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Associated factors with hand hygiene compliance by healthcare workers during the 2018-2020 Ebola virus disease outbreak in the Democratic Republic of Congo

Facteurs associés à l'observance d'hygiène des mains par les professionnels de santé durant l'épidémie de maladie à virus Ebola de 2018 à 2020 en République démocratique du Congo

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Résumé

*Contexte & objectif***.** L'observance de l'hygiène des mains (OHM) est essentielle pour garantir la sécurité des soins et prévenir la propagation des infections. Les objectifs de l'étude étaient d'évaluer l'OHM et d'identifier les facteurs associés à cette observance durant l'épidémie de maladie à virus Ebola (EVD) de 2018-2020 en République démocratique du Congo. *Méthodes***.** Une étude transversale a été conduite dans trois groupes différenciés par leurs niveaux d'exposition à l'épidémie de MVE : zone fortement exposée à l'épidémie (ZfaE, au moins 29 cas de MVE), zone non ou modérément affectée par l'épidémie (ZmaE, moins de 29 cas de MVE) et zone à risque d'épidémie (ZrE). Les professionnels de santé sélectionnés ont été interrogés et/ou observés suivant les directives de l'OMS. *Résultats***.** Sur 626 participants, 53,4% ont observé l'hygiène des mains avant et après la procédure (78,8% dans ZfaE, 42,8% dans ZmaE et 37,2% dans ZrE, p<0,001), 23,9% l'ont fait soit avant, soit après l'acte, tandis que 22,7% ne l'ont fait ni avant ni après (1,5% dans ZfaE, 30,9% dans ZmaE et 36,7% dans ZrE). Comparée à la ZrE, l'OHM était 10 fois plus élevée dans la ZfaE et 2 fois plus dans la ZmaE (p < 0,05). Ne pas être médecin ou infirmier et avoir un bas niveau d'éducation étaient associés à une faible observance d'hygiène des mains alors que les

Summary

Context and objective. Hand hygiene compliance (HHC) is the key to ensuring safety and preventing the spread of infections. The present study evaluated HHC, specifically regarding indications and steps, as well as factors influencing this compliance during the 2018-2028 Ebola virus disease (EVD) outbreak in the Democratic Republic of Congo, to propose improvement solutions. *Methods***.** A cross-sectional study was conducted in three settings based on outbreak scale: heavily affected areas (HAAs, more than 29 EVD cases), slightly or unaffected areas (SUAs, 0 to 29 EVD cases), and areas at risk of the Ebola outbreak (AREo). Healthcare workers were selected based on availability and were either interviewed or directly observed using World Health Organization guideline. *Results*. Among 626 participants, 53.4% (78.8% in HAAs, 42.8% in SUAs, and 37.2% in AREo) observed hand hygiene both before and after the procedure, 23,9% did so either before or after, and 22.7% did not practice it either before or after (1.5% in HAAs, 30.9% in SUAs, and 36.7% in AREo). Compared to the AREo group, HHC was 10 times higher in HAAs and 2 times higher in SUAs (p<0,05). Not being a doctor or nurse and having a low educational level were associated with poor HHC, with hand surfaces rubbing recording the lowest scores among the steps. *Conclusion*. HHC was better in the HAAs, but this should not ensure maximum safety against infection, because some

frottements des surfaces des mains ont enregistré les scores les plus bas pour les étapes. *Conclusion.* La meilleure OHM dans la ZfaE ne devrait pas garantir une sécurité maximale contre les infections, car certaines étapes n'étaient pas systématiquement respectées. Les responsables de programme devraient promouvoir la stratégie multimodale de l'OMS pour l'hygiène des mains, particulièrement dans les zones et groupes qui observent moins l'hygiène des mains.

Mots-clés : observance de l'hygiène des mains, stratégie multimodale, épidémie de maladie à virus Ebola, République démocratique du Congo

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steps were not systematically carried out. Program managers should promote HHC to indications and steps, notably by implementing the multimodal strategy for promoting hand hygiene.

Keywords: Hand hygiene compliance, Multimodal improvement strategy, Ebola virus disease outbreak, Democratic Republic of Congo

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Introduction

Hand hygiene compliance (HHC) in healthcare facilities (HCFs) is essential for improving quality of care and reducing infections. Inadequate HHC can significantly increase the risk of healthcare-associated infections (1). According to the World Health Organization's multimodal strategy to improve HHC, the critical moments include before and after patient contact, before aseptic procedure, after body fluid exposure and after touching patient surroundings (2). The patients are also at risk of these infections. They occur in 12.6% to 18.9% of patients, often involving antibiotic-resistant bacteria (3), and leading to prolonged hospital stays, absenteeism, higher

medical costs, and complications (4-6). Despite its importance, HHC remains low, with averages ranging from 5% to 89% (7), and even as low as 0% in some cases (8). HHC is vital for infection prevention and control (IPC) during outbreaks like those that result from Ebola virus disease (EVD). This is especially important in the Democratic Republic of Congo (DRC), which has seen the highest number of Ebola outbreaks worldwide (9). During outbreaks, efforts including training on IPC, installing handwashing stations, supplying disinfection products, and promoting HHC are important (2). During the 2018-2020 EVD outbreak in the east of the DRC (10), IPC measures accounted for 13.8% of the public health response budget (11). At the same time, the transmission of EVD in HCFs, particularly among healthcare workers (HCHs), was a significant concern, as they accounted for almost 6% of Ebola patients (12). In these contexts, HHC should be prioritized (13). In similar contexts, the COVID-19 pandemic also led to an increase in catheter-related infections, and several factors were implicated, including poor HHC (14). Establishing strategies for HHC is crucial in combating infectious diseases like EVD and COVID-19. However, this should be applied not only in isolation units (15), but also in routine care areas where HCWs may encounter patients with infectious diseases. During past Ebola outbreaks, significant investments were made in water, sanitation, and hygiene in HCFs, with two hospitals in Liberia serving as examples (16). However, a significant gap was observed between awareness (77.3%) and actual HHC (44.1%), forgetfulness and lack of resources were identified as major barriers (16). Some studies indicate that handwashing with soap and water can reduce bacteria on hands (17), but may be less effective than hydro-alcoholic solutions (HAS) (18). While hand hygiene techniques reduce bacterial levels, some bacteria such as Pseudomonas spp., Klebsiella spp., Enterobacter spp., Staphylococcus aureus and Escherichia coli can persist or even increase after handwashing (19-21). These evidences imply that the preferences of handwashing methods may affect effectiveness, as well some methods of drying hands, particularly with multi-use towels, might lead to hands recontamination (22-23). Thus, following HHC is crucial. However, there is limited evidence on HHC during epidemics in the DRC. This study aims to fill this gap and to propose improvement solutions by examining knowledge, perceptions, and compliance with HHC guidelines, specifically regarding indications and steps during the 2018-2028 Ebola outbreak in the DRC, as well as the factors that influenced this compliance.

Methods

*Study design, site and period*A cross-sectional study was conducted. Three settings were defined based on outbreak scale: The heavily affected area (HAAs) included health districts which reported more than 50 EVD cases. These areas focused on Beni and Butembo and were the epicenter of the ongoing EVD outbreak. They received several months of IPC measures interventions, including training HCWs, hygiene assessment, and providing personal protective equipment, hydro-alcohol solutions, and handwashing devices. These areas also benefited from improved water supply through rainwater harvesting systems, hand-pump wells and connections to existing networks. They also had a supply of garbage cans and sanitary infrastructure. Nearby, the slightly or unaffected areas (SUAs) were defined, including health districts with 0 to 49 EVD cases. These SUAs received the same interventions described below, but less intensively, as few or no EVD cases were reported there. Further away, HCWs in an area at risk of Ebola outbreak spread (AREo) were informed of infection risks with minimal IPC measures strengthening. Although SUAs and AREo extended into several provinces, we focused on South Kivu due to its strong cultural ties to the HAAs and easier access.

Data collection took place in April 2020 in the HAAs region and in May and early June 2020 in the SUAs and AREo regions, coinciding with the final stage of the outbreak. Although the scale was still low, this period also coincided with the reporting of the first cases of COVID-19 in the eastern part of the country, the site of the study. Measures implemented in response to the EVD outbreak to strengthen infection prevention and control have been maintained. These measures were also extended beyond EVD-affected areas. Several additional measures were put in place, including social distancing and mask-wearing. Another key measure was the lockdown of cities and the country. This lockdown meant suppressing travel to and from regions most severely affected by COVID-19, such as the capital Kinshasa, as well as neighboring provinces and countries.

Sampling

The study focused on HCWs in second-line HCFs, those offering general surgery and hospitalization.

The sample size was estimated using the procedure and equations below:

$$n \geq \frac{2(Z_{1-\alpha}+Z_{1-\beta})^2 * p(1-p)}{(p0-p1)^2} \quad (1)$$

$$p_1 = \frac{p_0 * OR}{1+p_0(OR-1)} \quad (2) \qquad p = \frac{p_0+p_1}{2} \quad (3)$$

In these equations, n represents the minimum required number of providers, α denotes the type 1 error risk, Z1-α is the standard normal value for 1-α, and Z1-β is the standard normal value for a power of 1-β. For a one-tailed test with a 5 per cent error rate, Z1-α equals 1.65. With a power of 0.80 (β = 0.2), Z1-β equals 0.85. The parameters p0, p1, and p represent the proportions of healthcare workers observing hand hygiene in the at-risk area, heavily affected areas, and both groups, respectively.

We used the proportion of healthcare workers with access to soap and water or a hydroalcoholic solution near their workplace. As national assessment data reported this proportion at 57% (École de Santé Publique de Kinshasa et ICF International, Rapport de l'évaluation des prestations des services de soins de santé en République Démocratique du Congo (EPSS RDC) 2017-2018), we assumed p0 was 0.57. We also assumed that the response to outbreak interventions increased the availability of infection prevention resources in healthcare services, resulting in p1 being 2.2 times higher in the outbreak area than in the at-risk area. Based on this, we estimated p1 at 0.761 (76.1%) and p at 0.665 (66.5%) using equations (2) and (3). After we applied a cluster effect of 1.7 and a 10 per cent non-response rate, the sample size was adjusted to 142.9. This was rounded up to 150 providers per area.

The research covered four health districts in each area. The selection of participants combined probabilistic and non-probabilistic methods. In the HAAs region, health districts were classified according to the number of EVD cases and days without new notifications. The first three health districts corresponding to Beni, Butembo and Katwa were selected; and the fourth was chosen randomly (Musienene). Four health districts were selected randomly in SUAs (Goma, Karisimbi, Bagira, Ibanda) and in AREo (Walungu, Nyangezi, Ruzizi, and Uvira). HCFs' selection was based on those listed in the DHIS2 database. The general referral hospital was included automatically, while other HCFs were selected randomly. Investigators visited services providing preventive care (family planning, vaccinations, HIV testing) and curative care (consultations, maternity, surgeries). Participants were selected based on their availability during patient interactions. Any unmet quotas in some HCFs were addressed at other HCFs.

To reduce the risk of participants changing their practices due to observation, two independent samples were set from 66 HCFs and 12 health districts for interview and observation. Nevertheless, some participants were in both samples. Then, we conducted the observation before the interview or postponed the observation to another day when the interview was conducted first.

Data collection techniques and tools

Data were collected through direct observations by trained field investigators using tools based on WHO guidelines (World Health Organization, Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care is Safer Care. Geneva, 2009). The semi-structured questionnaire included questions on hand hygiene indications and the recommended techniques. Six indicators of hand hygiene importance, promotion, or observance were measured on a 1 to 5 scale. The observation grid helped us track compliance with indications and steps: detailing twelve steps for handwashing with water and soap and nine steps for using an alcohol-based solution. All the tools were electronic, designed on Open Data Kit software.

Investigators' training and data quality assurance

The investigators were healthcare professionals with experience in surveys. They were all trained by the principal investigator. The training lasted two days, including videos, simulations, and a pre-test. Investigators worked in teams of three or four. Data quality was ensured through the recruitment and extensive training of field investigators, the use of electronic questionnaires with filters and constraints and effective team supervision. As HCWs may change their behavior when they know that they are observed, investigators initially observed multiple interactions without data collection. Actual observations began once HCWs appeared accustomed to the investigators' presence. Consistent data monitoring from the secured server enabled early identification and correction of potential issues.

Data processing and analysis

Data were exported to the Statistical Package for Social Sciences (SPSS) software, Version 27.0.1 for analysis. Descriptive statistics were generated. HHC was satisfactory when HCWs adhered to WHO guidelines before and after patient contact. The Chi-Square test assessed categorical characteristics, while ANOVA compared the means of age and seniority. A multivariate logistic regression analysis identified associations and estimated adjusted odds ratios (OR*), with significance set at $p < 0.050$.

Ethical considerations

The research received approval from the Kinshasa School of Public Health ethics committee (No ESP/CE/11/2020, February 5, 2020). Consent was obtained from both HCWs and patients for observations, and confidentiality was maintained, with no identifying information included in the data collected.

Results

Sample Description

The sociodemographic characteristics of participants regarding knowledge and perceptions of hand hygiene were relatively similar across areas. The awareness and perceptions assessments were conducted with 650 HCWs (Appendix 1a), while 626 were observed for HHC (Appendix 1b). Nearly 1 participant out of 3 was seen at a general referral hospital or a public HCF. The median age was 36 or 38, with equal gender distribution. About 3 participants out of 5 were nurses, while physicians accounted for 10%. Nearly 3 participants out of 5 achieved the highest educational level. The median employment duration was around 10 years.

Compliance with hand-washing indications and references

As shown in Table I, non-invasive procedures (44.3%) and invasive procedures (42.9%) were the most common contexts where HHC should be observed. Other instances included sanitation of the patients' environment (14.5%) and laboratory sample handling (11.5%). Significant differences across exposure levels to the outbreak were observed on some occasions of HHC, in particular when handling laboratory samples (6.4% in HAAs, 15.1% in SUAs, p=0,016) and invasive care (55.7% in HAAs, 32.9% in SUAs, p<0.001). The other occasions were similar across exposure levels (p>0.05).

Table I. HHC and preferences before and after procedure, by exposure levels to the 2018-2020 EVD outbreak, North and South Kivu.

Indicator	Level of exposure to Ebola			TOTAL	p-value
	HAAs	SUAs	AREo		
	n (%)	n (%)	n (%)	n (%)	
Effective	***n=203***	***n=152***	***n=218***	***n=573***	
Type of acts performed[a, b]					
No invasive procedures	83(40.9)	68(44.7)	103(47.2)	254(44.3)	0.419
Invasive procedures	113(55.7)	50(32.9)	83(38.1)	246(42.9)	**<0.001**
Perinatal care	11(5.4)	4(2.6)	4(1.8)	19(3,3)	0.105
Collection or handling of samples	13(6.4)	23(15.1)	30(13.8)	66(11.5)	**0.016**
Cleaning or sanitizing the patient's environment	37(18.2)	23(15.1)	22(10.1)	82(14.3)	0.055
HHC before the procedure					**<0.001**
Yes	173(85.2)	79(52.0)	93(42.7)	345(60.2)	

Non	30(14.8)	73(48.0)	125(57.3)	228(39.8)	
Hand hygiene preference before the procedure					**<0.001**
Soap and water	87(42.9)	51(33.6)	60(27.5)	198(34.6)	
Friction of a HAS	41(20.2)	26(17.1)	25(11.5)	92(16.1)	
Soap and water, then rubbing a HAS	34(16.7)	1(0.7)	4(1.8)	39(6.8)	
Water, then rubbing a HAS	11(5.4)	1(0,7)	4(1.8)	16(2.8)	
Nothing	30(14.8)	73(48.0)	125(57.3)	228(39.8)	
HHC after the procedure					**<0.001**
Yes	187(92.1)	91(59.9)	126(57.8)	404(70.5)	
Non	16(7.9)	61(40.1)	92(42.2)	169(29.5)	
Hand hygiene preference after the procedure					**<0.001**
Soap and water	91(44.8)	47(30.9)	90(41.3)	228(39.8)	
Friction of a HAS	55(27.1)	41(27.0)	23(10.6)	119(20.8)	
Soap and water, then rubbing in a HAS	31(15.3)	1(0.7)	5(2.3)	37(6.5)	
Water, then rubbing a HAS	10(4.9)	2(1.3)	8(3.7)	20(3.5)	
Nothing	16(7.9)	61(40.1)	92(42.2)	169(29.5)	
HHC before and after procedure					**<0.001**
Neither before nor after	3(1,5)	47(30.9)	80(36.7)	130(22.7)	
Before only	13(6.4)	14(9.2)	12(5.5)	39(6.8)	
After only	27(13.3)	26(17.1)	45(20.6)	98(17.1)	
Before and after	160(78.8)	65(42.8)	81(37.2)	306(53.4)	

*HHC: Hand hygiene compliance, HAAs: area affected by the Ebola outbreak, SUAs: High risk of the Ebola outbreak; AREo: Low risk of the Ebola outbreak spread, n: Effective or sample size, p: p-value. *Some participants performed more than one act HAS: hydro alcoholic solution*

Table 1 indicates that about 53.4% of participants followed hand hygiene practices at all required times. However, significant variations were observed across exposure levels to the outbreak with 37.2% in AREo, 42.8% in SUAs and 78.8% in HAAs (p<0.001). HCWs preferred to observe hand hygiene after procedures over before (70.5% versus 60.2%, p<0.001). When hand hygiene was observed, washing with soap and water was more common than using a hydroalcoholic solution, both before (33.5% vs. 15.8%, p<0.001) and after the procedure (39.2% vs. 21.0%, p<0.001).

Based on Fig. 1, the percentage of participants who could mention critical moments requiring HHC was higher in HAAs than in SUAs and AREo, with a significant difference for all indicators (p≤0.004). As an illustration, 81.5% HCWs mentioned “after touching a patient's surroundings” in HAAs, while only 65.5% and 64.4% did so in SUAs and AREo respectively (p<0.001). They were 95.3% in HAAs, 85.5% in SUAs and 77.2% in AREo, to mention “before touching the patient” (p<0.001), and respectively 94.3%, 84.1% and 81.3% who mentioned “after touching a patient” (p<0.001). Participants who mentioned antiseptic and surgical handwashing represented 62.1% and 52.1% in HAAs (p=0.038),

47.3% and 38.6% in SUAs (p=0.066), 42.5% and 33.3% in AREo (p=0.048).

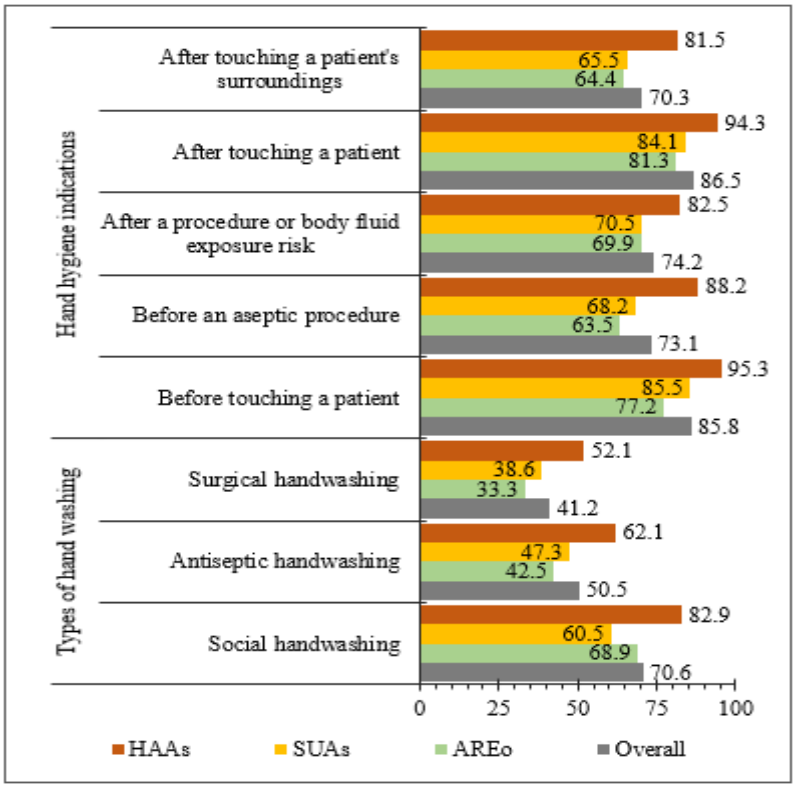
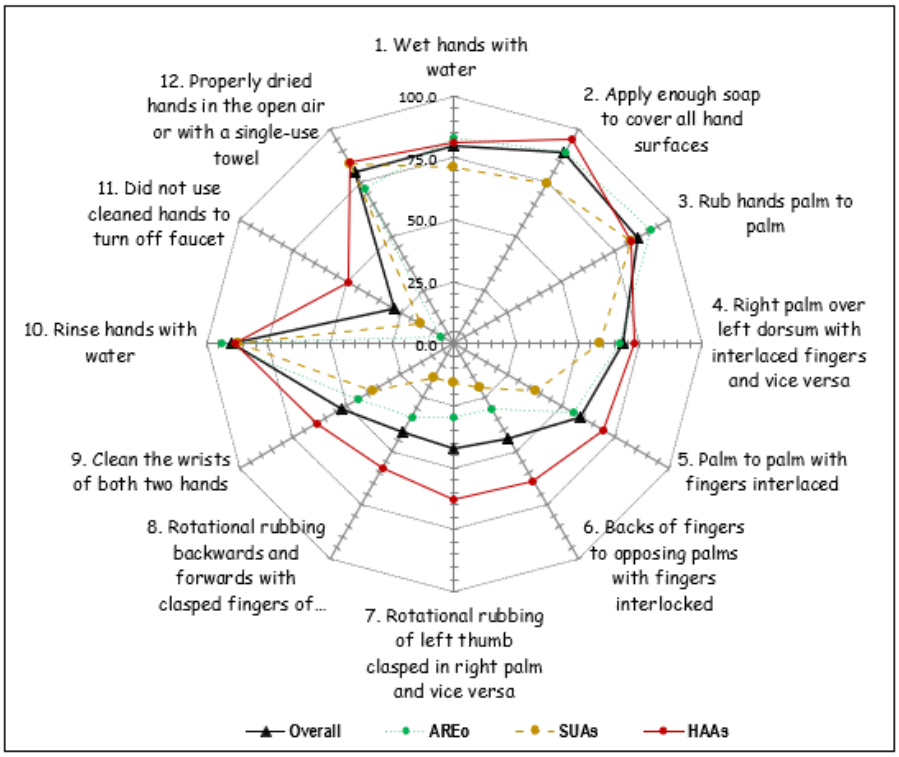


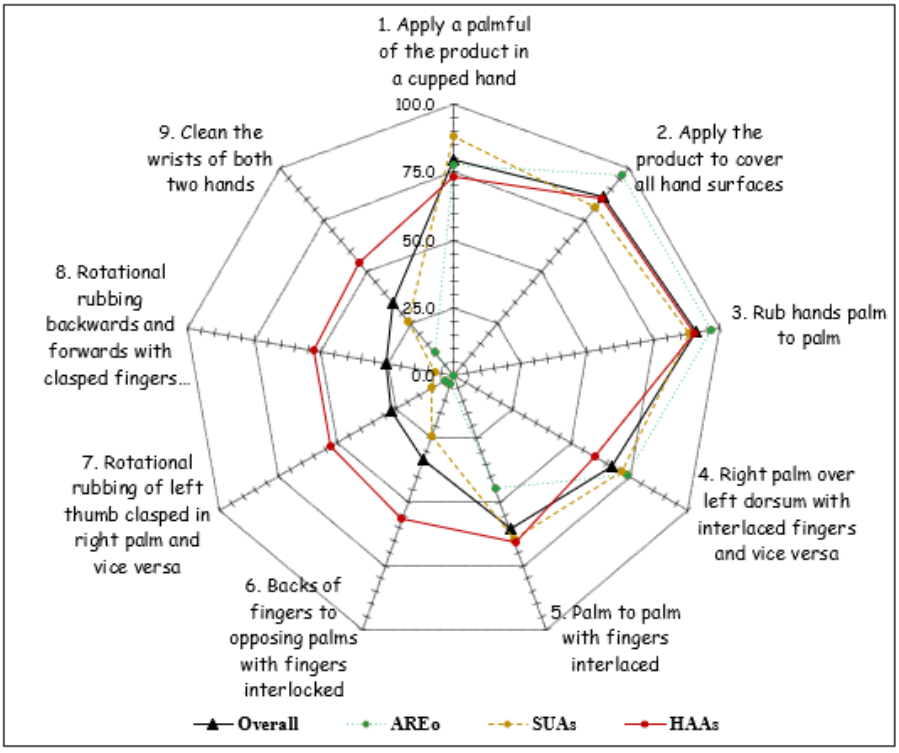
Fig 1. HHC knowledge among HCWs based on EVD outbreak exposure in North Kivu, 2020

Compliance with hand hygiene steps

Rinsing hands (90.0% in step 10), applying enough soap (89.1% in step 2), and rubbing hands palm to palm (85.7% in step 3), are the best-performed steps when washing hands (**Fig. 2a**). The lowest scores were for step 6 (43.9%), step 7 (42.1%), step 8 (41.4%), and step 11 (27.7%), relating to the rubbing of different hand surfaces and the prevention of re-contamination of hands cleaned by the washing device. Regarding rubbing hands with hydroalcoholic solution (**Fig. 2b**), the lowest scores were for step 8 (25.4% for rubbing finger pads), step 7 (27.0% for rubbing thumbs), step 6 (33.6% for rubbing backs of fingers), and step 9 (35.2% for rubbing wrists). The highest scores were for step 3 (91.0% for rubbing hand palm). Despite slightly higher scores in the HAAs group, the ranking of scores from different stages remained almost the same across exposure levels to the outbreak. It also clearly appears that the friction of HAS shows lower scores than soap and water handwashing.



2a



2b

Fig 2. Compliance with the steps for handwashing (Fig 2a) or rubbing with hydro-alcoholic solution (Fig 2a), by exposure levels to the 2018-2020 EVD outbreak, DRC

Factors associated with good HHC

The **table 2** show that the HHC to indications was 9 and 2 times higher respectively in the HAAs group (adjusted OR: 9.49; 95% CI: 5.51–16.36; p<0.001) and in the SUAs group (adjusted OR: 1.95; 95% CI: 1.15–3.29; p=0.013) compared to the AREo group. Compared to nurses, doctors were more compliant (adjusted OR: 2.21; 95% CI: 1.02–4.80; p=0.045), while other professionals showed lower compliance (adjusted OR: 0.53;

95% CI: 0.32–0.89; p=0.016). Compared to participants with higher education, those with secondary education level demonstrated lower compliance (OR adjusted = 0.57, 95% CI: 0.34–0.94; p=0.028) as well as participants with primary education or less (OR adjusted = 0.21, 95% CI: 0.07–0.68; p=0.009). Compliance was notably higher among HCWs involved in managing the patient's environment and contaminated equipment (adjusted OR: 2.40; 95% CI: 1.04–5.51; p=0.040). Other factors, such as the type and management authority of ESS, as well as the sex, age, and seniority of workers, were not significantly associated with compliance (p>0.001).

Table 2. Factors associated with HHC in areas with and at risk of EVD outbreak in 2018-2020, by analysis, DRC

Variable and categories	Hand hygiene compliance n(%)		Univariate		Adjusted	
	Yes	No	OR (95% CI)	p	OR (95% CI)	p
Effective (n%)	306(53.4)	267(46.6)				
Outbreak exposure level						
AFEo	160(78.8)	43(21.2)	6.29(4.08 ; 9.72)	**<0.001**	6.74(4.17 ; 10.88)	**<0.001**
HREo	65(42.8)	87(57.2)	1.26(0.83 ; 1.93)	0.278	1.34(0.85 ; 2.10)	0.211
LREo	81(37.2)	137(62.8)	1		1	
Type of HCFs						
Other hospital	188(51.9)	174(48.1)	0.85(0.61 ; 1.20)	0.356	0.95(0.60 ; 1.52)	0.830
General referral hospital	118(55.9)	93(44.1)	1		1	
HCF's authority						
Private	58(47.5)	64(52.5)	0.82(.52 ; 1.28)	0.372	0.81(0.45 ; 1.48)	0.499
Confessional	138(57.0)	104(43.0)	1.19(0.82 ; 1.73)	0.350	0.92(0.57 ; 1.46)	0.708
Public	110(52.6)	99(47.4)	1		1	
HCW's gender						
Male	144(51.6)	135(48.4)	0.87(0.63 ; 1.21)	0.403	0.78(0.53 ; 1.15)	0.216
Female	162(55.1)	132(44.9)	1		1	
HCW's age			1.02(1.00 ; 1.03)	0.155	1.02(0.99 ; 1.05)	0.250
HCW's seniority			1.02(1.00 ; 1.04)	0.118	0.99(0.95 ; 1.03)	0.578
HCW's qualification						
Non-medical	25(39.1)	39(60.9)	0.47(0.27 ; 0.81)	**0.007**	1.29(0.53 ; 3.14)	0.575
Other medical	60(42.9)	80(57.1)	0.55(0.37 ; 0.82)	**0.003**	0.57(0.35 ; 0.94)	**0.026**

professionnal						
Physicians	38(73.1)	14(26.9)	1.99(1.04 ; 3.82)	**0.039**	2.04(0.96 ; 4.35)	0.065
Nurses	183(57.7)	134(42.3)	1		1	
Education level						
None/primary	12(31.6)	26(68.4)	0.37(0.18 ; 0.75)	**0.006**	0.20(0.06 ; 0,61)	**0.005**
Secondary	89(53.6)	77(46.4)	0.93(0.64 ; 1.34)	0.676	0.68(0.42 ; 1.11)	0.121
Higher	205(55.6)	164(44.4)	1		1	
Procedures						
Non-invasive						
Yes	148(58.3)	106(41.7)	1.42(1.02 ; 1.98)	0.037	1.15(0.67 ; 1.98)	0.610
No	158(49.5)	161(50.5)	1		1	
Invasive						
Yes	142(57.7)	104(42.3)	1.36(0.97 ; 1.89)	0.072	1.06(0.60 ; 1.87)	0.836
No	164(50.2)	163(49.8)	1		1	
Contact with patient's environment						
Yes	46(56.1)	36(43.9)	1.14(0.71 ; 1.82)	0.597	1.24(0.58 ; 2.62)	0.579
No	260(53.0)	231(47.0)	1		1	
Sample collection/handling						
Yes	20(30.3)	46(69.7)	0.34(0.19 ; 0.58)	**<0.001**	0.55(0.24 ; 1.24)	0.147
No	286(56.4)	221(43.6)	1		1	

Perceptions on HHC

The perceptions on HHC improved significantly ($p < 0.001$) during the EVD outbreak in all groups, compared to before the outbreak (**Table 3**). As an illustration, more than 9 respondents of 10 rated the importance of hand hygiene during the outbreak as either high (18.5%) or medium (75.5%). Before the outbreak, only about 50% of them viewed it as important, with 10.5% rating it high and 46% as medium. The percentage of respondents giving high importance to HHC varied by the level of exposure to the outbreak: 4.7% to 30.3% in HAAs, 5.5% to 15% in SUAs, and 0.9% to 10.5% in AREo. During the outbreak, 74.6% of respondents reported that HCWs practiced hand hygiene before aseptic procedures, a significant rise from 28.5% before the outbreak.

Table 3. Changes in perceptions of HHC in HCFs before and during the 2018-2020 Ebola outbreak, RDC

Tthe participants' perceptions	Exposure level to the EVD outbreak									TOTAL		
	HAAs			SUAs			AREo					
	Before outbreak	During outbreak	*p*	Before outbreak	During outbreak	*p*	Before outbreak	During outbreak	*p*	Before outbreak	During outbreak	*p*
	n(%)	n(%)		n(%)	n(%)		n(%)	n(%)		n(%)	n(%)	
Participants	**n=211**			**n=220**			**n=219**			**n=650**		
The "perceived importance" of HHC in the HCFs												
Low	136(64.5)	4(1.9)	<0.001	105(47.7)	15(6.8)	<0.001	86(39.3)	20(9.1)	<0.001	327(50.3)	39(6.0)	<0.001
Medium	65(30.8)	143(67.8)		103(46.8)	172(78.2)		131(59.8)	176(80.4)		299(46.0)	491(75.5)	
High	10(4.7)	64(30.3)		12(5.5)	33(15.0)		2(0.9)	23(10.5)		24(3.7)	120(18.5)	
The heads of department (doctors and nurses) in this hospital are giving the example of HHC												
Agree	92(43.6)	193(91.5)	<0.001	142(64.5)	207(94.1)	<0.001	169(77.2)	205(93.6)	<0.001	403(62.0)	605(93.1)	<0.001
Disagree or undecided	119(56.4)	18(8.5)		78(35.5)	13(5.9)		50(22.8)	14(6.4)		247(38.0)	45(6.9)	
The HCWs in this hospital practice hand hygiene before touching a patient												
Agree	21(10.0)	166(78.7)	<0.001	16(7.3)	153(69.5)	<0.001	12(5.5)	142(64.8)	<0.001	49(7.5)	461(70.9)	<0.001
Disagree or undecided	190(90.0)	45(21.3)		204(92.7)	67(30.5)		207(94.5)	77(35.2)		601(22.5)	189(29.1)	
The HCWs in this hospital practice hand hygiene after touching a patient												
Agree	40(19.0)	177(83.9)	<0.001	28(12.7)	154(70.0)	<0.001	19(8.7)	173(79.0)	<0.001	87(13.4)	504(77.5)	<0.001
Disagree or undecided	171(81.0)	34(16.1)		192(87.3)	66(30.0)		200(91.3)	46(21.0)		563(86.6)	146(22.5)	
The HCWs in this hospital practice hand hygiene before an aseptic procedure												
Agree	75(35.5)	180(85.3)	<0.001	81(36.8)	163(74.1)	<0.001	29(13.2)	142(64.8)	<0.001	185(28.5)	485(74.6)	<0.001
Disagree or undecided	136(64.5)	31(14.7)		139(63.2)	57(25.9)		190(86.8)	77(35.2)		465(71.5)	165(25.4)	

The HCF is in the habit of educating patients on the importance of hand hygiene											
Agree	59(28.0)	177(83.9)	<0.001	123(55.9)	199(90.5)	<0.001	162(74.0)	196(89.5)	<0.001	344(52.9)	572(88.0)	<0.001
Disagree or undecided	152(72.0)	34(16.1)		97(44.1)	21(9.5)		57(26.0)	23(10.5)		306(47.1)	78(12.0)	

HAAs : area affected by the Ebola outbreak, SUAs: High risk of the Ebola outbreak; AREo: Low risk of the Ebola outbreak spread, EVD: Ebola virus disease, HCFs: healthcare facilities, HCWs: healthcare workers, HHC: hand hygiene compliance, p: p-value or level of significance, n: effective or sample size

Effectiveness of strategies for improving HHC

Base on **Fig 3**, improving access to hand hygiene supplies was viewed as the most effective way to enhance HHC in HCFs, followed by hygiene promotion, raising patient awareness, and leading by example. The participants appeared to place little importance on training.

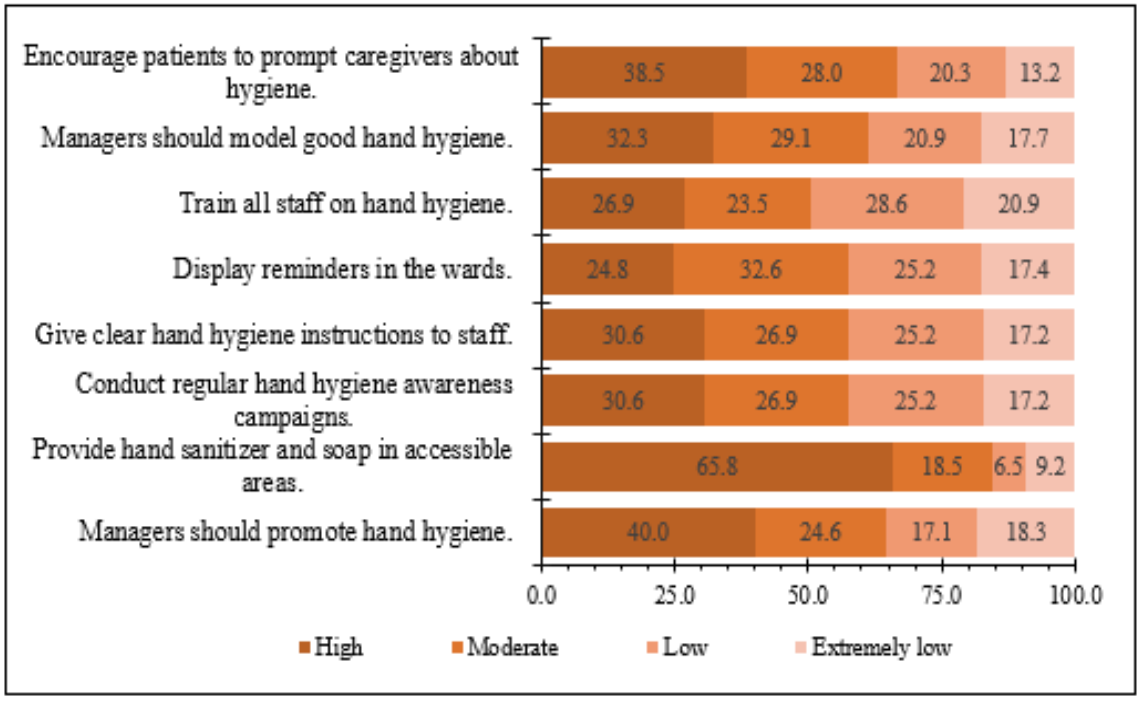


Fig 3. Workers' perceptions of how effective some interventions are in improving HHC in HCFs during the 2018-2020 EVD outbreak, DRC

Discussion

This study evaluated knowledge, perceptions and compliance with HHC guidelines, specifically regarding indications and steps, as well as factors influencing this compliance during the 2018-2028 Ebola outbreak in the DRC, to propose improvement solutions. The study revealed several key findings regarding HHC. It found that 53% of participants observed hand hygiene at each indication. Compliance was higher after patient contact than before (70.5% versus 60.2%), and handwashing with water and soap was more common than rubbing a HAS (44.2%/49.8% versus 25.7%/30.8%). Additionally, cleanings or rubbings the hand surfaces were the least practiced steps. Poor compliance was associated with being in non-epidemic areas, not being a nurse or doctor, and having a low level of education.

The percentage of participants observing hand hygiene indications when necessary is significantly higher than the 38% (24) and the 2.1% to 2.4% (25) reported in context without an EVD outbreak. HHC rates were 37.2% in the AREo, 42.8% in the SUAs, and 78.8% in the HAAs areas. The situation in the HAAs areas can be attributed to the perceived importance given by the existence of EVD cases, as well as the standard operating procedures (SOPs) and regular supervision during the outbreak (26,27). Follow-up, reminders, and feedback from assessments of hygiene performance are also crucial to improve HHC (2), as well as training techniques that use simulations and audiovisual materials (28). The situation in AREo better reflects the state of HHC in the country, which is linked, among other factors, to the poor availability of water, soap and HAS in RDC. These results indicate that there are challenges with HHC resources and the needs to implement the WHO's multimodal strategy for promoting HHC (2).

This evaluation showed a notable increase in respondents' considerations of HHC during the

outbreak compared to before. The pre-outbreak situation mirrored the country's, needing improvement regarding HHC. However, the HAS's availability alone is not enough. There must also be sufficient quantities to ensure better HHC. Before the outbreak, the availability of water, soap, and HAS was similar across the three groups, but there were significant differences between the services. HHC, deemed previously unimportant, became crucial during the outbreak, especially in the HAAs group, highlighting the outbreak 's role in improving HHC, probably due to fear of infection (29). Maintaining the high level of HHC observed in HAAs after the outbreak and extending it to the SUAs and AREo groups will be a significant challenge, but essential for ensuring safe care. To address this challenge, the study highlights the importance of ensuring the availability of HHC supplies and increasing awareness.

The physicians demonstrated adherence to HHC practices at a rate twice that of nurses (adjusted OR=2.21, p = 0.045). The contrast between this result and the prevailing literature on the subject (26) may arise from differences in task allocation or risk perception between the professional categories. Indeed, some studies have shown, first, that nurses perform more critical and contaminating tasks than other caregivers, and, second, that caregivers, in general, observe less hand hygiene before critical tasks, but observe more hand hygiene after contaminating tasks (30,31). This variation in task nature and sequence can affect HHC, highlighting the need for further research since this study focused solely on individual actions. The differences in task allocation between workers might also influence risk perception, impacting HHC.

Although HCWs were all trained or aware on HHC, those in the HAAs group were nine times more likely to observe hand hygiene compared to those in the AREo group (adjusted odds ratio of 9.49, p<0.001). Slightly less, workers in the SUAs group were twice as likely to observe hand hygiene than those in the AREo group (adjusted odds ratio of 1.95, p=0.013). The significant improvement in HHC during this EVD outbreak stems from perceptions of the EVD's severity. Few studies have examined the HHC of healthcare workers during outbreaks of severe diseases. For example, mixed results were noted regarding HHC during the COVID-19 pandemic: while a Danish study found no improvement in HHC (32), a meta-analysis suggested otherwise (7). We did not expect similar effects during the EVD and COVID-19 outbreaks due to differences in perceived severity, transmission routes, and preventive measures. As an illustration, the EVD primarily spreads through contact, while COVID-19 spreads via aerosols (33)~~–(41)~~. This can affect the importance of HHC, in both situations. However, the fact that HHC is better observed after the procedure rather than before suggests that fear of contamination plays a more significant role than concerns for patient safety. This study indicates that 4 out of 10 participants did not observe HHC before the procedure (15% in HAAs, 48% in SUAs and 57% in AREo), while 3 out of 10 participants did not do so afterwards (8% in HAAs, 40% in SUAs and 42% in AREo).

The decline in outbreak severity during the late stages may explain the non-compliance cases observed in the HAAs. This suggests that while outbreaks can raise awareness and improve HCW practices, memories fade as the situation resolves. Therefore, high HHC during the outbreak often stems from self-protection rather than a focus on patient safety, as evidenced by better adherence after procedures. The high non-compliance before the procedure, widely documented (7,34), can also suggest a gap between knowledge and practice regarding HHC protocols (35). Additionally, feelings of disgust after procedures might contribute to better post-contact HHC (30). Therefore, it's crucial to raise awareness about the benefits of HHC, particularly before procedures, for better patient safety and protection. Also, it's essential to improve HHC both before procedures and during outbreaks, as well as in routine care situations. Achieving this will require the development of appropriate strategies to address and improve these practices.

This study focused also on HHC and the steps involved in effective handwashing. The highest and lowest scores for washing with soap and water were observed at step 10 (rinsing hands) and step 11 (failing to use clean hands to turn off the tap), respectively. The lowest scores for handwashing as well as for hand rubbing in the three groups were concentrated between steps

5 and 9, which are about rubbing different hand surfaces. Nearly 20% of participants did not dry their hands properly after washing, risking their hands' recontamination with pathogens. Improper drying methods can compromise the effectiveness of HHC in removing harmful microbes (36,37). This can ultimately increase the risk of infection after hand washing with water and soap (22). Therefore, the use of a hydroalcoholic solution may prove useful, as it is more powerful against pathogens (24). Additionally, promoting compliance with the hand hygiene steps should also be emphasized to enhance efficiency (38).

Limitations of the study

This study has some limitations. First, the reliance on direct observation may influence participant behavior, as they might change their practices when they know they are being observed. Automated observation methods, which could address this limitation (39), were unfortunately unavailable. However, the observations were part of a larger process that began with an interview, after which consent was obtained for the interviewer to be present while the participant provided various services, without specifying the details of the observation. Additionally, the interviewers were trained to start their observations when the participants appeared to be behaving naturally and to discreetly note the elements of interest.

Second, the use of both probabilistic and non-probabilistic methods to select participants limits the generalizability of findings. Third, the cross-sectional design of the study restricts the ability to track changes over time. The lack of data from before the outbreak makes it challenging to ascertain whether the differences observed among the three areas were present before the outbreak, or if the high HHC in HAAs was the effect of the response to the outbreak. Despite these limitations, the study findings are consistent with existing literature and highlight areas for improvement.

Another limitation concerns the timing of data collection, which overlapped the end of the Ebola outbreak and the start of the COVID-19 pandemic. HCFs that had not reported EVD cases for weeks may have relaxed, while the emergence of COVID-19 may have encouraged stricter compliance. Overlooking this transition, as well as the severity differences between the diseases, and their effects on HCWs' behavior, are limitations that can be addressed by future evaluation. It may also be useful to include a large number of factors in future studies. However, the researchers believe this influence is minor, as few COVID-19 cases were reported locally. Nonetheless, Longitudinal studies during epidemic peaks could better track changes over time.

Conclusion

HHC indications were better in the HAAs but still fell short of optimal patient safety standards, particularly before procedures and in areas where no Ebola cases had been reported. The compliance with steps revealed that hand surfaces were not cleaned or rubbed adequately. This insufficient HHC can increase the risk of infections for both HCWs and patients. As well, HCWs in non-epidemic areas, those who are not nurses or doctors, and HCWs with a low level of education need attention. This evidence can guide interventions aimed at improving HHC. However, further studies are required to identify barriers to HHC during outbreak. Implementing sustainable programs aimed at promoting IPC, particularly in alignment with the WHO's multimodal strategy for hand hygiene, can enhance HHC and patient safety both during and beyond outbreaks.

Declaration of competing interests

The authors have declared that no competing interests exist.

Author contributions

GKK conceived the idea and developed the protocol. GMK, MRL, and KAG contributed to the design of the project. GMK directed the project, providing expertise at each step. GKK implemented the research by training the investigators and collecting data. GKK analysed data, interpreted the results and drafted the manuscript. All authors read, commented, and approved the manuscript.

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