ ጤንነት እንዲሻሻል አሁን ያሉትን የውሃ አቅርቦት ስርዓትን ለማሻሻል ምን ዓይነት አማራጭ ስልቶች አስፈላጊ ነዉ ብለው ያስባሉ?

በቤተሰብ ደረጃ የዉሃ ዋስትና ተሞክሮዎችን መመዘኛ መጠይቅ

ተ.ቁ	ምልክት	ዝርዝር ተግባራት
1	ጭንቀት	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው ለቤተሰብዎ ፍላጎቶች ሁሉ የሚሆን በቂ ዉሃ የለንም በማለት ምን ያህል ጊዜ **ተጨነቁ**?
2	ተቋረጠ	ባለፉት 4 ሳምንታት ውስጥ ዋናው የውሃ ምንጭዎ ምን ያህል ጊዜ **ተቋርጧል** ወይም ውስን ሆኗል (ለምሳሌ የውሃ ግፊት ማነስ ፣ ከሚጠበቀው በታች የዉሃ መጠን ፣ ወንዙ ደርቋል)?
3	ልብስ	ባለፉት 4 ሳምንታት ውስጥ ምን ያህል ጊዜ በዉሃ ችግር ምክንያት **ልብሶዎን** ማጠብ ፈልገዉ ማጠብ አልቻሉም?
4	ዕቅድ	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው በውኃ ችግር ምክንያት **የጊዜ ሰሌዳዎን** ወይም **ዕቅዶዎትን** ለምን ያህል ጊዜ ቀይረዉ ነበር? (ተቋርጠው የነበሩ ተግባራተ ለምሳሌት ሌሎችን መንከባከብ፣የቤት ውስጥ ሥራዎችን መሥራት፣የግብርና ሥራ፣የገቢ ማስገኛ ሥራዎች፣ወዘተ.)
5	ምግብ	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው በውኃ ችግር ምክንያት ለምን ያህል ጊዜ **የሚበሉትን ምግብ ለመለወጥ** ተገደዳችሁ (ለምሳሌ ምግብ ለማጠብ፣ምግብ ለማብሰል፣ወዘተ በቂ ዉሃ ስለሌለ)?
6	እጅ	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው እጆች እንዲቆሽሽ የሚያደርጉ ተግባራትን ከፈፀሙ በኋላ **እጃችሁን ሳትታጠቡ** ለምን ያህል ጊዜ ሄዳችኃል? (ለምሳሌ መጸዳዳት ወይም ዳይፐር መለወጥ፣ የእንሰሳት እበትን ማጽዳት/ማስወገድ)
7	ሰውነት	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው በውኃ ችግር/እጥረት ምክንያት **ሰውነቶን መታጠብ ፈልገዉ ሳይታጠቡ** ለምን ያህል ጊዜ ለመሄድ ተገደዱ (ለምሳሌ፣በቂ ውሃ ባለመኖሩ፣ቆሻሻ ዉሃ በመሆኑ ወይም ንጹህ ዉሃ ባለመሆኑ)
8	ጠጣ	ባለፉት 4 ሳምንታት ለእርስዎ ወይም ለቤተሰብዎ **የሚፈልጉትን ያህል የሚጠጣ ውሃ** ለምን ያህል ጊዜ ማግኘት አልቻሉም?
9	ብስጩ	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው በቤት ዉስጥ ስላሉት/ ስለሚያገኙት ውሃ ሁኔታ/መጠን ለምን ያህል ጊዜ **ተበሳጭተው** ነበር?
10	መኝታ	ባለፉት 4 ሳምንታት እርስዎ ወይም ከቤተሰብዎ ውስጥ ማንኛውም ሰው የሚጠጣ ውሃ በቤት ዉስጥ ባለመኖሩ ለምን ያህል ጊዜ **ተጠምታችሁ ተኝታችኃል**?
11	ምንም የለም	ባለፉት 4 ሳምንታት ውስጥ በቤቶ ውስጥ **ምንም የሚጠጣ ውሃ የሌለበት** ለምን ያህል ጊዜ ነበር?
12	ሀፍረት	ባለፉት 4 ሳምንታት ውስጥ እርስዎ ወይም የቤተሰብዎ ማንኛውም ሰው በውሃ ችግር ምክንያት ለምን ያህል ጊዜ **ሀፍረት** ወይም መገለል እንዲሰማዎት አደረጎት?

በመስከ ምልካታ ወቅት የሚከተሉት መረጃዎች ይሰበሰባሉ

ተ.ቁ	በመስከ ምልከታ ወቅት የሚታዩት ነገሮች	አስተያየት	
1	በመኖሪያ ጊቢ ዉስጥ መሬት ላይ ሰገራ ስለመኖሩ	አለ	የለም
2	የመፀዳጃ ቤት ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ
3	በመጸዳጃ ቤት ውስጥ ወይም አቅራቢያ የእጅ መታጠቢያ ቦታ ከሳሙና እና ውሃ ጋር ስለመኖሩ	አለ	የለም
4	ብዛት ያላቸው ዝንቦች/ቢንቢዎች በመኖሪያ ቤት አካባቢ ስለመኖራቸዉ	አለ	የለም
5	በቤቱ ዙሪያ የተኛ ውሃ ስልመኖሩ	አለ	የለም
6	በመኖሪያ አካባቢ ቆሻሻ ስልመኖሩ	አለ	የለም
7	የልጁ እናት እጆች ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ
8	የልጁ እጆች ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ
9	ምግቦቹ ባግባቡ ስለመከደናቸዉ	ተከድኗል	አልተከደነም
10	ምግብ የሚቀመጥበት ሁኔታዎች	ደህንነቱ በተጠበቀ መልኩ	ደህንነቱ ባልተጠበቀ መልኩ
11	የኩሽና ቤቱ ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ
12	የምግብ ማቅረቢያ ሳህኖች ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ
13	የመጠጥ ውሃ ማጠራቀሚያ ኮንቴይነሮች ባግባቡ ተከድነዋል	ተከድኗል	አልተከደነም
14	የውሃ ማጠራቀሚያ ኮንቴይነሮች ንፅህና ሁኔታ	ንፁህ የሆነ	ንፁህ ያልሆነ

የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ የሌላቸዉ ቤተሰቦች

ተ.ቁ	ዝርዝር ተግባራት	የውሃ ፍጆታ ባለፈዉ ቀን/በ24 ሰዐት ዉስጥ በሊተር							የቤተሰብ ብዛት
		ቀን1	ቀን2	ቀን3	ቀን4	ቀን5	ቀን6	ቀን7	
የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ **የሌላቸዉ ቤተሰቦች**	ባለፈዉ ቀን/24 ሰዓት ዉስጥ የተቀዳ ዉሃ በሊትር								
	አገልግሎት/ጥቅም ላይ የዋለ ዉሃ በሊትር								
	ጥቅም ላይ ያልዋለ/ቀሪ ዉሃ በሊትር								
ጥቅም ላይ የዋለ ዉሃ በዝርዝር									
1	ለመጠጥ የዋለ ዉሃ በሊትር								
2	እጅ ለመታጠብ የዋለ ዉሃ በሊትር								
3	ልብስ ለማጠብ የዋለ ዉሃ በሊትር								
4	ለምግብ ማብሰል የዋለ ዉሃ መጠን በሊትር								
5	ለቀሪ ለተለያዩ ተግባራት በቤት ዉስጥ የዋለ ዉሃ በሊትር ከግብርና በስተቀር								
	ጠቅላላ የዉሃ ፍጆታ በሊትር በባለፈዉ ቀን								

የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ ያላቸዉ ቤተሰቦች

ተ.ቁ	ዝርዝር ተግባራት	የውሃ ፍጆታ ባለፈዉ ቀን/በ24 ሰዐት ዉስጥ በሊተር							የቤተሰብ ብዛት
		ቀን1	ቀን2	ቀን3	ቀን4	ቀን5	ቀን6	ቀን7	
የቧንቧ ውሃ በመኖሪያ ቤት እና ጊቢ ዉስጥ **ያላቸዉ ቤተሰቦች**	ባለፈዉ ቀን/ 24 ሰዓት ምን ያህል ውሃ በሊትር ወደ ውኃ ማጠራቀሚያ እቃዎች ተሞላ								
	ጥቅም ላይ የዋለ ውሃ በሊትር ከዉሃ ማከማቻ ማጠራቀሚያዎች								
	ጥቅም ላይ ያልዋለ ውሃ በሊትር ከዉሃ ከማከማቻ ማጠራቀሚያዎች								
	በቀጥታ ከቧንቧ በደቂቃ/ሰአት ጥቅም ላይ የዋለ ውሃ (ለምን ያህል ደቂቃ ተጠቀሙ)								
ጥቅም ላይ የዋለ ዉሃ በዝርዝር									
1	ለመጠጥ የዋለ ዉሃ በሊትር								
2	እጅ ለመታጠብ የዋለ ዉሃ በሊትር								
3	ልብስ ለማጠብ የዋለ ዉሃ በሊትር								
4	ለምግብ ማብሰል የዋለ ዉሃ መጠን በሊትር								
5	ለቀሪ ለተለያዩ ተግባራት በቤት ዉስጥ የዋለ ዉሃ መጠን በሊትር ከግብርና በስተቀር								
	ጠቅላላ የዉሃ ፍጆታ በሊትር በባለፈዉ ቀን								

ለጥናቱ ተሳታፊዎች መረጃ መግለጫ ቅጽ (ለረጅም ጊዜ ጥናት)

<u>የጥናቱ ርዕስ</u>: ከአምስት ዓመት በታች በሆኑ ሕፃናት ላይ የሚከሰት የተቅማጥ በሽታ ላይ የውሃ ብዛት፤የውሃ ረቂቅ ተህዋሲያን ጥራት እና ተጓዳኝ ምክንያቶች ሚና ምን እንደሆነ ማጥናት ነው፡- በማዕከላዊ ኢትዮጵያ የሆሳና ከተማ ፡፡

ለጥናቱ ተሳታፊዎች የተሰጠው መረጃ እና በጥናቱ ላይ ለመሳተፍ ፈቃደኛነትን በተመለከተ

ጤና ይስጥልኝ! እኔ እዚህ የተገኘሁት የልጅነት ተቅማጥ እና ከእሱ ጋር በተያያዙ ጉዳዮች ላይ ምርምር ለማድረግ ነው፡፡ ይህ ጥናት በሆሳዕና ከተማ ከአምስት አመት በታች በሆኑ ሕፃናት ላይ በተቅማጥ በሽታ መከሰት ላይ የውሃ ብዛት፤የውሃ ረቂቅ ተህዋሲያን ጥራት እና ተጓዳኝ ምክንያቶች ሚና ምን እንደሆነ ለማጥናት ይሞክራል፡፡ ቤትዎ ከሌሎች ቤቶች ዉስጥ በዘፈቀደ ተመርጧል፡፡ በምርምሩ ላይ ያለዎት ተሳትፎ ጠቃሚ መረጃ በመስጠት፤ ከውሃ ብዛት፣ጥራት እና ከልጅነት ተቅማጥ ጋር ተያይዘው ሊከሰቱ የሚችሉትን ጉዳዮች ለመገንዘብ ይረዳኛል፡፡ ስለሆነም ከእርስዎ የተገኘው መረጃ ከውሃ ብዛት፣ጥራት እና ከልጅነት ተቅማጥ ጋር የተዛመዱ ችግሮችን ለመፍታት ይረዳል፣ በዚህም በጥናቱ አካባቢ የህፃናትን ጤና ለማሻሻል ይቻላል፡፡ እንዲሁም በመረጃ አሰባሰብ ወቅት ልጅዎ በተቅማጥ ተይዞ ከተገኘ ስለ ተቅማጥ ህክምና በቂ የሆነ ምክር እንዲያገኙ በማድረግ ከጥናቱ ተጠቃሚ እንዲሆኑ ይደረጋል፡፡ በመረጃ አሰባሰብ ሂደት ወቅት ቤተሰቦዎ ከማንኛውም የጤና አደጋ፣ጭንቀት ወይም ምቾት ማጣት ነፃ እንደሚሆኑ ዋስትና እንሰጦታለን፡፡ ስለሆነም እርስዎ የሚሰጡት መረጃ የጥናቱን ትንታኔ እና መደምደሚያ ስለሚወስን የእርስዎ እውነተኛ ምላሽ ለጥናቱ ስኬት በጣም አስፈላጊ ነው፡፡ ጥናቱ አንድ ዓመት የክትትል ጊዜ ይኖረዋል፡፡ የእፃናት ተቅማጥ መረጃ በየሁለት ሳምንቱ ለአንድ ዓመት ከህፃኑ እናት ወይም ተንከባካቢ ይሰበስባል፡፡ በተጨማሪም የውሃ መጠን እና ረቂቅ ተህዋሲያን የውሃ ጥራት መረጃ በበጋና እና ዝናብ ወቅት ይሰበሰባል፡፡ የሰጡት መረጃ ሚስጥራዊነቱ ይጠበቅሎታል እና ማንነቶን በሚያጋልጥ መንገድ ምንም መረጃ ጥቅም ላይ አይዉልም፡፡ ተሳትፎዎ በፈቃደኝነት ላይ የተመሰረተ ነው፣እና በማንኛውም ጊዜ ከጥናቱ የመዉጣት ሙሉ መብት አልዎት። በመረጃ መግለጫ ቅጹ ላይ የተጠቀሱት መረጃዎች በሙሉ በበቂ ሁኔታ ይብራራሎታል እና በመጨረሻም፣በጥናቱ ላይ ለመሳተፍ ፍቃደኛ ከሆኑ የስምምነት መጠየቂያ ቅጹ ላይ እንዲፈርሙ ይጠየቃሉ፡፡ በመረጃ መግለጫ ቅጹ ላይ የቀረቡትን መረጃ ማብራሪያዎችን በማዳመጥ እና በጥናቱ ላይ ለመሳተፍ ፍቃደኛ ስለሆኑ እናመሰግናለን፡፡

ለጥናቱ ተሳታፊዎች መረጃ መግለጫ ቅጽ (ለአንድ/አጭር ጊዜ ጥናት)

<u>የጥናቱ ርዕስ</u>: ከአምስት ዓመት በታች በሆኑ ሕፃናት ላይ የሚከሰት የተቅማጥ በሽታ ላይ የውሃ ብዛት፤የውሃ ረቂቅ ተህዋሲያን ጥራት እና ተጓዳኝ ምክንያቶች ሚና ምን እንደሆነ ማጥናት ነው፡- በማዕከላዊ ኢትዮጵያ የሆሳና ከተማ ጉዳይ፡፡

ለጥናቱ ተሳታፊዎች የተሰጠው መረጃ እና በጥናቱ ላይ ለመሳተፍ ፈቃደኛነትን በተመለከተ

ጤና ይስጥልኝ! እኔ እዚህ የተገኘሁት የልጅነት ተቅማጥ እና ከእሱ ጋር በተያያዙ ጉዳዮች ላይ ምርምር ለማድረግ ነው፡፡ ይህ ጥናት በሆሳዕና ከተማ በቤት ውስጥ የውሃ እጦት ፣ በእናቶች የእጅ መታጠብ ልምዶች እና በልጅነት ተቅማጥ መካከል ያለውን ግንኙነት ለመገምገም ይሞክራል ።:: ቤትዎ ከሌሎች ቤቶች ዉስጥ በዘፈቀደ ተመርጧል፡፡ በምርምሩ ላይ ያለዎት ተሳትፎ ጠቃሚ መረጃ በመስጠት፤ ከውሃ ብዛት፣ጥራት እና ከልጅነት ተቅማጥ ጋር ተያይዘው ሊከሰቱ የሚችሉትን ጉዳዮች ለመገንዘብ ይረዳኛል፡፡ ስለሆነም ከእርስዎ የተገኘው መረጃ ከውሃ ብዛት፣ጥራት እና ከልጅነት ተቅማጥ ጋር የተዛመዱ ችግሮችን ለመፍታት ይረዳል፣ በዚህም በጥናቱ አካባቢ የህፃናትን ጤና ለማሻሻል ይቻላል፡፡ እንዲሁም በመረጃ አሰባሰብ ወቅት ልጅዎ በተቅማጥ ተይዞ ከተገኘ ስለ ተቅማጥ ህክምና በቂ የሆነ ምክር እንዲያገኙ በማድረግ ከጥናቱ ተጠቃሚ እንዲሆኑ ይደረጋል፡፡ በመረጃ አሰባሰብ ሂደት ወቅት ቤተሰቦዎ ከማንኛውም የጤና አደጋ፣ጭንቀት ወይም ምቾት ማጣት ነፃ እንደሚሆኑ ዋስትና እንሰጦታለን፡፡ ስለሆነም እርስዎ የሚሰጡት መረጃ የጥናቱን ትንታኔ እና መደምደሚያ ስለሚወስን የእርስዎ እውነተኛ ምላሽ ለጥናቱ ስኬት በጣም አስፈላጊ ነው፡፡ ይህ የአንድ/አጭር ጊዜ ጥናት ነው እና ሁሉም አስፈላጊ መረጃዎች የተዋቀረ መጠይቅ፣የቡድን ውይይት፣የቁልፍ መረጃ ሰጭ ቃለመጠይቆችን እና የመስክ ምልከታን በመጠቀም ይሰበሰባሉ፡፡ የሰጡት መረጃ ሚስጥራዊነቱ ይጠበቅሎታል እና ማንነቶን በሚያጋልጥ መንገድ ምንም መረጃ ጥቅም ላይ አይዉልም፡፡ ተሳትፎዎ በፈቃደኝነት ላይ

የተመሰረተ ነው፣እና በማንኛውም ጊዜ ከጥናቱ የመዉጣት ሙሉ ሙብት አልዎት። በመረጃ መግለጫ ቅጹ ላይ የተጠቀሱት መረጃዎች በሙሉ በበቂ ሁኔታ ይብራራሎታል እና በመጨረሻም፣በጥናቱ ላይ ለመሳተፍ ፍቃደኛ ከሆኑ የስምምነት መጠየቂያ ቅጹ ላይ እንዲፈርሙ ይጠየቃሉ፡፡ በመረጃ መግለጫ ቅጹ ላይ የቀረቡትን መረጃ ማብራሪያዎችን በማዳመጥ እና በጥናቱ ላይ ለመሳተፍ ፍቃደኛ ስለሆኑ እናመሰግናለን፡፡

የጥናቱ ተሳታፊዎች ስምምነት መጠየቂያ ቅጽ

እኔ ____በጥናቱ ለመሳተፍ ስምምነቴን እገልጻለሁ ፡፡

<u>የጥናቱ ርዕስ</u>: ከአምስት ዓመት በታች በሆኑ ሕፃናት ላይ የሚከሰት የተቅማጥ በሽታ ላይ የውሃ ብዛት፤የውሃ ረቂቅ ተህዋሲያን ጥራት እና ተጓዳኝ ምክንያቶች ሚና ምን እንደሆነ ማጥናት ነው፡- በደቡብ ኢትዮጵያ የሆሳና ከተማ፡

ፍቃዴን ስሰጥ የሚከተሉትን አዉቄ ነዉ፡-

1. ከላይ በተጠቀሰው ጥናት የመረጃ መግለጫ ቅጽ ላይ የተጠቀሰውን መረጃ አንብቤ መረዳቴን አረጋግጣለሁ
2. ስለ ጥናቱ ማንኛውንም ጥያቄ ለመጠየቅ እድሎች አግኝቻለሁ እናም ለሁሉም ጥያቄዎቼ በቂ መልስ አግኝቻለሁ
3. እኔ የሰጠሁት መረጃ ሚስጥራዊነቱ እንደሚጠበቅ እና ማንነቴን በሚያጋልጥ መንገድ ምንም መረጃ ጥቅም ላይ እንደማይውል ተረድቻለሁ፡፡
4. በመረጃ መግለጫ ቅጹ ላይ በተጠቀሰው መረጃ መሰረት በፈቃደኝነት ጥናቱ ላይ ለመሳተፍ ወስኛለሁ እናም በዚህ ጥናት ላይ የመሳተፍ ምንም ግዴታ አልተጣለብኝም፡፡

በመረጃ መግለጫ ቅጹ ላይ የተጠቀሱት መረጃዎች በሙሉ ለእኔ በሚገባ መልኩ በበቂ ሁኔታ ተገልፆልኛል እና በዚሁ መሠረት ከላይ በተጠቀሰው ጥናት ላይ ለመሳተፍ ተስማምቻለሁ፡፡

ፊርማ ________________ ቀበሌ _____________________ቀን__________________________