Water Quality, Sanitation, Hygiene, and Diarrheal Diseases among Children in Adadle District, Somali Region, Eastern Ethiopia

Abdifatah Muktar Muhummed (abdifatah.muhummed@swisstph.ch)
Swiss Tropical and Public Health Institute
Yahya Osman
Swiss Tropical and Public Health Institute
Rahma Abdillahi
Jigjiga University
Jan Hattendorf
Swiss Tropical and Public Health Institute
Jakob Zinsstag
Swiss Tropical and Public Health Institute
Rea Tschopp
Swiss Tropical and Public Health Institute
Guéladio Cissé
Swiss Tropical and Public Health Institute

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Abstract

Even though simple and effective treatments are available for diarrhea, it remains one of the leading causes of death in children under the age of five, accounting for 1.6 million deaths in 2017. Inadequate access to safe drinking water, particularly for pastoralists in Ethiopia, who are compelled to search for water during dry season. Thus, this study aimed to evaluate the quality of drinking water, sanitation, hygiene, and the prevalence of diarrhea among pastoralists' children in Ethiopian.

Methodology: Using a questionnaire, a cross-sectional study of 538 randomly selected households was done in 2018 to assess the prevalence of diarrhea in children younger than five years old and its association with water quality, sanitation, and hygiene. Portable DelAgua field kits were utilized to evaluate sources and home water for Escherichia coli contamination (E. coli). Logistic regression was used to assess the risk factors of water quality and diarrhea.

Results: The prevalence of diarrhea was found to be 26.6% and 31.4% in the first and second weeks, respectively. There was an association between the prevalence of diarrhea in children and the consumption of low-quality water, improper storage conditions, caregivers who did not wash their hands prior to feeding a child, whenever their hands were filthy, and children aged 12 to 24 months. In terms of drinking water, households dependent on river water and unprotected dug wells had a considerably greater likelihood of faecal contamination than those dependent on protected water (Barkad). With regard to sanitation, almost all of the households surveyed lacked basic sanitation (95.9%) and hygiene.

Conclusion: Water quality, hand-washing practice, water storage conditions, and the age of the children were found to be significantly associated with diarrhea. Thus, the current burden of diarrheal diseases in these children can be reduced by promoting widespread use of proven preventative measures, such as increasing awareness on handwashing, sanitation, waste disposal management and better treatment of stored water, and periodic monitoring of water quality.

Introduction

Mortality and morbidity due to diarrheal diseases remain a major public health concern globally (1). Even with the availability of simple effective treatments for diarrhea, it still remains one of the leading causes of death in children less than five years(2). Asia and Africa had the highest incidence diarrhea related mortality (1). In low-middle income countries diarrheal diseases are most prevalent in children less than 2 years of age (3). However mortality from diarrheal diseases occurs in different age groups, and the majority of the deaths occurred among children less than five years of age (4).

In developing countries, the main causes of diarrheal diseases are bacteria, protozoa, viruses, and helminthes (5). Among these *rotavirus, Escherichia coli (E.coli), Shigella, Campylobacter, Cryptosporidium and Gardia* are the most common known agents (2, 6–9). Pathogens can be transmitted via the ingestion of unsafe drinking water, contaminated food or oral contact with unclean hands. Lack of sanitation and inadequate hygiene promote the transmission of these pathogens (10). Poor quality of water, absence of basic sanitation, and insufficient hygiene are the main risk factors for diarrhea and contribute to nearly 90% of deaths from diarrhea (11).

In 2020, six percent of the global population lacked access to an improved water source (12). Of these, more than half drink water that would require treatment (between 10 *E. coli* to 100 *E. coli* per 100ml) (13). The contamination of water is most prevalent in Africa and Southeast Asia. Water in rural areas is found to be more polluted compared to urban areas (14). Even though African countries make a remarkable effort to increase access to improved water sources, they cannot manage to match the pace of population growth.

The Ethiopia Demographic Health Survey (EDHS) 2016 showed that six percent of children under the age of five in SRS were reported to have an episode of diarrhea as compared to 12% overall in Ethiopia (15). The Somali Regional State (SRS) in Ethiopia is one of the developing regions of Ethiopia. Nearly eighty five percent of the population are pastoralists, who depend on their livestock and livestock products, which they sell and/or consume. Moreover, SRS is one of the driest regions in Ethiopia, with regular water shortages during dry seasons and spells of flooding during rainy season. A significant number of people continue to face humanitarian challenges, including malnutrition, acute watery diarrhea, and critical water and sanitation shortage, which compromise the well-being of children (16).

In 2016 and 2017, SRS was hit by back-to-back severe draughts. A large number of pastoralist people and their livestock were forced to travel long distances in search for water, resulting in existing water sources becoming overloaded with people and their livestock and contributing to the pollution of existing water sources. The possibility of infectious diseases related to water, sanitation, and hygiene was therefore high. Thus, we aimed to assess the quality of drinking water, sanitation, and hygiene conditions, and prevalence of diarrhea in children in rural communities in Eastern Ethiopia to identify evidence-based interventions for safer drinking water, and improved sanitation and hygiene in order to reduce the burden of water borne disease.

Methods

A cross-sectional study was carried out between October and November 2018 in Adadle Woreda (district), Shabelle Zone, Eastern Ethiopia, which is 1200 km away from Addis Ababa, the capital city of Ethiopia, and 17 km away from Gode city. A household survey and microbial analysis of drinking water samples from water sources and households were used (shown in Fig. 1).

Sample size and sampling technique

A cluster sampling formula was used to compute the sample size (17). The kebeles were the clusters, assuming an intra-cluster coefficient of 0.2, a standard error of 3%, and a prevalence of diarrhea of 13% (18). The calculation resulted in 20 eligible children per kebele and sub-kebele for a total sample size of 540 children (illustrated in Fig. 2).

Out of the thirteen Kebeles, six were randomly selected using the simple random (lottery) method. Having allocated the district into six kebele, we determined the households proportionally to the population of the Kebele. In order to reach the required sample size, households were randomly selected from the six kebeles. For the random selection, kebele and sub-kebele leaders and village elders were asked to point out the center of the kebele. A pen was spun, and data collectors moved to the closest sub-kebele or village in the direction where the pen pointed. The selected cluster (village or sub-kebele) leaders were asked the number of households in the village. Where the number of households in the cluster was between 25 and 50, all the houses in the village were numbered and number randomization was used to choose the starting house. From there, the data collectors were told to turn to the right and move to every other house until the number of samples per cluster was collected. In total 538 caretaker, which had at least one child less than five years were surveyed between August to December 2018.

Data collection tools

Data collectors and supervisors received extensive training in order to preserve the data quality. The questionnaire was developed from the 2017 WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation, and Hygiene core questions on water, sanitation, and hygiene for household surveys (19) and other sources. A pre-tested structured questionnaire that was translated into the local language (Somali) was administered to the caretakers. Questions posed to caregivers included socio-demographic factors (age, level of education, marital status, monthly income, occupation, and family size), the age of the child, child health, the source of water, sanitation, and hygiene. In addition, recall questions about the occurrence of diarrhea among children less than 5 years old 14 days prior to the survey, which is the dependent or outcome variable. In addition, recall questions about the occurrence of diarrhea among children less than 5 years old 14 days prior to the survey, which are the dependent or outcome variable. Diarrhea was defined as the passage of loose or watery stool at least three times per day or more frequently than is normal for an individual at any time within the two weeks prior to the survey (20). Finally, interviewer's observation, for instance, the presence of hand wash facility and soap, observing cleanness of the toilets and water storage.

Drinking water analysis

For water sample collection, each household that was surveyed, a 500ml sterilized bottle was used for the collection of water samples. The caretakers were asked to give a cup or glass from which the child usually drinks water, with water poured from the storage source, and this was transferred carefully to the sterilized bottle. We immediately placed them in a cold chain box. All water samples from the kebele sources and surveyed households were analyzed for feacal contamination within 6 hours using a DelAgua (OXFAM, Oxford, United Kingdom) portable water testing kit with standard protocols recommended by World Health Organization (WHO guideline for drinking water quality fourth edition, Volume IV) (21).

The four main steps in preparing and analyzing water samples were culture medium preparation, water filtration, incubation, and readout of results. For the culture medium, CHROMagar Liquid ECC was used which allowed simultaneous detection of *E.coli* and thermos-tolerant coliforms (TTC). For filtration, 100ml of a water sample was filtered through a 0.45μm pore size membrane filter to catch any present bacteria. Then, the membrane filter was taken off the filter and put on the prepared pad in the petri dish, which was then transferred to the incubator. After incubation at 37^0C for 24 hours, the petri dishes were removed from the incubator and the number of colonies was counted. The blue color dots forming colonies on the surface membrane were determined as *E.coli* and the purple color as TTC.

Data analysis

Stata 15 software (Statacorp, LP, Lakeway, USA) was used for statistical analysis. Descriptive statistics were the first analysis for all factors, to provide an overview of the local situation, mainly focusing on socio-demographic characteristics, water, sanitation, and hygiene. Frequency tables were generated for categorical variables, while means, standard deviations (SD), and confidence interval were computed for continuous variables. In order to determine the association between diarrhea and water quality, sanitation and hygiene, a logistic regression modeling was used, as the outcome variable of interest (diarrhea) is dichotomous. Large model including all variables (age, sex, education, sanitation practice, hygiene, source of water, quality of water) from prior knowledge from the literature was introduced, and the model was improved by removing variables which did not add sufficient information ($p > 0.2$) one at a time based on their influence on overall model fit. Variables with a p-value less than 0.2 were kept in the model. To determine which model had better fitness, a Likelihood Ratio Test was used to compare the model with the new variable and the model without the same variable.

Results

A total of 538 households were surveyed. Nearly all of the respondents were mothers (95.4%), with majority of them had no formal education (91.3%), while 7.7% went to primary school and two went to high school and college. The mean age of the respondents and family size was 30.2 years (SD 7.9, range 16–60) and 7 (SD 2.5) individuals. Among the selected children, 58.7% were female and 41.3% were male, the mean age of the children was 15 months (SD 13.0, range 1–55) (Table1).

Table 1
Socio-demographic and household characteristics of the participants in Adadle district, Eastern Ethiopia

Variables	Frequency	%	95% CI
Sex			
Female	513	95.4	93.2–96.9
Male	25	4.6	0.03 - 0.06
Educational Level			
Primary school	42	7.1	0.05–0.09
High school	2	0.37	-
College and above	2	0.37	-
Never attend a school	491	91.3	88.5–93.5
Occupation			
Farmer	13	2.4	0.01–0.04
Merchant	10	1.9	-
Employed	13	2.4	0.01–0.04
Unemployed	11	2.0	0.01–0.03
Housewife	467	86.8	88.6–89.5
Student	1	0.2	-
Others	23	4.3	0.03–0.06
Family size			
< 4	45	8.4	0.06–0.11
4–6	196	36.4	32.4–40.6
≥ 7	297	55.2	51–59
Source of water			
Protected birkad (pool)	177	33.3	29.3–37.3
River	174	32.8	28.8–36.7
Unprotected well	149	28.1	24–32
Rainy water	31	5.8	3.8–7.8
Container for water transportation			
Plastic jerry-can	529	98.3	97-99.4
Plastic barrel	8	1.5	0.4–2.5
Bucket	1	0.2	-

Variables	Frequency	%	95% CI
Sex			
Collection time			
< 30 minute	304	56.5	52-60.7
> 30 minute	234	43.5	39.3–47.7
Container for water storage			
Plastic jerry-can	519	96.5	94–98
Plastic barrel	16	3.0	1.5–4.4
Bucket	3	0.7	-
Status for water storage container			
Open	131	24.4	20.7–28
Closed	406	75.6	71.9–79
Water treatment			
Adding chlorine	254	70.6	66.7–74.5
Stand and settle	193	53.8	49.6–58
Water quality (E.coli)			
Compliant (< 1)	160	29.74	26–33
Tolerable (1–10)	133	24.7	21- 28.5
Requires treatment (11–100)	156	29	25–33
Unsuitable for consumption (> 100)	89	16.5	14–20
Owning toilet			
Yes	516	95.9	
No	22	4.1	
Sharing a toilet			
Yes	18	82.82	
No	4	18	

The majority of households collected the water from the river (39%), followed by birkad (38%) (open cement-lined storage tanks that collect and hold rainwater), unprotected dug wells (24.8), and 31 households (5.8%) had rainwater in storage during the data collection period. About 56.5% of the households collected water from source within 30 minutes round trip, while the rest obtained water from sources over one hour round trip. 98.3% of the respondents used plastic jerry-can with a lid for transporting water from the source, and all of them were closed with a lid during transportation. Plastic jerry-can was the most frequently used container for water storage

(96.5%), and approximately three quarters of the containers were covered with a lid for water storage at the time of data collection.

Water quality was satisfactory in 29.7% of the households surveyed, with the value of *E. coli* less than one, and classified as compliant based on the WHO guideline (reference). For 25.1% of the samples, the *E. coli* were between 1 and 10 per 100ml and therefore classified as tolerable. In 28.6% of the households, water treatment is necessary to make it safe for drinking due to contamination of *E. coli* ranging from 11 to 100 *E. coli* per 100ml. In 16.9% of water samples, results exceeded 100 *E. coli* per 100ml, and these were classified as high risk (requires urgent treatment). All most of the households (95.5%) were practicing open defecation, where only 22 households reported owning a toilet, and of these, eighteen were sharing with other families (Table 1).

As illustrated in Fig. 3. Boholhagere, Bursaredo, and Gabal, who get their water from the river and unprotected dug wells had an *E.coli* count above the WHO recommendation for water quality, while Higlo, Harsug, and Malkasalah had better water quality. The red line indicates the WHO standard limit (*E.coli* count less than ten, which is considered low risk).

As demonstrated in Fig. 4, the majority of caregivers wash their hands before (71.7%) and after (66.2%) eating. About 29.9% of households stated that they wash their hands prior to cooking, whereas 28.8% do so whenever their hands are filthy. Before feeding (16.9%), after defecation (15.8%), before taking care of the child (10.8%), after taking care of the child (10.4%), and before breast-feeding (5.9%), had the lowest rates of handwashing. Handwashing facilities and soap were not observed in the houses.

The reported diarrhea prevalence in children < 5 in the two weeks before the interview day were 26.6% (95% CI = 22.8–30) and 31.4% (95% CI = 27–35). By children's age category, children aged 12–24 months were prone to diarrhea (34.9%), followed by 25 months and older (23%), and the least prevalence was reported from children aged 0–11 months (21.6%) (shown in Fig. 5).

After univariate and multivariate analysis, reported diarrhea episodes in children < 5 were significantly associated with children’s age, open storage container, mothers who were not washing their hands before feeding their child, mothers who were not washing their hands when dirty, drinking unsuitable water, and drinking water that needed treatment (Table 2). Children aged between 12 and 24 months were 1.7 times [AOR = 1.8, 95% CI (1.02–3.2)] more likely to have diarrhea compared to children aged 25 months and older. The odds of having diarrhea were 1.8 times higher for family sizes greater than seven compared with family sizes less than four [AOR = 1.8, 95%CI (0.9–3.5)]. Children drinking unsuitable water [AOR = 3.0, 95%CI (1.45–5.8)] or water that needs treatment [AOR = 3.2, 95%CI (1.78–6.1)] had three times higher odds of diarrhea compared to children drinking compliant water. The odds of children having diarrhea were 1.7 times possibly greater in the household with open storage container [AOR = 1.7, 95%CI (1.1–2.8)]. The children whose mothers were not washing hands before feeding their child were 2.6 times [AOR = 2.6, 95%CI = 1.23–5.4)], and children whose mothers were not washing their hands when dirty were 1.9 times [AOR = 1.9, 95%CI (1.04–3.43)] more likely to have had diarrhea (show in Table 2).

Table 2
Logistic regression model for the testing 1st -week prevalence of diarrhea as outcome variable; estimates are given as ORs in Addale district, Eatern Ethiopia

Explanatory Variables		Frequency	Row percent	Uni-variable OR (95% CI)	Multi-variable OR (95% CI)	P-value
Quality of water	Compliant	24	16.8	1	1	
	Tolerable	22	15.4	1.1(0.6–2.1)	1.3(0.6–2.6)	0.416
	Requires treatment	61	42.7	3.6(2.1–6.2)	3.2(1.78–6.1)	0.000***
	Unsuitable for consumption	36	25.2	3.85(2.1-7.0)	3.0(1.45–5.8)	0.002**
Source of water	Improved	33	23.4	1	1	
	Unimproved	108	76.6	1.7(1.1–2.8)	1.5(0.93–2.57)	0.09
Storage status	Closed	52	36.6	1	1	
	Open	90	63.4	2.0(1.26–3.03)	1.7(1.1–2.8)	0.02 *
Washing any time the hands are dirty	Yes	21	14.7	1	1	
	No	122	85.3	2.6(1.5–4.29)	1.9(1.07–3.5)	0.028*
Washing the hands after eating	Yes	105	73.4	1	1	
	No	38	26.6	0.68(0.44–1.05)	0.69(0.4–1.1)	0.150
Washing the hands before feeding	Yes	14	9.8	1	1	
	No	129	90.2	2.3(1.23–4.28)	2.6(1.1–4.7)	0.025*
Family size	< 4	17	11.9	1	1	
	6–7	35	24.5	1.23(0.63–2.4)	1.2(0.6–2.6)	0.545
	> 7	91	63.6	1.7(0.91–3.06)	1.8(0.9–3.5)	0.083
Age of the child	< 11months	49	34.3	0.9(0.5–1.57)	1.1(0.6–1.89)	0.86
	12-24months	66	46.1	1.8(1.06–3.1)	1.8(1.02–3.2)	0.042 *
	> 25months	28	19.6	1	1	

Discussion

In this study, results of microbial testing in the drinking water sources from river, unprotected dug wells, and some of the protected birkads were found to be higher than the WHO standard limits for drinking water quality. This is in agreement with the findings of other studies conducted in Ethiopia, suggesting that there may be widespread issues with the quality of drinking water in the country (22, 23).

About 70.7% of the families were treating the water at the household level in order to make it safe for drinking, which was higher than in previous studies done in Ethiopia but very close to a study done in Zambia (24, 25). One explanation might be the droughts, which affected the region leading to outbreaks of water-borne disease, especially acute watery diarrhea, which the government and various NGOs responded to by providing water treatments and food for both animals and humans. However, in most cases, the district has difficulties getting water treatment.

Hand washing was infrequently practiced among the people in the Adadle community. However, some of the households reported washing hands at critical times. Of these, only water was used for hand washing which is similar to another study done in Ethiopia (26). Handwashing facilities, water, soap, or other reagents for hand washing were not observed at all. Most African countries have less than fifty percent coverage of basic handwashing services (27). In a study in rural Ethiopia, fifty five percent had handwashing facilities, only seven percent were noted to have soap, water or other reagents of hand washing at the hand washing facility (15).

Our study was found to be similar to a systemic review of 31 studies in Ethiopia, in which the Somali region was found to be the second highest region in diarrhea prevalence (26%) (28). Another study done in rural areas of the Somali region reported the same prevalence of diarrhea (26%) as the current study (29, 30). Furthermore, there are slight differences with these other studies in rural Somali region, Eastern (28.9%), Gondar, North (22.1%), Beninshangul Gumez, North West (22.1%) Gojam, Northwest (21.5%), and Jigjig town, Eastern (14%) (31–34). Despite the fact, those other studies showed either similar or close to our reported prevalence of diarrhea, EDHS reported a very low prevalence. The grounds for this significant difference might be due to difficulties reaching the remote areas of the Somali region. In addition, the region was affected by severe drought for two consecutive years, with severe climate changes, might also increase the outbreaks of disease. As well, the pastoralist way of living in the region and low socio-economic development of the region compared to other regions might enhance the prevalence of diarrhea.

The risk for children suffering diarrhea was shown to be significantly associated with drinking water quality. Similarly, results from systematic review have shown significant association between increased risk of diarrhea of under-five children and *E. coli* in drinking water (35). Diarrhea occurrence was high for children who drank contaminated drinking water with *E. coli* greater than the standard limit of WHO in Botswana, Cambodia, Lesotho, Philippianes, Gambia and Bangladesh (36–40).

Children aged 12–24 months were found to have a significant association with reported diarrhea prevalence and a higher possibility of having diarrhea than children greater than 24 months, which is in agreement with other studies (41–43, 31, 44). The fact that children older than 6 months start eating solid food might increase their risk of infection. In addition to that, the children may become mobile to expose themselves to environmental pollution, any they maybe more prone to put their hands in their mouths or have poor hygiene practices.

For the caregivers or mothers who did not wash their hands at critical times, their children were more likely to suffer from diarrhea. This agrees with studies done in Ethiopia and Nigeria (45, 46). This emphasizes the importance of good hygiene practices, particularly handwashing, in preventing the transmission of diarrheal diseases.

Conclusion

Water quality, hand-washing practice during critical times, water storage conditions, and the age of the children were found to have significant association on the prevalence of diarrhea in this study. Thus, the current burden of diarrheal diseases in these children can be reduced by promoting widespread use of proven preventative measures, such as increasing awareness on handwashing, sanitation, waste disposal management and better treatment of stored water, and speeding up the introduction of the rotavirus vaccination. A surveillance system for the early identification of the infectious pathogens responsible for diarrhea and periodic monitoring of water quality is also essential. It may also be helpful to consider the specific needs and challenges of this population, such as limited access to resources, when designing and implementing such interventions.

Declarations

Ethics approval and consent to participate.

The ethical approval for this study was obtained from Swiss Ethics Committee of North-western and Central Switzerland (EKNZ BASE Req-2017-00394), and Jigjiga University Research Ethics Review Committee, in accordance with the Declaration of Helsinki. Jigjiga University also notified and sent a letter to the zone and district administrations regarding the upcoming survey. A written informed consent was provided and explained to the caregivers prior to enrollment. Before participating children were enrolled in the study, their legal guardians provided informed consent. All subjects/participants involved in the study provided informed consent.

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Corresponding author: Abdifatah Muhummed

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Authors information:

Abdifatah Muktar Muhummed, MSc, Ph.D student.

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Allschwil, Switzerland; and Jigjiga University, Ethiopia.

Email: Abdifthmu123@gmail.com

Dr. Yahye Osman, DVM, MSc,

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland and Jigjiga University, Ethiopia.

Email: maidane.osman@swisstph.ch

Dr. Rahma Abdilaahi, MD. MSc.

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Allschwil, Switzerland and Jigjiga University, Ethiopia.

Email: shuushu17@gmail.com

Jan Hattendorf, MSc PhD

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Allschwil, Switzerland

Email: jan.hanttendorf@swiss.tph

Prof. Jakob Zinsstag, DVM MPH Ph.D

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

Email: jakob.zinsstag@swiss.tph

Rea Tshcopp. DVM, PhD

Human and Animal Health Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

Email: rea.tschopp@swisstph.ch

Prof. Guéladio Cissé, MSc, PhD

Ecosystem Health Sciences Unit, Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Allschwil, Switzerland

Email: gueladio.cisse@swisstph.ch

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Figures

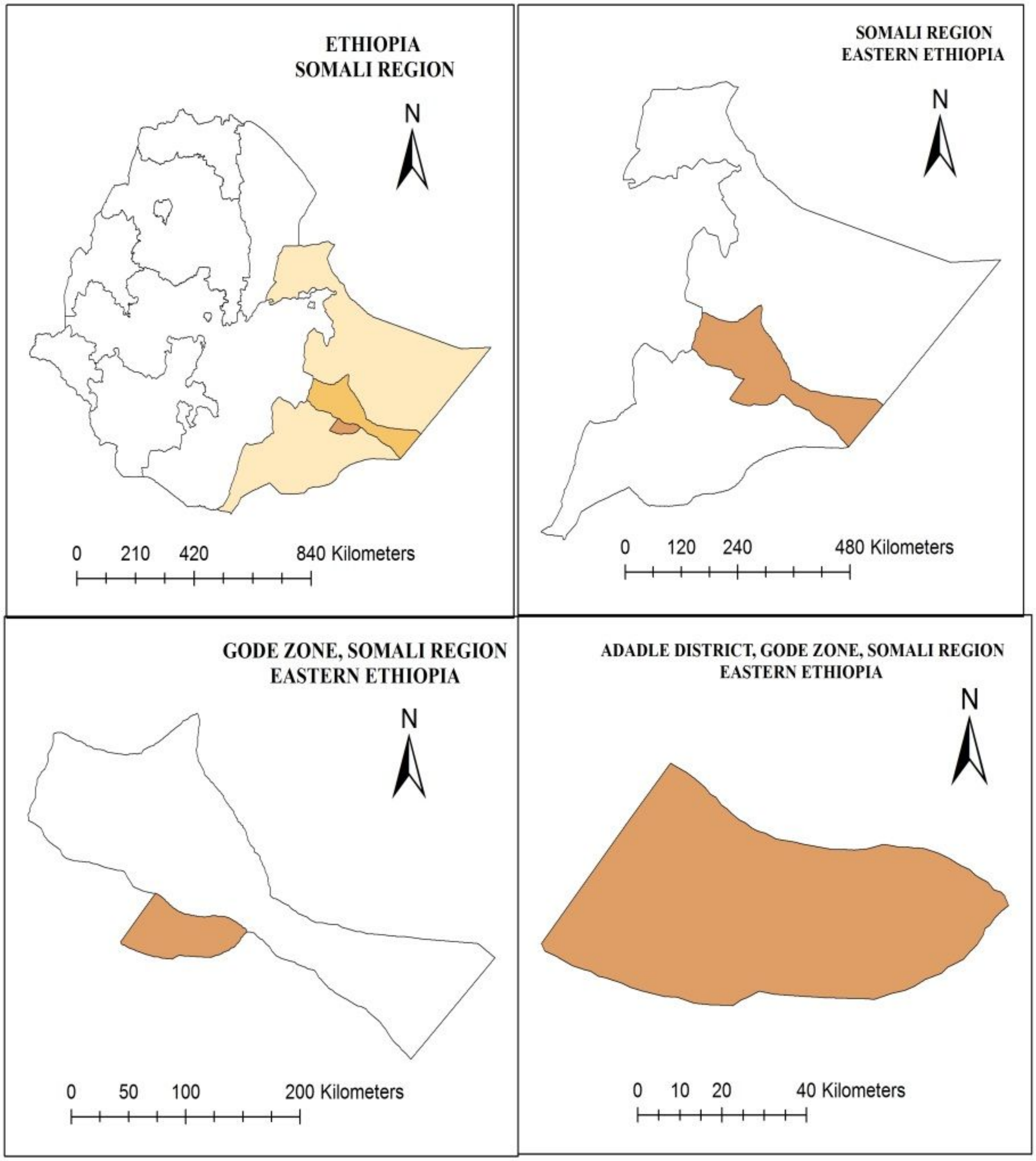

Figure 1

Map of the study area Adadle, Eastern Ethiopia

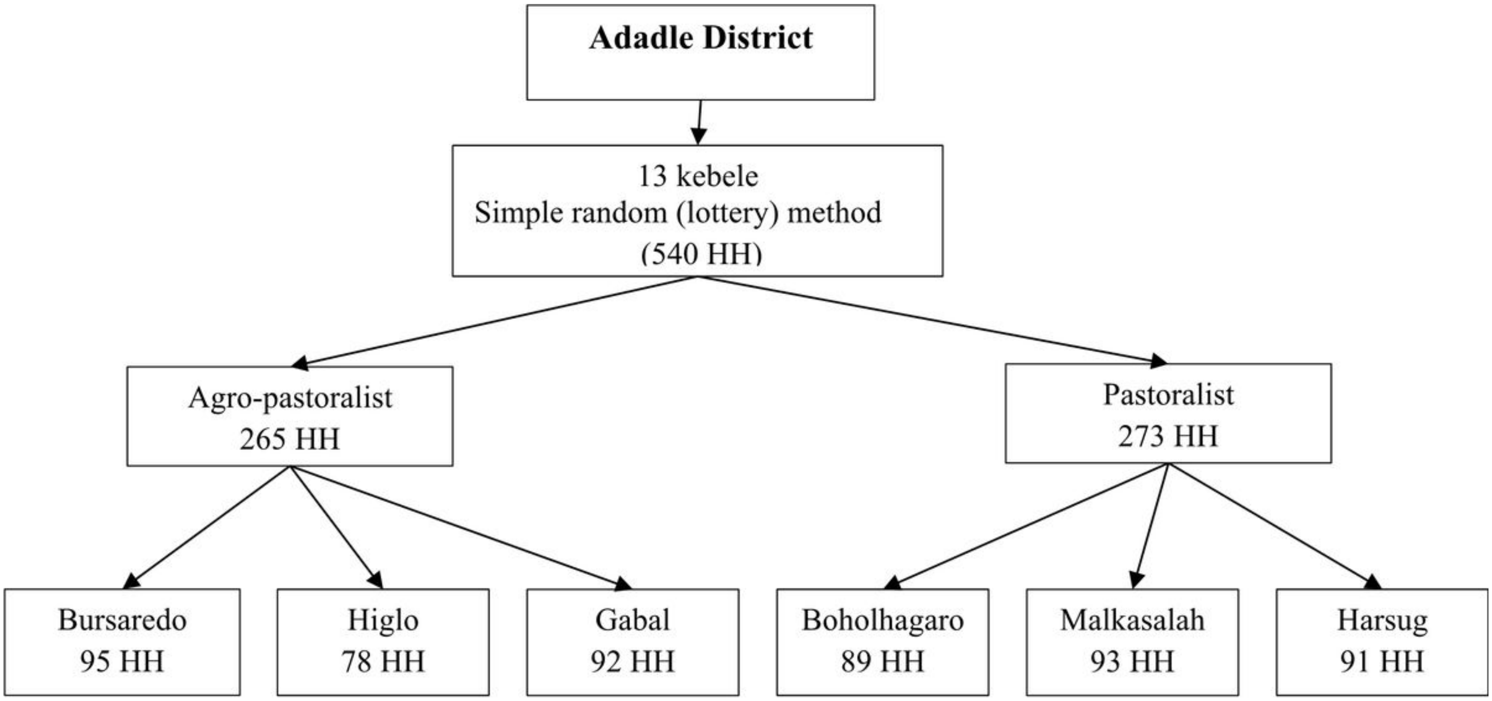

Figure 2

Sampling technique of the study in Adadle district, Eastern Ethiopia

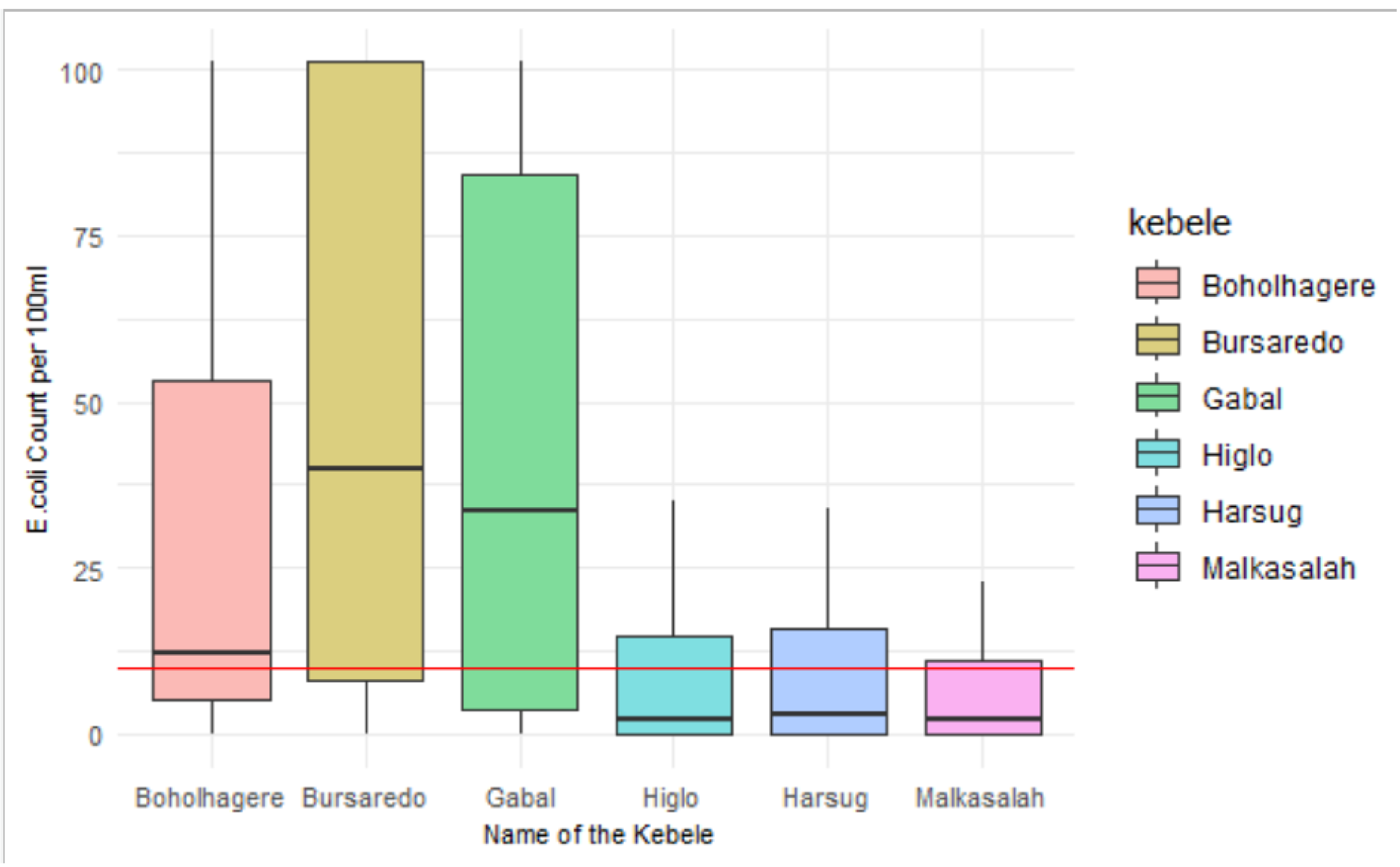

Figure 3

Drinking water quality by kebele based on the *E. coli* count per 100ml water in Adadle district, Eastern Ethiopia.

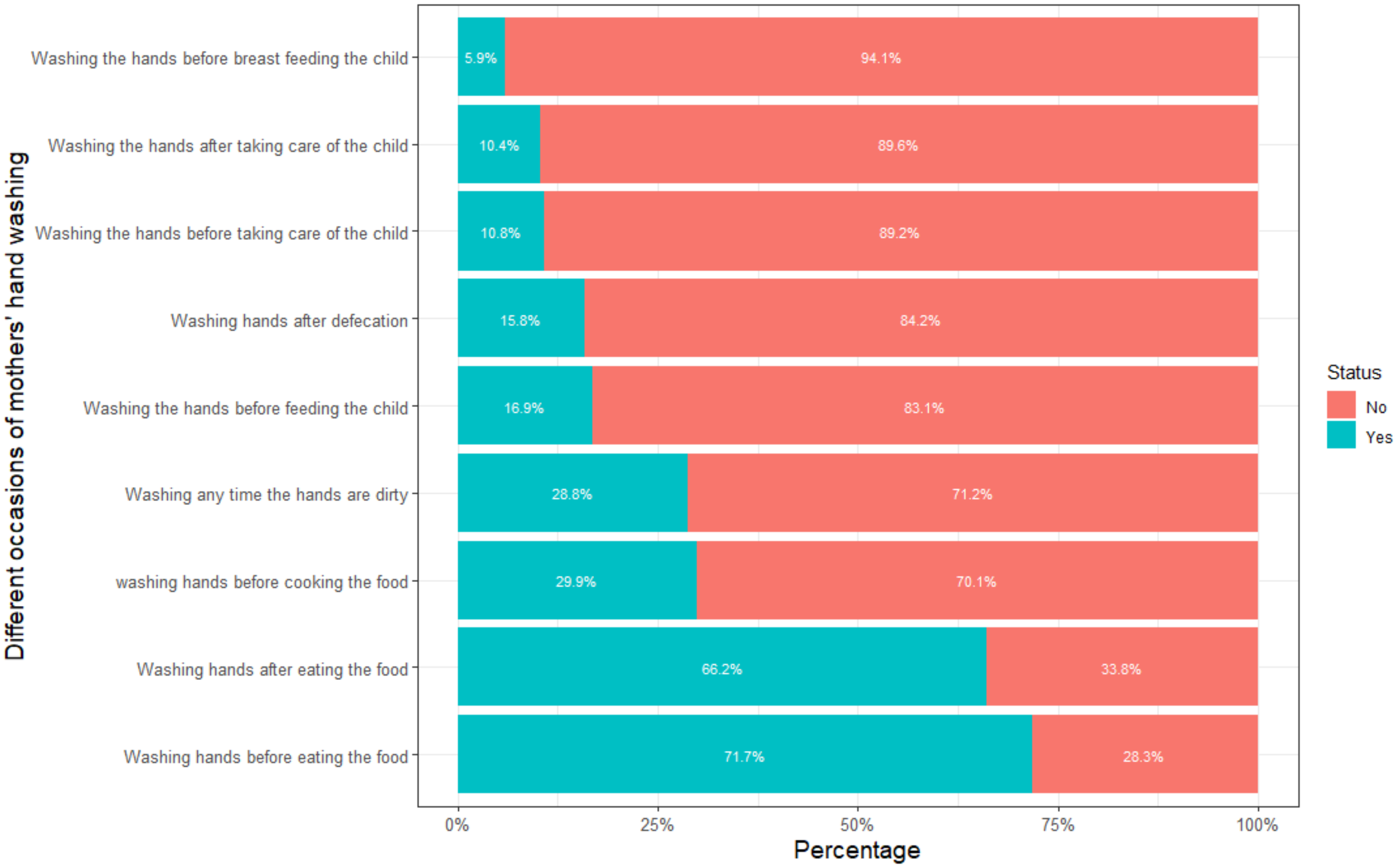

Figure 4

Different occasions of caregivers' hand washing practice in Adadle district, Eastern Ethiopia

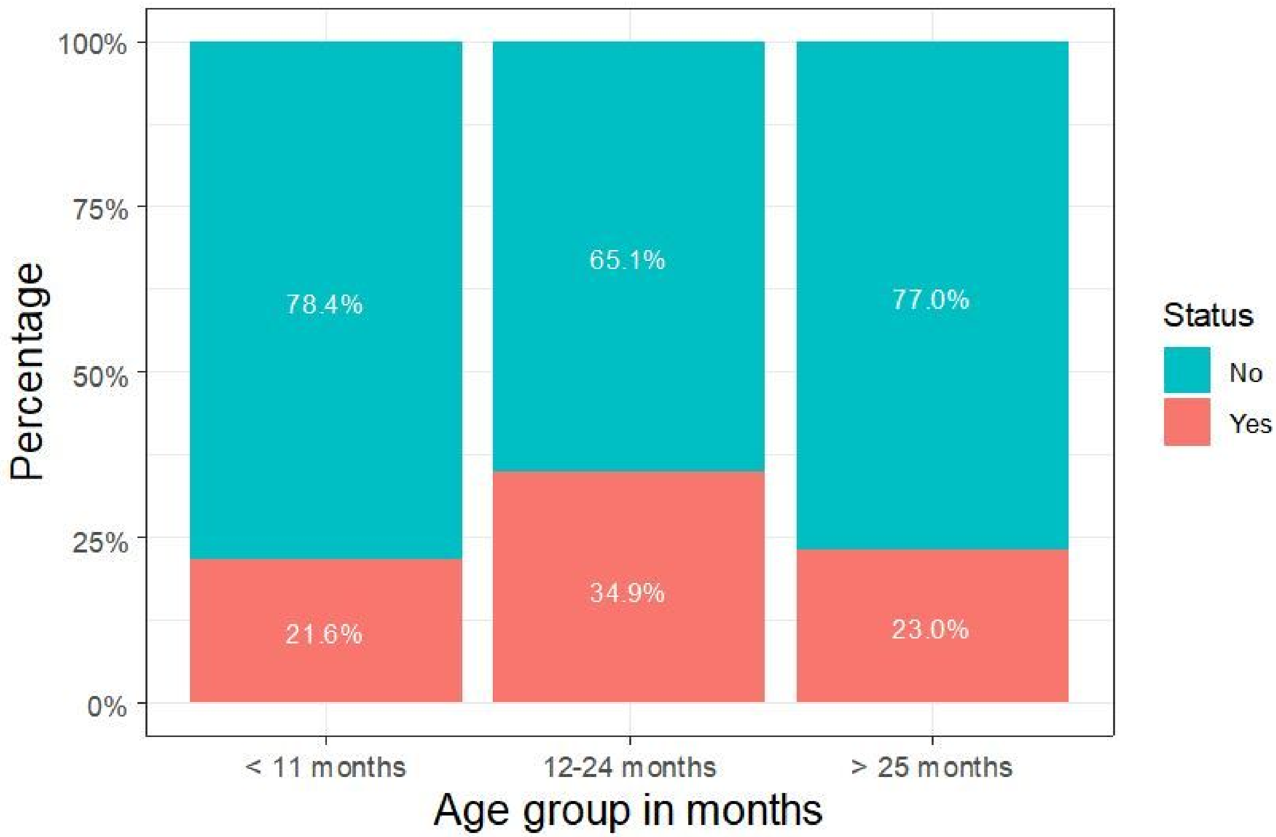

Figure 5

Prevalence of reported diarrhea in different age groups in Adadle disctrict, Eastern Ethiopia.