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Comparison of hand hygiene compliance self-assessment and microbiological hand contamination among healthcare workers in Mwanza region, Tanzania

Devis Rayson^{a,b}, Namanya Basinda^a, Ruanda Adam Pius^c, Jeremiah Seni^{c,*}

^a School of Public Health, Catholic University of Health and Allied Sciences, Mwanza, Tanzania

^b Mwanza Interventional Trial Unit, National Institute for Medical Research, Mwanza, Tanzania

^c Department of Microbiology and Immunology, Weill Bugando School of Medicine, Catholic University of Health and Allied Sciences, Mwanza, Tanzania

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SUMMARY

Background: Compliance with hand hygiene (HH) practices remains a major challenge in preventing healthcare-associated infections (HCAI). Little is known whether self-reported HH compliance reflects the level of hand contamination microbiologically as a guide for specific infection prevention and control (IPC) measures.

Methods: A cross-sectional study was conducted between July and September 2019 involving 18 healthcare facilities (HCF) in Mwanza region, Tanzania. It assessed HH using a structured questionnaire and microbiological analysis of hand samples for culture (n=212), and the WHO Hand Hygiene Self-Assessment Framework (2010) (n=74).

Results: The overall median HH score (interquartile range) was 212.5 (190–245) and designated at basic level in the WHO framework. The scores progressively increased from basic level in health centres to intermediate level in a tertiary hospital. Self-reported HH compliance using the WHO recommended cut-off value of $\geq 81.0\%$ was 10.8% (8/74). A total of 56 (26.4%) healthcare workers (HCWs) hands had bacterial contamination; 17.9% (n=38) by Gram negative bacteria (including coliforms, *Acinetobacter* spp and *Pseudomonas aeruginosa*), 8.0% (n=17) by methicillin-resistant *Staphylococcus aureus* (MRSA) and 0.5% (n=1) by both. Hand contamination was significantly higher in district hospitals (P -value=0.0437), and among HCWs residing in the rural areas (P -value=0.017).

Conclusion: The median HH score amongst HCF in Mwanza region was at basic level. A quarter of HCWs hands were contaminated by bacteria which mismatched self-reported HH. A need to incorporate HH microbiological parameters to the WHO HH assessment tool is needed, and future IPC interventional measures should be tailored to the HCF tier and in rural areas.

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* Corresponding author. Address: Department of Microbiology and Immunology, Weill Bugando School of Medicine, Catholic University of Health and Allied Sciences, P. O. Box 1464, Mwanza, Bugando, Tanzania.

E-mail address: senijj80@gmail.com (J. Seni).

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Introduction

Millions of patients in healthcare facilities worldwide are affected by healthcare-associated infections (HCAI) leading to prolonged hospital stays, long-term disability, potential increased resistance of microorganisms to antimicrobials and significant additional costs [1]. The burden of HCAI is greater in developing countries than in developed countries [1]. The transmission of HCAI can be through contaminated hands, by bacteria from the gastrointestinal tract of healthcare workers (HCWs), contamination of environmental premises or endogenous carriage among patients. [2,3]. Moreover, these infections can also be transmitted from inanimate items in the hospital environment through medical devices such as stethoscopes, blood pressure machines and indwelling devices such as catheters if stringent aseptic measures for infection prevention are not adhered to [4,5]. The most common HCAIs are urinary tract infections, surgical site infections and bloodstream infections; and are frequently caused by multi-drug resistant bacteria such as methicillin-resistant *S. aureus* (MRSA) and extended spectrum beta lactamase (ESBL) producing Enterobacteriaceae [1,6].

Adherence to hand hygiene (HH) practices during healthcare reduces the risk of HCAI and the spread of antimicrobial resistance [7]. HH is a key cost-effective measure to prevent the transmission of HCAI particularly in settings where these infections are common such as Sub-Saharan Africa [8]. The HH can be performed by washing hands with running water and detergents, or by the use of antiseptics such as 70% alcohol or chlorhexidine [9]. The World Health Organization (WHO) has recommended five areas where HH is should be performed in the hospital setting including from before touching patients, during patient care and after being in direct contact with patients. Despite this, efforts to reinforce HH practices in the hospital settings has largely remained variable across countries and in different hospitals within the same country [8]. The factors contributing to this variation have ranged from individual HCW practices, hospital infrastructures and the governments' logistical supports, reiterating the need to assess the compliance at all these levels and to identify possible factors facilitating or hindering HH compliance [7,8].

Tanzania, like other developing countries, faces the challenge of preventing HCAI [10,11]. The available research reports show significant rates of HCAI ranging from surgical site infections to bloodstream infections, and these infections are associated with adverse patient outcomes [3,10,11]. In Tanzania, post-caesarian section surgical site infections range from approximately 10% to 50% across regions [10,11].

To address these research gaps this study has compared the self-reported HH compliance among HCWs using a questionnaire and the standardised WHO tool across healthcare facilities, with microbiological assessment of hand contamination. In addition, the study has also determined the species of bacteria isolated and antimicrobial susceptibility patterns to two key resistance phenotypes to guide future preventive measures. As part of supporting the National Action Plan for antimicrobial resistance, the findings of this study also provided baseline information which can be used for future monitoring of the change in trends in infection prevention and control (IPC) measures at individual level, unit level, healthcare facility level and regional level [12].

Methods

Study settings, participants and sampling procedures

This cross-sectional study was conducted between July and September 2019, involving 18 healthcare facilities across six districts of Mwanza region. The districts included Magu, Kwimba, Nyamagana, Illemla, Sengerema and Misungwi. HCWs (clinicians, nurses and medical attendants) working in these healthcare facilities who consented to participate were included in this study. Healthcare workers working in these facilities but who do not have direct contact with patients (for example those with administrative roles) were excluded from this study. Using a prevalence of 16.5% of HCW with good HH from Northwest Ethiopia [13], a minimum sample size was estimated to be 212 using the Kish Leslie formula (1965) [14].

A total of 18 healthcare facilities were involved in Mwanza region. Sampling took place in 7 hospitals namely Bugando Medical Center (BMC), Sekou Toure Regional Referral Hospital, Nyamagana hospital, Magu hospital, Misungwi hospital, Sumve hospital and Sengerema hospital; and 11 health centres (one randomly selected per district among those with all three units in place). The six priority interventional units included in the hospitals were: Emergency department, labour ward, operating theatre, surgical ward, paediatric ward and intensive care unit. For health centres, three units were involved, which were; outpatient/emergency, labour ward and operating theatre. A total of 225 HCWs were approached and 212 (74 head of units and 138 other HCWs) gave consent and agreed to participate in interviews and to have their hands sampled for microbiological analysis to identify Gram negative bacteria and MRSA.

Data collection and laboratory methods

The aim of this research project and the sampling procedures were explained to participants by the principal investigator or research assistant, and each participant was requested to voluntarily consent before any data or sample collection. HCWs were evaluated using interviews and observation using the *WHO Hand Hygiene Self-Assessment Framework Tool (2010)* which has five components: System Change (SC); Training and Education (TE); Evaluation and Feedback (EF); Reminders in the work place (RW); Institutional safety climate (ISC). [15,16].

During sampling, approximately 200 to 250mL of sterile normal saline was placed into a sterile polyethylene bag. Each participant was instructed to wash his/her hands within the bag for approximately 30 seconds (wash hands, scrape gently under nails and rinse the hands within the bag). Using a pipette, 2 mL was taken from the bag and placed into 20 mL of Brain Heart Infusion Broth (OXOID, UK) in a universal bottle. The sample were kept in a cool box at 4 to 8°C and transported to the laboratory to be processed within 4 hours [17,18]. The samples were inoculated into blood agar and MacConkey agar (OXOID, UK) and incubated at 35 to 37°C. Identification of coliforms were done using standard biochemical identification tests [17]. Cephalosporin-resistant Gram-negative bacteria were screened using MacConkey agar supplemented with 2µg/mL of cefotaxime. Methicillin-resistant *Staphylococcus aureus* was isolated from blood agar and identified using haemolysis, catalase test, coagulase test and DNase test. Confirmation of MRSA was based

on the zone of inhibition to a cefoxitin disk (30µg) of ≤ 21 mm on Muller Hinton agar [19]. Hand contamination of HCWs was as defined as culture positive for Gram-negative bacteria and/or MRSA from post-hand wash samples.

Quality assurance control

Research assistants were recruited and trained data collection procedures. A pilot investigation was performed in the Psychiatric department at BMC (the department was not part of this study) to pre-test the questionnaire and other tools. All completed questionnaires were cross-checked at the end of each day by the Principal Investigator and where necessary relevant amendments were made by re-visiting the respective entries from participants and/or visiting the respective hospital. Standard reference bacterial strains (*Staphylococcus aureus* ATCC 25923 for Gram-positive bacteria and *E. coli* ATCC 25922 for Gram-negative bacteria) were used to ascertain the reliability of the laboratory procedures and the identity of the isolated bacteria from HCWs. Tap water used for hand washing and selected alcohol hand sanitizers were tested for the presence of Gram-negative bacteria/coliforms on a weekly basis from each healthcare facilities during sampling period, and the results indicated no Gram-negative/coliform contamination.

Data analysis

Data collected were entered into Microsoft Excel spreadsheets for refining and consistency checks; and then exported to STATA version 13.0 software for analysis according to the objectives of this study. Each of the five indicators has a sub-total score of 100, giving an overall maximum HH score of 500. Final cumulative scores stratified each healthcare facility's unit into inadequate (0–125), basic (126–250), intermediate (251–375) or advanced (376–500) HH level. Categorical variables like sex, level of education, professional discipline [hospital attendants, nurses (registered/enrolled nurse or nurse officer) and clinicians (assistant medical officer, medical doctor and medical specialist), and hand contamination status were presented as proportions (percentages). Continuous variables such as hygiene scores in various components and indicators were described as mean \pm standard deviation or median scores (interquartile range) depending on the distribution of data. Comparison of HH scores in various variables such as healthcare facility (Tertiary hospital, Regional referral hospital, District hospitals and Health centres) and healthcare facility units were done. Crude odds ratio was used to assess the strength of the association between hand contamination and various variables. A *P*-value of <0.05 was used as a cut-off value to show significant association between hand contamination and variables. Self-reported HH among HCWs using the questionnaire and the WHO HH assessment tool were compared with microbiological hand contamination using one sample test of proportion and two-samples of proportions, respectively.

Ethical considerations

Ethical approval was provided by the Catholic University of Health and Allied Sciences/Bugando Medical Centre Research and Ethical Committee (CREC/387/2019). Permission to conduct this study was sought from all relevant government authorities.

Written informed consent was obtained from all study participants prior to data and sample collection.

Results

Socio-demographic characteristics of healthcare workers

The median age (IQR) of 212 HCWs was 34 (30–47) years, with the majority being females (69.3%, *n*=147) and nurses (62.7%, *n*=133). Of all 212 interviewed HCWs, 96 (45.3%) had attained certificate level of education, and 164 (77.3%) had more than one year working experience. A total of 52 (24.5%) were from labour wards, whereas 45 (21.2%) and 41 (19.3%) were from surgical wards and emergency department/outpatient department, respectively (Table I).

Hand hygiene level and compliance across healthcare facilities and units in Mwanza region

Of the 74 units assessed from 18 healthcare facilities, the majority were surgical wards (25.7%, *n*=19), labour wards

Table I

Socio-demographic characteristics of healthcare workers (HCWs) (*n*=212)

Characteristics	Category	Number N (%)
Age	20–29 years	49 (23.1)
	30–39 years	83 (39.2)
	40–49 years	36 (17.0)
	50 and above years	44 (20.7)
Gender	Male	65 (30.8)
	Female	147 (69.3)
Education Level	Certificate	96 (45.3)
	Diploma	70 (33.0)
	Degree and above	46 (21.7)
Residence	Rural	115 (54.2)
	Urban	97 (45.8)
Number of people in the household	1–2	36 (16.9)
	3–4	88 (41.5)
	5–6	52 (24.5)
	7 and above	36 (16.9)
Professional discipline	Clinicians	42 (19.8)
	Nurses	133 (62.7)
	Medical attendants	37 (17.5)
Working Experience	0–5 years	107 (50.5)
	6–10 years	43 (20.3)
	>10 years	62 (29.3)
Healthcare Facility	Health centre	54 (25.5)
	District hospital	86 (40.6)
	Regional referral hospital	26 (12.2)
	Tertiary hospital	46 (21.7)
Hospital unit	ED/OPD	41 (19.3)
	Intensive Care Unit (ICU)	8 (3.8)
	Labour Ward	52 (24.5)
	Operating theatre	33 (15.6)
	Paediatrics ward	33 (15.6)
	Surgical ward	45 (21.2)

ED/OPD: Emergency department/Outpatient department.

(23.0%, n=17) and outpatient units (23.0%, n=17). The overall median hand hygiene score (IQR) was 212.5 (190–245) (i.e. WHO basic level). A total of 56 units (75.7%) had basic level, whereas 18 (24.3%) had intermediate (or consolidation) level. The scores progressively increased from health centres (n=33 units): 190 (175–215), district hospitals (n=29): 215 (205–240), regional referral hospital (n=6): 275 (275–287.5) to tertiary hospital (n=6): 320 (315–325). The overall hand hygiene level for each unit was basic level with the highest median scores of 230 (205–315) in operating theatres, 232.5 (210–262.5) in Intensive Care Units (ICU) and 240 (202.5–277.5) in paediatric wards (Table II).

Evaluation of hand hygiene indicators in healthcare facilities

Evaluation of five HH indicators across healthcare facilities showed that the respective median hand hygiene score (IQR) were SC 45 (35–55), TE 25 (15–40), EF 40 (30–80), RW 35 (20–35) and ISC 65 (60–70). Availability of clean and running water were found in 64/74 (86.5%) healthcare facilities and alcohol hand rub in 54/74 (73.0%). Single use towel/tissue papers which are used to dry hands after hand washing were available in 34/74 (45.7%) healthcare facilities. It was reported that education and training on HH among HCWs had never been received in 16/74 (23%) healthcare facilities, while in 49/74 (66.2%) received only once. In addition, approximately 9/74 (12.2%) healthcare facilities had regular HH training and education in their working places. It was also reported that only 20/74 (20.0%) healthcare facilities had a process in place to confirm that all HCWs completed HH training. Of all 74 healthcare facilities, only 15 (20.3%) reported to have a dedicated budget that allows specifically for HH training.

Self-reported hand hygiene compliance by healthcare facility units

Overall self-reported hand hygiene compliance assessment using the WHO cut-off value of $\geq 51.0\%$ and the WHO recommended cut-off value of $\geq 81.0\%$ were 39.2% (29/74) and 10.8% (8/74), respectively. Low compliance was predominantly noted in the lower healthcare facility tiers (Health centres and District hospitals) and high compliance was noted in the higher healthcare facility tiers (Regional referral hospital and Tertiary hospital) (Table III).

Table II
Hand hygiene scores and levels by healthcare facility units (n=74)

Healthcare facility unit	Median HH score (IQR) (n=74 units)	HH level
Labour ward (n=17)	215 (190–230)	Basic
Operating theatre (n=7)	230 (205–315)	Basic
ED/OPD (n=17)	205 (175–227.5)	Basic
Surgical ward (n=19)	200 (180–230)	Basic
Pediatrics (n=8)	240 (202.5–277.5)	Basic
ICU (n=6)	232.5 (210–262.5)	Basic

HH: Hand hygiene; IQR: Interquartile range; ED/OPD: Emergency department/Outpatient department; ICU: Intensive care unit.

Table III
Self-reported hand hygiene in healthcare facilities (n=74)

HH compliance score (%)	Healthcare facility				Total
	Health centres	District hospital	Regional referral hospital	Tertiary hospital	
≤ 30	22	19	1	0	42
31–40	3	0	0	0	3
41–50	0	0	0	0	0
51–50	2	0	0	0	2
61–70	5	2	2	0	9
71–80	0	6	1	3	10
≥ 81	1	2	2	3	8

HH: Hand hygiene.

Hand contamination of the healthcare workers

Self-reported HH using the questionnaire on the day of assessment was reported in 203 (95.8%). Out of 212 post-hand wash samples which were collected, 56 (26.4%) had culture positive results. Microbiological hand contamination was significantly higher, 26.4% (56/212) than the self-reported lack of HH practices, 4.2% (9/212), P -value < 0.001 .

Of the 56 HCWs, 38 (17.9%) had Gram-negative bacteria (including coliforms, *Acinetobacter* spp and *Pseudomonas aeruginosa*), 17 (8.0%) had MRSA and 1 (0.5%) HCW had both Gram-negative bacteria (*Citrobacter* sp) and MRSA. The proportion of MRSA among all *Staphylococcus aureus* isolated was 58.1% (18/31). Amongst the 39 Gram-negative bacteria, the predominant bacteria were *Citrobacter* spp [26 (66.7%)] and *Pseudomonas aeruginosa* [5 (12.8%)] (Table IV). Among 39 Gram-negative bacteria, 36 were cephalosporin-resistant. Therefore, the prevalence of cephalosporin-resistant Gram-negative bacteria contaminating HCWs hands was 17.0% (36/212). Of the 212 HCW, 83 (39.2%) had previous history of

Table IV
Bacteria isolated from healthcare workers (HCWs) who had culture positive results (n=56)

Bacteria	Clinicians	Nurses	Medical attendants	Total
<i>Acinetobacter</i> spp	0 (0.0)	3 (100.0)	0 (0.0)	3 (100.0)
<i>Citrobacter</i> spp	5 (19.2)	19 (73.1)	2 (7.7)	26 (100.0)
<i>Enterobacter</i> spp	0 (0.0)	1 (100.0)	0 (0.0)	1 (100.0)
<i>Klebsiella pneumoniae</i>	1 (100)	0 (0.0)	0 (0.0)	1 (100.0)
<i>Pseudomonas aeruginosa</i>	0 (0.0)	4 (80.0)	1 (20.0)	5 (100.0)
Unidentified Gram-negative bacteria	0 (0.0)	2 (66.7)	1 (33.7)	3 (100.0)
MRSA	4 (22.2)	12 (66.7)	2 (11.1)	18 (100.0)
Overall contamination	10 (17.5)	41 (72.0)	6 (10.5)	57 (100.0)*

MRSA: Meticillin-resistant *Staphylococcus aureus*.

*One HCW had dual contamination (i.e. had both MRSA and *Citrobacter* spp).

Table V

A univariate logistic regression analysis to determine factors associated with healthcare workers (HCWs) hand contamination (n=212)

Category	Hand contamination n (%)	Crude OR (95% CI)	p value
Age			
20–29 years (49)	11 (22.5)	1	
30–39 years (83)	19 (22.9)	1.03 (0.41–2.66)	0.9533
40–49 years (36)	12 (33.3)	1.73 (0.59–5.07)	0.2644
50 and above years (44)	14 (31.8)	1.61 (0.58–4.53)	0.3089
Gender			
Male (65)	17 (26.2)	1	
Female (147)	39 (26.5)	1.02 (0.51–2.12)	0.9542
Education level			
Certificate and below (96)	24 (25.0)	1	
Diploma (70)	24 (34.3)	1.56 (0.75–3.25)	0.1925
Degree and above (46)	8 (17.4)	0.63 (0.22–1.64)	0.3098
Residence			
Urban (97)	18 (20.6)	1	
Rural (115)	38 (27.5)	2.17 (1.09–4.38)	0.0171
Number of members in the households			
0–4 (124)	33 (26.6)	1	
≥ 5 (88)	23 (26.1)	0.98 (0.50–1.89)	0.9382
Discipline			
Clinicians (42)	10 (23.8)	1	
Nurses (133)	40 (30.1)	1.38 (0.59–3.44)	0.4333
Medical attendants (37)	6 (16.2)	0.62 (0.16–2.16)	0.4020
Working experience			
0–5 years (107)	24 (22.4)	1	
6–10 years (43)	13 (30.2)	1.50 (0.62–3.52)	0.3161
>10 years (62)	19 (30.7)	1.53 (0.71–3.27)	0.2373
Healthcare facility tier			
Health center (54)	13 (24.1)	1	
District hospital (86)	35 (40.7)	2.16 (0.96–5.04)	0.0437
Regional referral hospital (26)	3 (11.5)	0.41 (0.07–1.74)	0.1892
Tertiary hospital (46)	5 (10.9)	0.38 (0.10–1.29)	0.0867
Healthcare facility unit			
EMD/OPD (41)	11 (26.8)	1	
Intensive Care Unit (8)	1 (12.5)	0.39 (0.01–3.71)	0.3886
Labour Ward (52)	14 (26.9)	1.00 (0.36–2.83)	0.9919

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Table V (continued)

Category	Hand contamination n (%)	Crude OR (95% CI)	p value
Operating theatre (33)	8 (24.2)	0.87 (0.26–2.82)	0.8001
Pediatrics ward (33)	13 (39.4)	1.77 (0.59–5.32)	0.2511

EMD/OPD: Emergency department/Outpatient department.

antibiotic use in the past three months. Only six (2.8%) HCWs had a history of hospital admission in the previous three months.

Factors associated with hand contamination with pathogenic bacteria among HCWs

Crude logistic regression analysis showed two factors which had significant association with hand contamination. These were HCWs working in District hospitals OR (95%CI): 2.62 (1.23, 5.56); P -value=0.0437; and HCWs working in rural settings OR (95%CI): 2.17 (1.09–4.38); P -value =0.0171 (Table V).

Discussion

This study observed that the majority of the HCWs were female (69.3%) and nurses (62.7%). This observation is similar to that of previous studies conducted in Tanzania and Jamaica [20,21]. This could be because the nursing profession is the predominant healthcare discipline in Tanzania regardless of the type of healthcare facility.

This study also found that approximately a quarter of HCW hands were contaminated with Gram-negative bacteria and MRSA. The predominance of Gram-negative bacteria and *Staphylococcus aureus* has also been previously reported in Vietnamese hospital HCWs [22]. In another study in South Africa only one HCW hands were colonised with *Escherichia coli*, which is in contrast to our study whereby the predominant Gram-negative bacteria were *Citrobacter* spp and *Pseudomonas aeruginosa*, and that no HCW's hands were contaminated with *Escherichia coli* [18].

This study found the prevalence of MRSA contaminating HCW hands to be 8.5%, which is lower compared to studies conducted in India and Nepal which reported a prevalence of 51.6% and 25.0%, respectively [23,24]. Additionally, a study conducted in Portugal showed the prevalence MRSA on the hands of HCWs to be 4.7% [25], whereas in the systematic review study which involved studies conducted in North America, Europe and Asia in 31 cross-sectional studies, the pooled prevalence of MRSA was 3.25% [26]. The differences between our study and the mentioned studies above could be attributed by the difference in geographical location, difference in methodology employed and difference in IPC measures. Therefore, in contrast to many previous studies which were largely focused on MRSA, our study has found a significant proportion of HCWs whose hands were contaminated with Gram-negative bacteria including coliforms. *Acinetobacter* spp and *Pseudomonas aeruginosa*. This calls for urgent HH interventional measures as these organisms have both the

potential to cause infections among HCWs themselves and can be transmitted to patients and cause HCAs.

The current study revealed that the overall HH level was basic with the median score of 212.5 (190–245). This finding is similar to a study conducted in Dodoma (median score: 187.5 (112.5–260)) and in India among the facility's ICUs (overall score: 225) [21,27]. The HH scores were high in hospitals compared to health centres, and this also correlated with HH compliance. This may reflect that most hospitals have higher staff numbers, are better equipped with material resources, active IPC teams and have better access to information regarding HH. Studies from developed countries are showing predominance of healthcare facilities with intermediate and advanced HH level [7,28], in contrast to the present study where the basic HH level predominated in approximately three quarters of units assessed. For example, a study conducted in Italy among healthcare facilities showed that, among 50 healthcare facilities 70.4%, 19% and 11% had an intermediate level, advanced level and basic level of hand hygiene, respectively [28]. An observational study conducted among healthcare facilities in United States of America showed that out 129 healthcare facilities evaluated in the study, 48.9%, 45% and 6.2% had an advanced, intermediate and basic level of HH respectively [7]. The differences compared with our study could be due to the economic differences between the countries and the different levels of IPC resources and different IPC strategies.

The continuous supply of clean and running water through conventional or improvised sinks in healthcare facilities was seen to be high (86.5%), as compared to the presence of alcohol hand rub which was observed in (73.0%) of healthcare facilities. In a similar study to assess the impact of HH intervention conducted in Dodoma, the continuous supply of running water and the presence of alcohol hand rub were 90.3% (213/236) and 30.9% (73/236), respectively [21]. The similarities in the availability of improved supply of running water in healthcare facilities across Tanzania are consistent with our findings and in the study in Dodoma. These findings are also in line with Tanzania's aspiration to attain the strategic development goal number six on improving clean water supply and sanitation by 2030, which in turn will improve HH and thereby reduce waterborne diseases and HCAs. In contrast to this study, a study conducted in Italy among healthcare facilities showed that all of the facilities observed had a continuous supply of clean running water and soap, while alcohol hand rub solutions were available in 90% of the observed healthcare facilities [28]. These differences could be due to the difference in economic level between the two countries which in turn determines the availability of financial and materials resources for HH interventional measures.

We have found that TE on HH had never been received by approximately a quarter of HCWs. These findings are lower compared to that of the study conducted in Dodoma which showed that TE on HH was not received in 44.2% [21]. The differences could be due to the involvement of dispensaries in the latter study which accounted for approximately 90% of all healthcare facilities assessed. Dispensaries are not well equipped with resources as compared to healthcentres and hospitals. In contrast to our findings, a study conducted in Italy showed that 70% of the healthcare facilities received TE on HH at least once [28]. Furthermore, in this study 20.3% units reported to have a dedicated budget that allows for HH

training. This finding is lower compared to Italy (50%) [28]. Again, the differences could be due to the differences in economic levels of the two countries.

The HH compliance rates among HCWs in assessed units in this study were low. Only 10.8% units reached the WHO recommended rate of $\geq 81.0\%$. However, 39.2% units managed to reach the cut off value of $\geq 51.0\%$. The compliance rates of $\geq 81.0\%$ in this study was low as compared to baseline compliance rates reported in Switzerland, Ethiopia and in a systematic review involving 96 studies with [61.4%, 22.0% and 40.0%; respectively] [8,29,30]. Interestingly, variable compliance has been previously exhibited in six ICU from different hospitals in Italy ranging from 3.0% to 100.0% [31]. The differences in HH compliance rates across countries may reflect governmental, institutional and individual differences regarding HH practices, availability of resources and HH guidelines/policies. The findings of a lower proportion of individuals (4.2%) who acknowledged to have not washed their hands on the day of interview compared to the microbiological hand contamination (26.4%) measured underscores the subjectivity when HCWs are assessing themselves for HH compliance. On the other hand, using the both the interview and observation components of the WHO HH tool, the non-compliance with HH was overestimated (60.8%) reinforcing the subjectivity of this assessment method. Therefore, to increase objectivity in the assessment, we suggest the WHO tool should be complemented with HH microbiological parameters.

Hand contamination among healthcare workers was significantly higher in health centres (24.1%) and District hospitals (40.7%) compared to Regional referral hospitals (11.5%) and Tertiary hospitals (10.9%). This can be explained by the limited hand washing facilities, limited human resources who are experts in IPC measures and limited continuing medical education in the health centres and District hospitals. Also, the Regional referral hospitals and Tertiary hospitals involved from Mwanza are university teaching hospitals where operational procedures and interventional research are routinely done to inform continuous improvement of practices [4,5,32]. HCWs residing in rural areas were significantly contaminated compared to those living in urban areas (P -value=0.0171). This could be due to the limited hand washing infrastructures in the rural areas. Therefore, interventional measures to improve HH should be directed to health centres and District hospitals in rural areas. Strengthening of these measures should be done in Regional referral and Tertiary hospitals in urban areas. Also, on-going IPC supportive supervision by the Tertiary hospital to all lower tier healthcare facilities in the North-western part of Tanzania should specifically include a HH component.

This cross-sectional study had some limitations. It obtained information on HH among HCWs at one time period, and therefore could not show HH trends over time. Also, this study addressed only one component of IPC (HH) and did not cover other parameters of IPC. Despite these limitations, information obtained is crucial in creating baseline data for specific IPC measures and to help identify future trends.

Conclusions

The median HH score across 74 units in 18 healthcare facilities in Mwanza region was at basic level. The scores were progressively increasing from health centres and District hospitals (Basic level) to Regional referral hospitals and Tertiary

hospitals (Intermediate level). Although the majority of HCW (95.8%) self-reported in the questionnaire that they had washed their hands prior to sampling procedures, a quarter of them were found to have hands contaminated with Gram-negative bacteria (including coliforms, *Acinetobacter* spp and *Pseudomonas aeruginosa*) (17.0%) and MRSA (8.5%). Using the WHO tool, self-reported HH compliance using cut-off value of $\geq 51.0\%$ and the WHO recommended cut-off value of $\geq 81.0\%$ were 39.2% and 10.8%, respectively. Hand contamination among HCW was significantly higher in District hospitals and in the rural areas.

Strengthening of routine evaluation of performance of the HH compliance among HCWs and incorporation of microbiological assessment in the WHO tool is recommended to allow objective assessment of HH status. Both individual (EF) and system/facility-wide (RW) HH interventions should be specifically addressed in Mwanza region to ensure that the recommended WHO HH compliance of $\geq 81.0\%$ is attained. Future IPC interventional measures should be tailored to the healthcare facility tiers and specifically healthcare facilities in the rural areas.

CRedit author statement

DR, NB and JS: conceived, designed and executed the study; DR and RAP: enrolled participants, collected participants' data and samples; DR, RAP and JS: performed microbiological procedures; DR, NB and JS: curated, analysed and interpreted the data. DR wrote the initial draft of the manuscript, which was critically reviewed and revised by all authors.

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Conflict of interest statement

There are no conflicts of interest. All authors have read and approved this manuscript.

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