Heliyon 7 (2021) e08430

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Safe water supply challenges for hand hygiene in the prevention of COVID-19 in Southern Nations, Nationalities, and People's Region (SNNPR), Ethiopia

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ARTICLE INFO

Keywords:
Challenge
COVID-19
Hand hygiene
Safe water
Prevention

ABSTRACT

Background: Proper hand hygiene practices are critical in disease prevention and control, including preventing the spread of the COVID-19 pandemic, but according to a recent global report, three billion people lack access to basic hand washing facilities (soap and water) at home. Therefore, this study aimed to determine the challenges related to safe and adequate water provision for hand hygiene in the prevention of COVID-19 in Gedeo Zone, SNNPR, Ethiopia.
Methods: An institutional-based cross-sectional study design was used to assess the challenges associated with safe water supply in the prevention of COVID-19 in Gedeo Zone. Simple random sampling was used. The water sector's challenges were assessed using in-depth interviews with key informants. Water samples were collected from hand washing stations using a sterile bottle and the standard tap water sampling procedure. Bacterial analysis was carried out using membrane filtration techniques. The Wagtech Palin test and the Delagua portable water testing kit procedure was used to analyze World Health Organization (WHO) critical physicochemical parameters.
Result: The physicochemical analysis of the sample water from the hand washing facilities reveals that the pH (6.5–8) is within the WHO guideline in all samples except Gedeb town (11.1%). The residual chlorine in the samples was less than 0.2 mg/l, which is below the standard in all towns, but 15.8% of the samples in Wonago town were between 0.2–0.5mg/l. Faecal coliforms were not found in 27.5%, 21.0%, 16.6%, and 40.7% of the samples collected in Dilla, Wonago, Yirgachefe, and Gedeb town, respectively. The remaining samples were all positive for faecal coliforms. Unbalanced demand versus supply, inaccessibility, supply interruptions, financial constraints, a scarcity of competent human resources, a lack of regular water quality assessments, and a lack of stakeholder support were all identified as major challenges by all water sectors of the study towns. The majority of hand washing water samples from all of the study towns were bacteriologically unsafe. The water sector must work hard to ensure that the community has safe drinking water. All responsible bodies and potential stakeholders must support the water sectors in the Gedeo zone.

1. Introduction

Coronavirus disease (COVID-19) is a human-to-human communicable respiratory disease caused by a new coronavirus strain that is associated with acute respiratory syndrome (SARS-CoV) [1, 2]. COVID-19 spreads primarily via droplets and close contact. The main symptoms of COVID-19 infection were fever, fatigue, and cough and in addition less frequently sputum production, headache, and diarrhea were reported symptoms [3, 4, 5, 6]. Hand washing with soap and water on a regular basis, avoiding eating uncooked food, wearing a face mask, covering nose and mouth while coughing and sneezing, and keeping physical distance are all COVID-19 pandemic prevention methods [1, 6, 7].

Safe and adequate water supply is a major challenge in low-income countries; approximately 80% of disease cases are caused by a lack of adequate and quality water, sanitation, and hygiene [8, 9]. According to a study conducted in Zimbabwe [10], hand washing with contaminated water increases the risk of re-contamination with disease-causing agents. Another study found that E. coli levels on hands after washing are

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https://doi.org/10.1016/j.heliyon.2021.e08430
Received 25 July 2021; Received in revised form 16 August 2021; Accepted 16 November 2021

significantly related to contaminated handwashing water [11]. A study conducted in Bangladesh revealed that handwashing with contaminated water was significantly associated with microbial contamination of hands after rinsing [12]. Another finding revealed that handwashing with non-potable water was ineffective at lowering the risk of infection from hand-to-mouth contacts [13].

According to expert review findings [6], hand washing with soap is essential for removing pathogens from the hands. Furthermore, the findings of the study revealed that handwashing with non-antibacterial soap and water is more effective at removing bacteria of possible fecal origin from hands [14].

According to a recent global estimate, 3 billion people lack access to soap and water at home; 6 billion have limited hand washing facilities but no soap or water; and 1.4 billion have no access to any hand washing facilities at all [15]. Furthermore, the availability of basic hand washing services varied between and within countries. In low-income countries, only one in every four people access to hand-washing facilities [16]. Many factors contribute to water contamination in developing countries, including improper handling practices, transportation, storing containers, length of storage time, knowledge of water handlers, and brakes in distribution lines [17].

According to a report released in April by the Gedeo Zone Health and Water Office, the Zonal water supply coverage for 2020 is less than 20%. This deficit could worsen COVID-19 pandemic prevention efforts in this zone, which include frequent hand washing. Previously, no research had been conducted on the challenges of providing adequate and safe handwashing water for COVID-19 prevention and control. Therefore, the objective of this study was to determine the challenges of providing safe and sufficient water for COVID-19 pandemic prevention activities in Gedeo Zone, SNNPR, Ethiopia.

2. Methodology

2.1. Description of the study area and period

Gedeo Zone is one of fifteen zones in the SNNPR, Ethiopia. It is located at latitudes 5°53′N to 6°27′N and longitudes 38°8′ to 38°30′ east. The zone's elevation ranges from 1268 to 2993 m above sea level (masl). The average annual temperature ranges between 12.6°C and 30°C, and the average annual rainfall ranges between 1001 and 1800 mm. The study was conducted in the towns of Dilla, Gedeb, Yirga chefe, and Wenago (Figure 1). The study was conducted between December 2020 and February 2021.

2.2. Design of the study

A cross-sectional study design was used. This study included food and beverage vendors, schools, health institutions, commercial centers, and various governmental and non-governmental organizations that have hand washing facilities.

2.3. Water sample collection, bacteriological and physicochemical analysis

The selection of woredas was done using a purposive sampling technique, and the study subjects were selected using a simple random sampling technique (hand washing stations).

2.4. Water sample collection procedure

The following procedures were used to collect water samples from various hand washing stations:

1. Clean the tap-wipe out to remove dirt
2. Open the tap-turn on the tap at the maximum low run for 1–2 min
3. Sterilize the tap (methanol) blue flame
4. Open the tap for 1–2 min at medium flow
5. Open the sterilized bottle
6. Fill the bottle, stopper or cap the bottle

2.5. Bacteriological analysis

The membrane Filtration technique was used for sample processing. Bacteria were grown in Lauryl Sulphate Broth culture media, and samples were incubated at 44°C for 18 h to identify Thermotolerant Coliforms (Faecal Coliforms). After removing the petri dishes, all yellow colonies were counted.

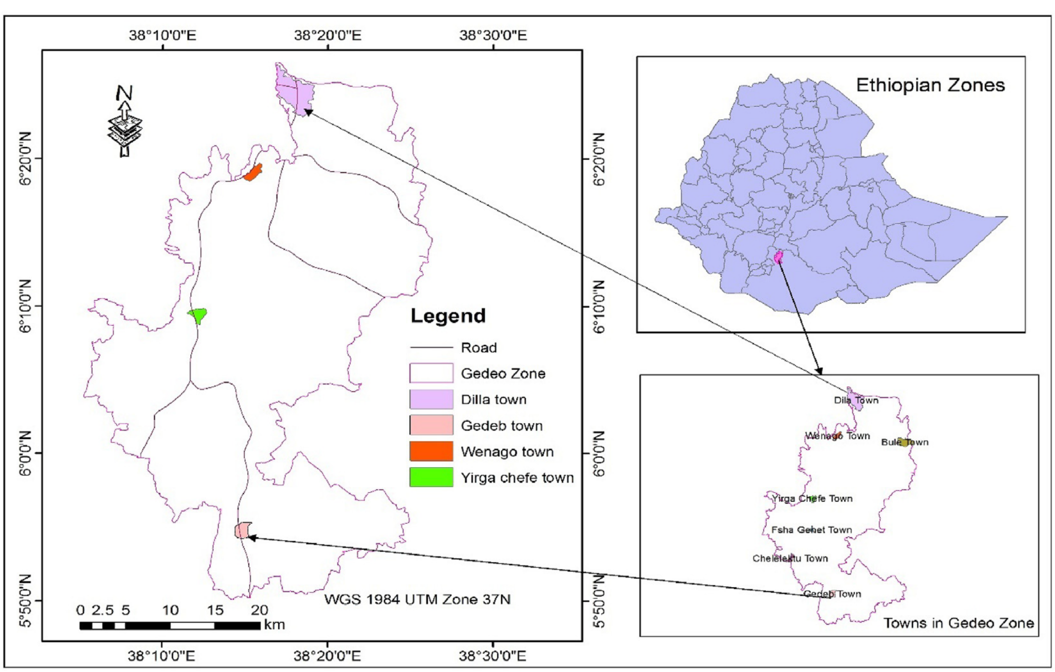

Figure 1. Map showing the study areas.

2.6. Physicochemical analysis

The Delagua portable water testing kit and manuals were used in this study to assess physicochemical parameters such as residual chlorine, pH, and turbidity [18]. The color was compared to daylight using a color comparator DPD No.1 for free chlorine residual and Phenol Red for pH (Figure 2). While turbidity was measured with a graduated turbidity tube [18].

3. Result and discussions

3.1. Physicochemical quality of water from hand washing facilities and the sources

A total of 42 samples were collected and tested for physicochemical and bacteriological quality in Dilla, Wonago, Yirgachefe, and Gedeb towns; of these, 2, 1, 1, and 2 were water sources in Dilla, Wonago, Yirgachefe, and Gedeb, respectively. The pH of all hand washing water in the study area was within WHO drinking water quality guidelines for COVID-19 prevention. This study's findings are consistent with those of a previous study conducted in Bahirdar town, where more than 91% of private tap and household water quality analyses were found to be within acceptable limits [19]. Similarly, Girum et al. found that the pH of all water samples tested in Dilla town was within the normal range [20].

The turbidity of the water in the hand washing facilities was measured and found to be less than 5 NTU, with the exception of Gedeb woreda, where three of them (11.1%) were greater than 5 NTU, which is above the WHO recommendation for safe drinking water. This finding is consistent with the previous study at Bahir Dar, which showed a result of 2.9% [19]. Furthermore, this result is consistent with a study conducted in Iran, where the Turbidity value is less than the permissible limits of 0.4–2.5 NTU [21].

Residual chlorine is another important physicochemical parameter of water. To prevent re-contamination of water by harmful microorganisms during collection, transportation, and at the household level, the residual chlorine level in the drinking-water supply system should be in the range of 0.2 mg/L-0.5 mg/L, similar to hand washing [22].

To that end, with the exception of some hand washing facilities in Wonago woreda (15.8%), none of the other woredas' hand washing facilities met the WHO guideline of less than 0.2 mg/l. This is consistent with the findings of a study conducted in Ethiopia's Addis Ketema woreda, which found that the concentration of residual chlorine in 96.7% of samples was below the normal range (0.2 mg/L-0.5 mg/L) [23].

Another study in rural Honduras found low levels of chlorine residue in household water. Residual chlorine levels in that study ranged from 0.05 mg/l to 0.1 mg/l, which is below the normal range [24]. This study was supported by another study in Nigeria Africa, which investigated the physicochemical parameters of water samples collected from five different domestic water sources in the Samaru community. The results showed that the pH value ranged from 6.5 to 7.44, indicating that all of the samples were within the range of the WHO guideline, whereas the residual chlorine was recorded at 3.2–30mg/l, deviating from both this study's result and the WHO guideline limit [25]. This high chloride concentration could be due to pollution of water sources without chemical treatment, or it could be due to water sources that have been treated with a large amount of chlorine and a sample was collected immediately. This could endanger water users and lead to the spread of a variety of waterborne diseases in the community (Table 1).

3.2. Bacteriological quality of water from hand washing facilities and sources

All water sources in each town were free of faecal coliforms, with the exception of Yirgachefe, which tested positive for thermotolerant coliforms (9CFU/100ml). Drinking water should be free of pathogenic (disease-causing) microorganisms. The presence of thermotolerant bacteria like E. coli is conclusive evidence of fecal pollution Figure 3.

From the hand washing facilities in Dilla town, 27.5% had zero coliforms, 57.6% had positive faecal coliforms, which is outside of the WHO guidelines, and 15% had too many to count (Table 2), indicating that the water is full of faecal coliforms, implying that it is very dangerous for the public who use it.

A study conducted in Jimma zone revealed that the majority of the faecal coliforms counts in the water samples were greater than 0 CFU/100ml, indicating that the majority of the water used at the household level was unsafe for health. This study's findings indicated that the majority of water used at the household level was unsafe for human consumption, which is consistent with the current study in the Gedeo zone [26].

Faecal coliforms were detected in the majority of the hand washing facilities that were above 0 CFU/100ml (57.6%, 57.9%, 56.7%, and 48.1%) of the facilities in Dilla, Wonago, Yirgachefe, and Gedeb woredas, respectively (Table 2). This result indicated that the water intended for

Figure 2. Color comparator device for free chlorine residual and pH determination. Taken from [18].

Table 1. Physicochemical quality of hand washing water in Gedeo Zone, 2020/21.

Town	No of samples	pH						Turbidity (NTU)				R.Cl (mg/l)					
		<6.5		6.5 ≤ pH ≤ 8		>8		≤5		>5		<0.2		0.2≤Cl⁻≤0.5		>5	
		Frq	%	Frq	%	Frq	%	Frq	%	Frq	%	Frq	%	Frq	%	Frq	%
Dilla	40	0	0	40	100	0	0	40	100	0	0	40	100	0	0	0	0
Wenago	19	0	0	19	100	0	0	19	100	0	0	16	84.2	3	15.8	0	0
Yirga chefe	30	0	0	30	100	0	0	30	100	0	0	30	100	0	0	0	0
Gedeb	27	0	0	27	100	0	0	24	97.4	3	2.6	27	100	0	0	0	0
Total	116	0	0	116	100	0	0	113	97.4	3	2.6	113	97.4	0	2.6	0	0

NTU: Nephelometric Turbidity Unit; R.CL: Residual Chlorine.

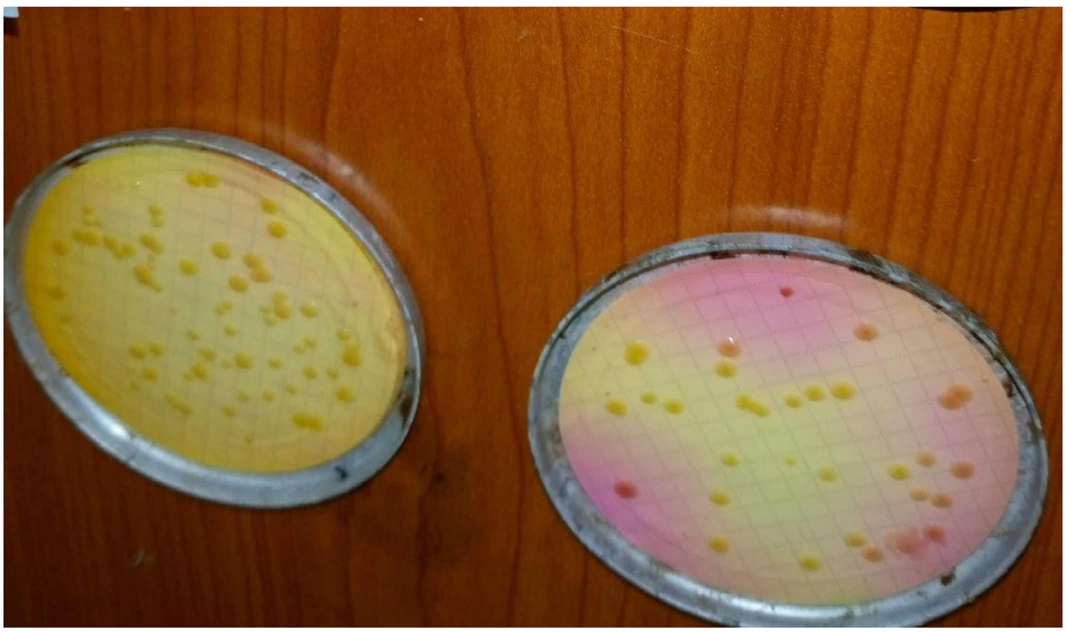

Figure 3. Faecal coliform colonies appear as with yellow colonies using lauryl sulphate broth media.

Table 2. Bacteriological analysis of hand washing facilities at different town Gedeo Zone, 2020/21.

Town	Number of samples	CFU/100ml					
		≤0		>0		TNTC*	
		Ferq	%	Ferq	%	Ferq	%
Dilla	40	11	27.5	23	57.6	6	15
Wenago	19	4	21.0	11	57.9	4	21.0
Yirga chefe	30	5	16.7	17	56.7	8	26.7
Gedeb	27	11	40.7	13	48.1	3	11.1
Total	116	31	26.7	64	55.2	21	18.1

* TNTC = Too Numerous TO Count; CFU: Colony Forming Unit.

hand washing in all towns was contaminated at the facilities or brought from water sources contaminated with human waste, such as river water and unprotected springs, due to a lack of continuous drinking water supply in towns and possibly a lack of community awareness about the equivalent hand washing quality of water with drinking water.

Studies at different place in Ethiopia showed that in most of water samples taken from sources, tap and point of use (households) both total coliform and faecal coliforms were detected [27, 28, 29]. Several studies in Ethiopia found total coliforms and faecal coliforms in the majority of water samples collected from sources, taps, and points of use (households) [30]. A similar pattern was observed in a study conducted in Nigeria, which concluded that pathogenic organisms were present in hand-wash water samples. The majority of the organisms isolated from that study were E. coli, S. aureus, Pseudomonas sp, Shigella sp, and Enterobacter sp. [31].

The high percentage of faecal coliform in hand washing facility water could be due to the bacteriological quality of water sources. The results of Dilla town's sanitary survey, which were completed in 2020, confirmed to this fact. The paper concluded that Dilla town's sanitary survey results suggested that both surface and groundwater sources were not safe in terms of bacteriological quality [20]. Furthermore, a study conducted at the Internally Displaced Persons Sites in the Gedeo Zone revealed that the majority of water sources tested positive for faecal coliforms [32]. Comparison of water safety in terms of bacteriological quality among the study towns showed that Yirgachefe town is the most unsafe (only 16.7% of the hand washing water was safe) next to Wonago (only 21.0%) and Dilla (27.5%). Better safety was seen at Gedeb town that accounts 40.7% of them were safe.

In another study conducted in Andhra Pradesh, India, total coliforms and E. coli levels exceeded both national and international guidelines. The majority of the samples contained microbes, indicating that the drinking water sources were contaminated at the time of sampling in that study area [33]. The bacteriological quality assessment results of drinking water in the Amritsar district of northern India reported that a total of 42.9% (565/1,317) samples from various sources were found to be unfit for human consumption. This finding also supports the current hand washing water quality assessment [34].

The contamination of hand washing water is not unique to this study area; rather, it is a global issue that affects even drinking water quality. This problem was clearly demonstrated in a study conducted in Khulna, Bangladesh, for example. In that study area, the bacteriological analysis experiment was carried out from the mains (pump water) and corresponding residences (households) were tested for the presence of coliform organisms. Analysis of the bacteriological quality of pump water and household water revealed the presence of faecal and non-faecal coliforms in 36.36% of the pump water and 42.86% of the household water.

Finally, the study concluded that 71.43% of Khulna city's drinking water sources were unsafe and unfit for human consumption [35].

Another study in the same country (Bangladesh) concludes that the overall quality of drinking water in the study area is unsafe and unfit for consumers. The microbiological counts, hardness, and iron concentration of water continue to be the most concerning. The presence of numerous Fecal and Total coliform counts indicated the presence of pathogenic organisms that could pose a risk to consumers' health, as in our cases from different towns [36].

Another study in Nepal found similar results to ours. The findings of that study in Nepal revealed that 100% of the tap water samples and 87.5% of the bottled water samples were contaminated with heterotrophic bacteria. Of the tap water samples, 55.3% were positive for total coliforms and 21.1% and 14.5% being contaminated with fecal coliforms and fecal streptococci respectively [37].

3.3. Challenges of water supply

In-depth interviews with key informants for the woreda's office of water and sewerage authority were used to assess the water supply challenges in the selected four woredas. In general, the challenges of the water sector in each of the four towns were assessed independently, but the results revealed that they are nearly identical. The following are summaries of the sector's common and major challenges in the Gedeo zone:

1. Water scarcity as a result of unbalanced community water demand and supply. Unbalanced water demand and supply was a common issue among the towns studied in this study, and it is one of the causes of water scarcity. Increased population growth, rapid urbanization, and an inappropriate initial water design plan could all contribute to this problem. In this regard, there were different studies that identified similar results for example Chala 2015, showed that the water demand and supply in Addis Ababa in general and Bole and Kolfe Keranyo Sub Cities in particular have never been matched due to the fast population growth of the city [38]. Furthermore, water harvesting techniques were not used in the study area to address the problem of water scarcity; for example, in Sudan, family water tanks were used to provide safe water for the community [39].
2. Many kebeles and villages lacked water line connections, implying that a significant number of community members were not provided with safe drinking water in all of the study towns.

Continuous water interruptions, low pressure and insufficiencies are present in the town water supply system. The water supply system of the town is rendering unequal distributions among the residents of the town, which was a common cause for complaints from the community shortage of budget unequal distribution lack of awareness [40].

3. The continuous water supply is impacted by electric power fluctuations at the pumping station.

An interruption of water supply was a common problem throughout the study area, as observed by the investigators during data collection. This problem is caused primarily by power fluctuation. According to a study conducted in Abo town, the major causes of water interruption are the town's topography, an outdated water supply system, the nature of the soil, a lack of water power, and an electrical power outage [41].

4. Poor pressure management and water wastage due to lack of maintenance for broken water pipes at different places.

This problem is a very common problem not only in this study but also other studies done previously for example poor pressure management and other many specified problems were identified as a major problem for drinking water supply at Mekell city [42].

5. Lack of spare parts, maintenance materials, shortage of water treatment chemicals (basically calcium hypochlorite), poor financial management and Poor initial planning

This problem might be due to the shortage of annual budget allocation which is a common problem not only in Gedeo zone but also across the country even the capital city Addis Ababa is a victim of this problem as indicated [38]. In other study lack of spare parts due to shortage of budget and poor management system of the town administration at Harer town was investigated [43].

6. Shortage of skilled personnel of different professionals like chemist, engineers and plumbers etc.

Skilled water professionals are critical in the water sector, but almost all studied sectors are not well organized, and the sectors are managed with a limited number of professionals, as noted by key informants of each water sector of the woredas. This problem was evidenced by a study conducted at Harer and other locations throughout the country as a lack of trained personnel who fully understand how to operate the systems [43].

7. Limited public stands and main lines from the reservoirs to the end-users

This is another common problem faced in all the study towns due to shortage of budget, lack of support from different stakeholders. This result is supported by the research finding done in Amhara region, population accessed to the public stand at Rebu Gebeya town Amhara regional state accounts for only 54.8% [44]. Lack of regular and/or periodic water quality assessment (both physicochemical and bacteriological tests).

The water quality assessment problem is directly related to the lack of professional experts and unavailability of laboratory test kits in the water sector this problem identified in this study supported by the previous study done at Harer in Ethiopia Lack of quality assurance due to absence of laboratory equipment [43] and study in Kazakhstan showed that, the water sources were not tested for compliance with the sanitary standards before and during the operation [45].

8. Lack of stakeholders supports in terms of knowledge and finance too.

In the study area of all the town water service key informants stated that there was a significant problem with support from different governmental and nongovernmental organizations in terms of both technical knowledge and finance. This finding is supported by study results from the West Gojjam Zone, which revealed a lack of adequate human resources, budget, and support from responsible bodies [46]. All the listed problems led to water crises and the effect of this water crises might be causes for water scarcity, poor water quality and high spread of water related diseases among the community.

4. Conclusions

The bacteriological quality of water used for hand washing in all study towns was not safe, with levels exceeding 0 CFU/100ml. Except for pH, the physicochemical quality parameters (pH, Turbidity, and Residual Chlorine) of the hand washing water were above the WHO guideline value. The bacteriological quality of water used for hand washing in all study towns was not safe, with levels exceeding 0 CFU/100ml. Except for pH, the physicochemical quality parameters (pH, Turbidity, and Residual Chlorine) of the hand washing water were all above the WHO guideline value.

Water scarcity was a major problem in all of the towns studied. The presence of Faecal coliform bacteria in the majority of the samples requires immediate investigation. Furthermore, the physicochemical parameters were higher than the WHO guideline value. Dilla University and other stakeholders should provide scientific knowledge to all of the study towns' water sectors. The water sector should be equipped with operation and maintenance tools, as well as various professionals.

5. Ethical consideration

Both verbal and written consent were considered and supportive letters from Dilla University and different stakeholders have been secured, and approval from the IRB of the university was also secured before the implementation of the research.

Declarations

Author contribution statement

Mekonnen Birhanie Aregu & Zemachu Ashuro: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Girum Gebremeskel Kanno & Awash Alembo: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Addisu Alemayehu: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Funding statement

This work was supported by Dilla University Research and Dissemination Office.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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