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ABSTRACT

BACKGROUND: Ineffective hand hygiene in healthcare settings is a global challenge that is associated with a high rate of nosocomial infections. The study aimed to measure the effectiveness of handwashing at Dilla University referral hospital.

METHOD: This study consisted of 2 parts; the survey work and laboratory analysis. A total of 63 participants were selected to take surveys using an interviewer-administered questionnaire to collect the data regarding the socio-demographic and hand hygiene-related practices. A laboratory tests (swab test) was used to assess handwashing effectiveness from 63 participants by taking 126 swab test (63 before and after hand washing sessions). A swab test was collected from the palms of each participant before and after hand washing using a sterile technique. The cultures were then incubated aerobically overnight at 37°C, and examined for microbial growth. The bacterial load was reported as the number of colony-forming units (CFU).

RESULT: The proportion of effective hand washing in Dilla University Referral Hospital was 82.5%. The mean colony-forming unit before and after handwashing were 55 and 2 CFU/ml, respectively with an average reduction of 94.6% in terms of CFU/ml. The mean amount of water used for effective handwashing was 336.03 (±219.46) ml. There was a significant mean difference in the amount of water used and duration of hand rubbing between effective and non-effective handwashing among the participants ($P < 0.01$). The bacterial load before and after handwashing indicated that there was a significant (53.3 mean CFU) reduction in bacterial load after handwashing practice which indicated that the handwashing intervention in the Referral hospital was effective ($P < 0.01$).

CONCLUSION: The proportion of effective Hand washing in Dilla University referral Hospital was 82.5% with a 94.6% reduction in terms of (CFU/ml). The amount of water use and the duration of hand rubbing showed a significant difference in the reduction of the microbial load.

KEYWORDS: Hand washing, hand Washing effectiveness, Swab test

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Introduction

Even if effective or thorough hand hygiene is assumed to be the simplest intervention by many, it is one of the cost-effective components of infection control for reducing healthcare-associated infections (HAIs) including COVID-19 worldwide.[1-3] The hands of Healthcare workers' could be one of the means for transmitting healthcare-associated pathogens from one patient to the other and within the healthcare setting.[4] Hospital-acquired infections (HCAIs) are infections acquired during care or treatment in a healthcare facility are global challenges to assure patient safety.[5]

HAIs are a potential threat to patient safety and cause patient morbidity and mortality and their impact is linked with many adverse consequences including prolonged hospital stay, long term disability, increased resistance of microorganisms to antimicrobials, an increase in extended financial burdens, excess deaths, high financial costs for the health systems and psychological stress for patients and their families.[5,6]

Estimations done in Europe indicated that HAIs due to poor hand hygiene are among the highest disease burdens of communicable diseases with more than 2.5 million new HAI cases registered each year which can be translated as 501 disability-adjusted life years (DALYs) per 100 000 general population.[7] In developed countries, HCAI is the reason for 5% to 15% of hospitalization of patients and 9% to 37% of those admitted to intensive care units (ICUs).[8,9]

HAIs due to poor hand hygiene is also a challenge in developing countries, where the prevalence is estimated to be more than 19% and around 50% of them occur due to the contaminated hands of health care providers (HCPs).[10,11]

In addition to the burden posed by HAIs, the fact that disease-causing microorganisms can stay for 2 to 60 minutes on health care workers' hands highlights the need to address these infections at the health facility level using effective methods such as hand hygiene is prominent.[12]

Adherence to hand hygiene recommendations and effectiveness of each hand hygiene session were primary focuses since the start of the COVID-19 pandemic because physical contact or contact with infected surfaces and material is one of the major transmission routes other than the projection of aerosols.[13]

A recent study indicated that hand hygiene was a very critical issue among Ethiopian health care workers with a national hand hygiene compliance status of 38% and Southern Nations and Nationalities and Peoples Regional State (where Dilla University Referral Hospital located) had the lowest hand hygiene compliance which was only 9%.[14]

The main reason responsible for low compliance and ineffective hand hygiene practices among health care workers was the knowledge and attitude of the HCW regarding hand hygiene.[14] Other factors that play key roles in better compliance and effective hand hygiene includes, the availability and provision of handwashing infrastructures at the hospital level, the provision of adequate logistics for hand hygiene, and the presence or absence of hand hygiene compliance monitoring mechanisms in the health care set up.[15,16]

The World Health Organization had launched global guidelines and recommendations for hand hygiene in healthcare facilities in 5 critical moments which include, before and after touching a patient, before aseptic procedures, after touching patient surroundings, and after body fluid exposure risk.[11]

There was a recommendation, for effective or thorough hand hygiene, where the health care facility must ensure the presence and the use of a proper volume of hand hygiene products such as (soap, water, or alcohol-based hand rubs) for a sufficient amount of time, and avoid re-contamination of hands after hand washing by using a paper towel to turn off the faucet.[17]

Assessing the thoroughness (technique) of hand hygiene in the health care setup is as important as monitoring the action of hand hygiene.[17] Microbiological methods using swab tests have been suggested as simple and appropriate methods for assessing hand hygiene thoroughness or effectiveness in resource-limited health care settings.[17,18] Although, there are a number of studies that assessed the hand hygiene compliance at the health facility level, there is an information gap in the hand hygiene effectiveness of health care providers at the health facility level. The amount of hand hygiene products such as water, that is needed for effective hand hygiene practice is also missing from the scientific literature as far as the authors of this research are concerned. Therefore this study intends to assess the effectiveness of handwashing practice in Dilla University Referral Hospital.

Materials and Methods

Study site, setting, and design

The study was conducted in Dilla University Referral Hospital which is found in Southern Nation Nationality and People Regional State (SNNPRS), Ethiopia. Dilla University Referral Hospital is a practical training center for more than 5 departments, as well as providing curative services with a total bed capacity of 200. A cross-sectional survey was used to study the effectiveness of hand hygiene among health professionals, students, and janitors in Dilla University Teaching Hospital, Southern Ethiopia by measuring the effectiveness before and after handwashing. This study has been done from September to October 2021.

Sample Size, Sampling Technique, and Procedure

A total of 63 participants were selected (health workers, janitors, and health science students) and they were randomly selected for their handwashing effectiveness. The wards with higher patient load were selected for this study and the COVID-19 treatment center was purposely included in this study. The participants were selected by random sampling technique at each station who meets the inclusion criteria. The criteria for inclusion was the participant's skin was intact and had not done handwashing or used hand rub at least 4 hours before sample collection. Both hands were swabbed before and after performing the handwashing with soap and water. After swabbing, the swabs were directly sent to the Microbiology Laboratory of Dilla University referral hospital to count the colony of the bacteria which colonize the hand.

Data collection methods

Microbiology sample processing. Sterile cotton swabs dampened in 0.85% saline were used to take samples from the entire palm surface (Figure 1). Pre-moistened swabs were rotated on the palm surface and the cotton swabs were immersed in 50 mL sterile saline and immediately transported to Dilla University referral hospital microbiology laboratory for further analysis. 0.5 mL of each sample were then inoculated onto blood agar enriched with 5% sheep blood (Becton, Dickinson, and Company). Plates were incubated at 37°C under aerobic conditions, and colony-forming units (CFUs) were counted after 24 to

48 hour using a colony counter. The colony-forming units ranged between 0 and 105. Gram staining was done for the identification of gram-positive and gram-negative from the culture based on their gram reaction using the 4 basic gram staining reagents like crystal violet, gram's iodine, acetone–alcohol, and safranin and interpreted as gram-positive bacteria will stain blue to purple while gram-negative bacteria will stain pink to red.

According to Aregu et al,[19] the quality of the water used for hand hygiene is a key determinant for effective hand hygiene practice. Therefore, 4 water samples were taken from the 4 wards before the beginning of the study for microbial analysis. All the samples were free from any bacterial contamination with 0 E Coli and faecal coliforms. For measuring the amount of water used for handwashing a standard graduated cylinder was used (Figure 2).

A swab test was taken before the beginning of handwashing and the participants were allowed to wash their hands.

The water used for hand washing was collected in the handwashing container. One data collector measured the duration of handwashing practice, another 2 data collectors measured the amount of water used for handwashing, 1 data collector takes a swab test after the handwashing practice and the final data collector manage the interview using the interviewer-administered questionnaire.

Figure 1. Swab sample taking for hand hygiene effectiveness at Dilla university referral hospital.

Data analysis

The handwashing practice effectiveness using soap and water is defined as the reduction of the number of mean colonies on the samples before and after the handwashing performance. We have used timers to measure the duration of hand rubbing and handwashing times separately. An independent data collector was assigned for these tasks. The average reduction of the colony forming-units (CFUs) before and after handwashing was compared using a paired samples *t*-test. An independent sample *T*-test was also used to analyze the duration of hand rubbing, handwashing, and amount of water used with effective handwashing practice. Only results with post swab test of no colony-forming unit were considered as an effective handwashing practice. A *P*-value $\leqslant .05$ was considered for statistical significance.

Result

General characteristics of the participants

The 63 participants predominantly were males 46 (73%), between the age of 20 to 30 years 43 (68.8%), had a tertiary level of education 52 (82.5%) and with no working experience 39 (61.9%). More than half of the study participants were health science students 32 (50.8%). Only 25 (39.7%) of the participants reported that they have taken basic infection prevention training (Table 1).

Hand hygiene at critical times

Respondents were asked, after which procedure they are making a handwashing practice, the swab test before handwashing

Figure 2. Measuring the amount of water used for handwashing using graduated cylinder in Dilla University referral hospital southern Ethiopia.

Table 1. Socio-demographic characteristics of the study participants in Dilla university referral hospital southern Ethiopia.

SR NO	VARIABLE	FREQUENCY	PERCENT
1	Gender		
	Male	46	73.0
	Female	17	27.0
2	Marital status		
	Married	19	30.2
	Single	44	69.8
3	Education level		
	No formal Education	8	12.7
	Primary education	3	4.8
	Secondary Education	52	82.5
	Tertiary and Above		
4	Age		
	15-20	6	9.5
	20-30	43	68.8
	>30	14	22.2
5	Monthly Income in Ethiopian Birr*		
	<1000	23	36.5
	1000-3000	18	28.6
	>3001	22	34.9
6	Profession		
	Health Professional	21	33.3
	Health Science student	32	50.8
	Cleaners	10	15.9
7	Total work experience		
	No experience	39	61.9
	<4 years	14	22.2
	>5 years	10	15.9
8	Training on Infection prevention		
	Yes	25	39.7
	No	38	60.3

*Currently 1 US Dollar($) = 55 Ethiopian Birr.

indicated that the highest bacterial growth was detected in hands who have been exposed to body fluids right before the handwashing session as indicated in (Figure 3).

Among the study participants, hand washing was mainly performed after touching with patient surroundings 26 (41. 27%) followed by after patient contact which was 23 (36.51%) as shown in (Figure 4).

Swab test result before and after handwashing

Bacterial count before handwashing with soap and water ranged from 0 to 120 CFU/hand, with a mean of 55.4 (±32.5) CFU/hand. The bacterial count after handwashing with soap and water ranged from 0 to 25 CFU/hand, with an average of 2.08 (±5.049) CFU/hand. It was found that the average reduction in the number of colonies (CFU/ml) was 94.6% as shown in (Figure 5).

Effectiveness of the handwashing practice

The result of the swab sample collected before handwashing showed that there was Bacterial growth on 47 samples while only 16 samples showed No bacterial growth which indicated that the proportion of effective handwashing was 82.5%. The Result of the swab sample collected after hand washing indicated that Bacterial growth was detected on 11 of the samples and No bacterial growth was seen in the remaining 52 samples. Based on gram staining 92% of the isolated bacteria were gram-positive while only 8% were gram-negative. The handwashing located at the nursing station exhibits the highest effective as well as non-effective handwashing practice as shown in (Figure 6).

The effectiveness of handwashing across the different study participants showed that students were the highest in having effective and non-effective handwashing practices as indicated in (Figure 7).

Amount of water used for effective handwashing

The average water used for hand hygiene was 336.03 (±219.46) in Dilla University Referral Hospital and the average amount of water used for effective handwashing was 364.3 (±230.9) ml. The COVID-19 center in the hospital has used a higher amount of water on average whereas the nursing station utilized the lowest as indicated in (Table 2). The mean amount of water used by those who effectively wash their hands and those who didn't was 364.3 and 202.5 ml, respectively, with a significant 161.8 ml of water difference between the 2 groups.

Duration of handwashing and frequency of handwashing

As indicated in (Table 3), the average duration of hand rubbing was 14.8(±8.92) seconds, whereas the average handwashing duration was 20.2 (±11.12) seconds.

Table: duration, frequency and amount of water used for handwashing, in Dilla University Referral Hospital southern Ethiopia (Table 3).

An independent-samples *t*-test was conducted to compare (the amount of water in ml), (duration of hand rubbing in seconds) and (duration of handwashing in seconds) between those who wash their hands effectively and not effectively. There was a significant mean difference in the amount of water used in those who wash their hands effectively

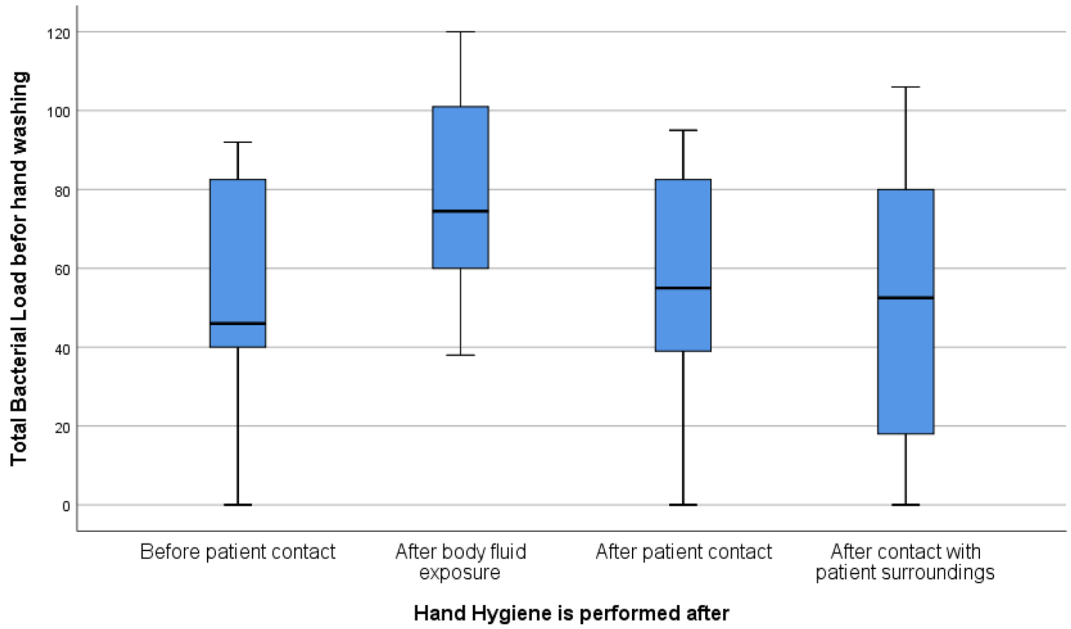

Figure 3. Hand bacterial counts in CFU/ml among different critical times in Dilla university referral hospital southern Ethiopia.

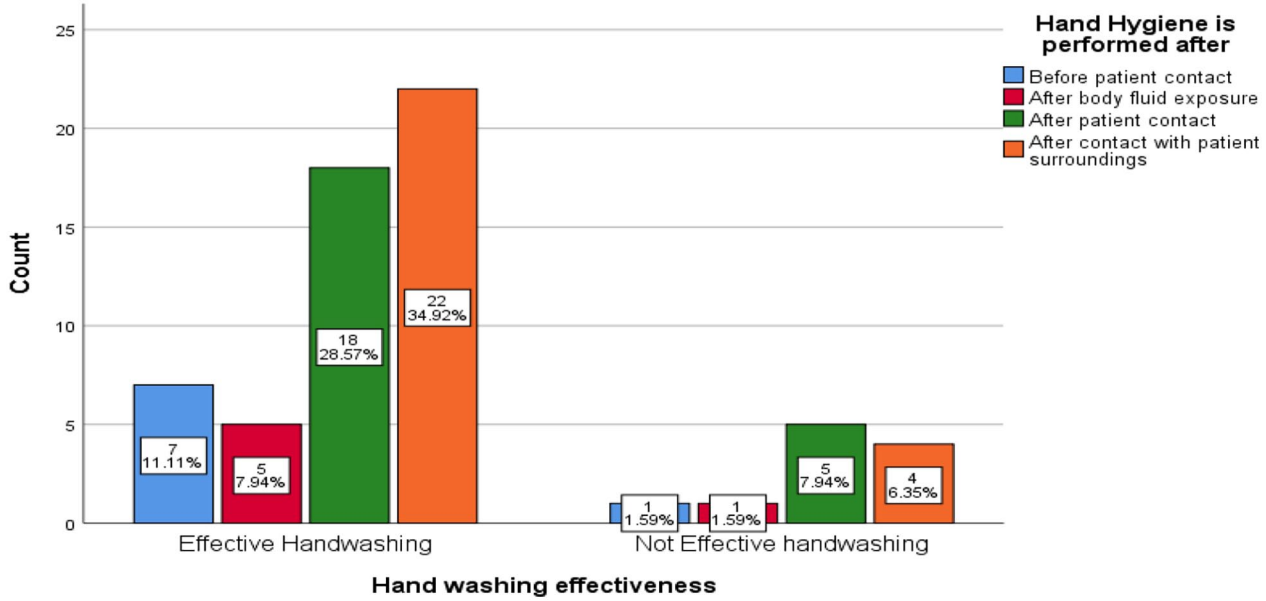

Figure 4. Hand hygiene effectiveness at critical times in Dilla University referral hospital southern Ethiopia.

($M = 364.3$ ml, $SD = 230.9$ ml) and in those handwashings in the second group ($M = 54.5$ ml, $SD = 16.4$ ml) which was not effective; $t\,(61) = 2.297$, $P = .025$. Similarly, there was a significant difference in the duration of hand rubbing ($M = 15.9$ second, $SD = 9.14$ seconds) among those who were found to wash their hands effectively ($M = 9.47$ second, $SD = 3.35$ seconds) and among those who were ineffective in their handwashing, $t\,(61) = 2.252$, $P = .028$. However, there was no significant difference in the duration of handwashing after hand rubbing ($M = 21.17$ second, $SD = 11.44$ seconds) among those who washed their hands effectively and among the other group ($M = 15.45$ second, $SD = 8.38$ seconds) with ineffective hand washing, $t\,(61) = 1.567$, $P = .122$ as shown in (Table 3).

A paired sample T-test between the bacterial load before and after hand washing indicates that there is a significant difference (53.3 mean CFU), which indicates that the handwashing intervention has shown effectiveness ($P < 0.01$).

Discussion

Bacterial count before handwashing ranged from 0 to 120 CFU/hand, with a mean of 55.4 (±32.5) CFU/hand whereas a similar finding at Alexandria University Students' Hospital in Egypt during routine patient care showed that, the bacterial count before application of hand hygiene ranged from 10 to 900 CFU/hand, with an average mean of 131.9 (±154.8) CFU/hand.[20] The difference might be attributed

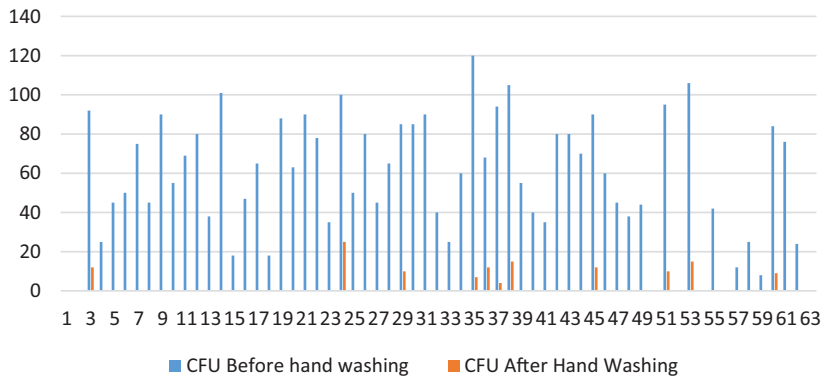

Figure 5. Bacterial reduction in (%) before and after handwashing practice in Dilla University Referral Hospital, Southern Hospital.

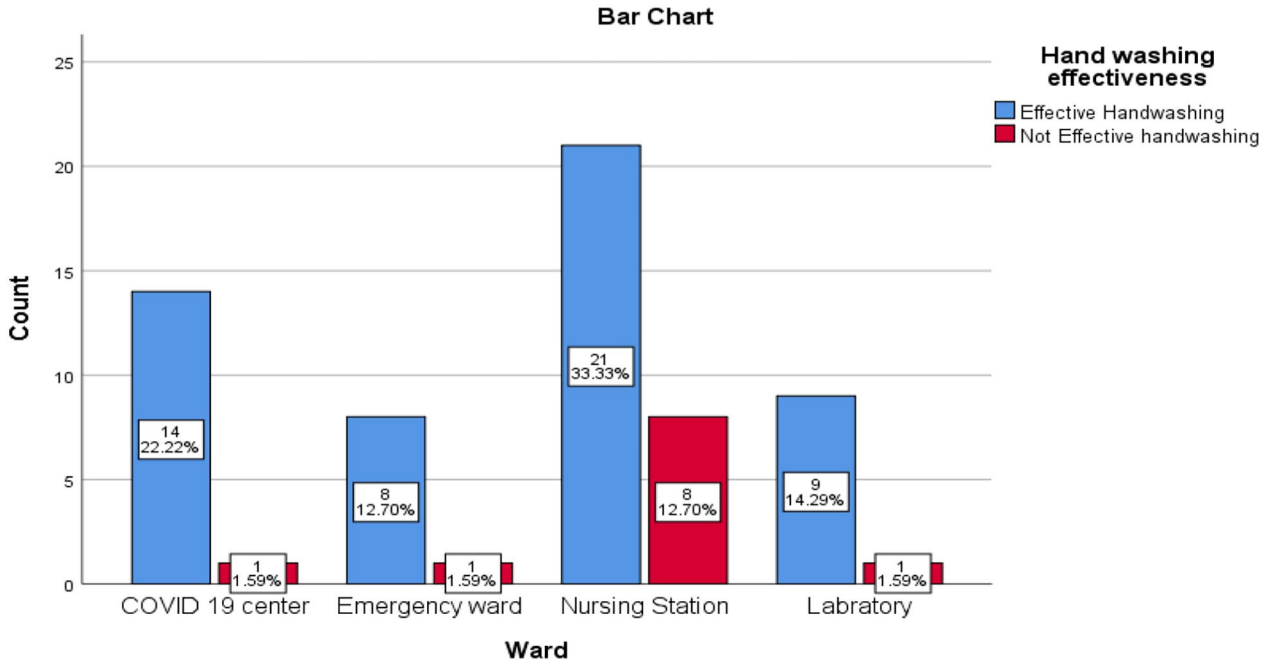

Figure 6. Effective handwashing practice across wards at Dilla University Referral Hospital, Southern Hospital.

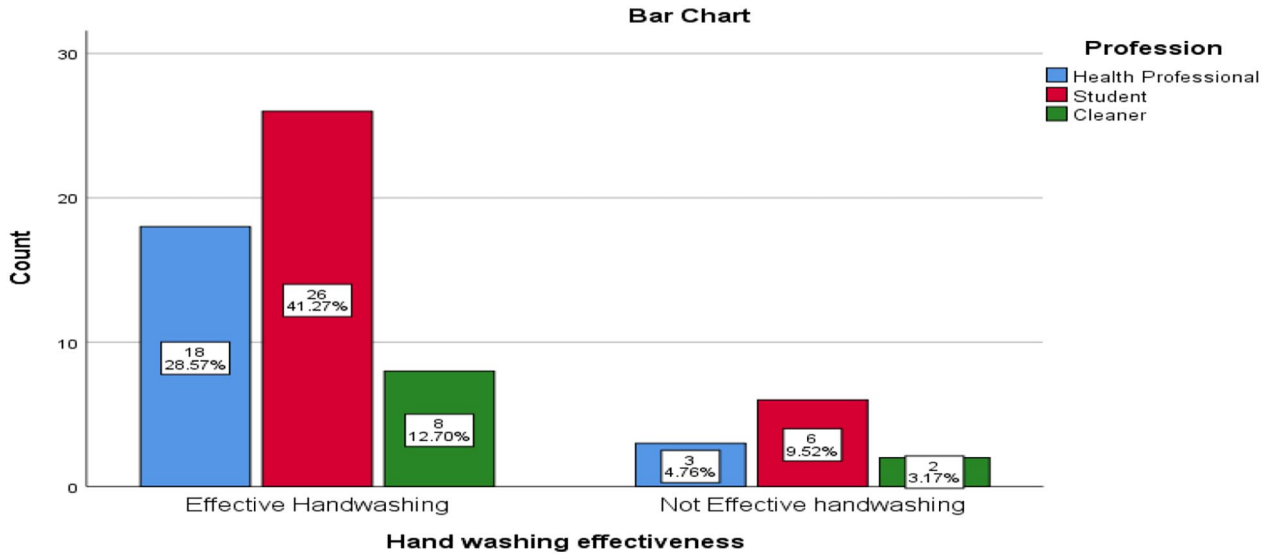

Figure 7. Effective handwashing practice in Dilla University Referral Hospital, Southern Hospital.

Table 2. Amount of water used for handwashing across the wards, in Dilla University referral hospital southern Ethiopia.

WARD	WATER USED FOR HAND WASHING			
	MINIMUM	MAXIMUM	AVERAGE	SD
COVID-19 center	127	900	389.8	241.5
Emergency ward	110	785	384.9	245.8
Nursing station	144	1160	304.1	204.01
Microbiology laboratory	144	985	382.9	260.2
Overall	110.00	1160.00	336.03	219.46

Table 3. Duration, and frequency of handwashing at Dilla University Referral Hospital, Southern Hospital.

	N	MINIMUM	MAXIMUM	MEAN	STD. DEVIATION
Amount of water used for hand washing	63	110.00	1160.00	336.0317	219.46
Duration of hand rub	63	3.00	37.00	14.8	8.92
Duration of hand washing	63	6.00	60.00	20.17	11.12
Frequency of Hand Wash	63	1	15	6.27	2.88
Total Bacterial Load before hand washing	63	0	120	55.37	32.53
Total Bacterial load after hand washing	63	0	25	2.08	5.05
% reduction of CFU	63	.00	100.00	94.6	18.1

to the type of service delivered, the preceding procedures before the hand hygiene practice, or the duration of clinical activities.[21] In this study, the highest bacterial count was observed during the handwashing practice after body fluid exposure. This is in line with the finding, where the highest average count before hand hygiene was recovered from HCWs without direct patient contact.[22]

The average reduction in the number of colonies (CFU/ml) was higher when compared with other findings with a bacteria colony count reduction after handwashing with soap and water was found be a 50% reduction among Nurses in Choithram Hospital and research center Indore, India,[23] 30% in Alexandria University Students' Hospital in Egypt,[20] (26.4%) in healthcare facilities (HCF) in Tanzania,[24] and 49.6 % reduction in a large public university hospital in Barcelona.[25] In another study a lower reduction in number of bacterial colonies which was 59.55% was recorded among nurses at Universitas Sumatera Utara Hospital.[26] This could be attributable to challenges linked with hand hygiene facilities and the level of infection prevention protocols in the implementation in the health facilities. Another main possible reason for the difference in the reduction among the institutions might be due to the fact that, this research has been conducted during the era COVID-19 where handwashing has been massively advocated, whereas the other studies were conducted during the pre-COVID-19 period. The finding was more or less in line with a similar finding conducted on 354 hand hygiene instances, in an Ebola treatment centers in Georgia where a median thoroughness of hand hygiene among the 4 facilities was 83% which ranged from 67% to 100%.[27]

Other reasons might included for the disparities in hand hygiene effectiveness might include, lack of safe and adequate water, soap, liquid soap dispensers, alcohol gel or foam, disposable hand towels, inappropriate and poor choice of the hand washing facility location in the wards, level of follow up to infection prevention and control (IPC)practices by the health care providers as indicated by.[28]

The significant mean reduction difference in the bacterial counts before and after the handwashing practices was comparatively similar with the study in Choithram Hospital and research center Indore, India, where a significant reduction in the transient flora after hand washing ($P = .01$-$.03$ in paired t-test)was detected.[23] However, in another study done in France much difference in the hand microbial load was not observed before and after handwashing.[29]

The finding indicated that the duration of hand rubbing significantly differs between effective and non-effective handwashing practices, which is in line with international standards for the duration of hand scrubbing for effective hand washing, where at least 20 seconds of scrubbing is recommended.[30] This was in line with the study,[28] where duration of hand rubbing was significantly associated with bacterial counts on hands ($P < .001$).[27,31]

In this study, the amount of water used among those who effectively wash their hands and those who didn't differ

significantly, which is in line with recommendations by[32] which indicated that other than vigor handwashing practice, the amount of water is an important factor in determining the number of bacteria removed from the hands.[32] From this finding, an average of 364.3 ml water can be considered adequate for hand hygiene purposes in the health care setup when using soap and water for hand washing. The finding of this study can also be 1 input for the issue raised by Kanno et al,[33] where he and his team implied that data regarding the amount of water that is needed for hygienic purposes such as hand hygiene during pandemics should be determined for planning and demand calculations.[33]

One of the limitations of this study was that handwashing effectiveness was conducted for the traditional hand washing practice using soup and water. The application of hand hygiene effectiveness using different hand rubs as recommended by WHO was not included. Therefore, the conclusions and recommendations could only be forwarded for handwashing practices performed using soap and water. Further studies should include the comparison of the hand hygiene effectiveness using both hand hygiene products.

Conclusion

The effectiveness of handwashing practice in Dilla University referral hospital was 82.5% and duration of hand scrubbing and the amount of water used were found to significantly affect the effectiveness of handwashing practice. The handwashing practice and the products used for handwashing other methods should be regularly monitored to keep this effective handwashing practice for the future.

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Author Contributions

GGK and MBA conceptualize the research idea. KD, BN, BG, and GGK conducted the swab test analysis for this study. GGK, AA, MTL, AC, and BGA involved in the project administration and initial manuscript write up. NES, SYAB, MBA were involved in the data analysis and supervision of the project. NES, SYAB, MBA also involved in checking the final manuscript.

Ethical Consideration

The data collection was conducted after Dilla University, College of health and medical sciences, Institutional Research Review Board Health Research Ethics Commission (IRB) has approved the study.

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