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Impact of direct hand hygiene observations and feedback on hand hygiene compliance among nurses and doctors in medical and surgical wards: an eight-year observational study

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S U M M A R Y

Background: The improvement of hand hygiene compliance (HHC) is vital for preventing healthcare-associated infections (HAIs).
Aim: To determine whether observation and feedback influences HHC among nurses and doctors in surgical and medical wards, and whether these actions impact HAI incidence.
Methods: In this longitudinal observational study, HHC and the incidence of HAIs were observed in six medical and seven surgical wards in a tertiary hospital in Finland from May 2013 to December 2020. Data of the observations of five hand hygiene (HH) moments were collected from the hospital HH and the HAI monitoring registries. For statistical analyses a multivariable logistic regression analysis and a Poisson regression model were used.
Findings: HH monitoring included 24,614 observations among nurses and 6396 observations among doctors. In medical wards, HHC rates increased 10.8%, from 86.2% to 95.5%, and HAI incidence decreased from 15.9 to 13.5 per 1000 patient-days ($P < 0.0001$). In surgical wards, HHC increased 32.7%, from 67.6% to 89.7%, and HAI incidence decreased from 13.7 to 12.0 per 1000 patient-days ($P < 0.0001$). The overall HHC increased significantly among nurses (17.8%) and doctors (65.8%). The HHC was better among nurses than doctors (in medical wards, OR: 3.36; 95% CI: 2.90–3.90; $P < 0.001$; and in surgical wards, OR: 9.85; 95% CI: 8.97–10.8; $P < 0.001$).
Conclusion: Direct observations and feedback of HH increased HHC significantly among nurses and doctors over an eight-year period. During the same period, the incidence of HAIs significantly decreased in both medical and surgical wards.

Introduction

Monitoring 'My five moments' for hand hygiene (HH) by direct observation during routine patient care is recommended

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by the World Health Organization (WHO) and constitutes a critical measure for the prevention of healthcare-associated infections (HAIs) [1]. According to WHO recommendations, alcohol-based hand rubs containing 70% (volume/volume) ethanol (tested according to European Standard, EN 1500) are generally used in hospitals for HH in wards and outpatient clinics. The length of hand rubbing recommended by WHO is 20–30 s, which requires the approximate volume 1.6 or 3.2 mL of hand rub depending on the size of hands [2]. A direct observation allows assessment of compliance rates for all of the WHO hand-hygiene moments, and this has been considered as the reference standard for monitoring hand hygiene compliance (HHC) [3].

It is well known that there are differences in between doctors' and nurses' HHC [4–6]. Notably, high workloads, activities with a high risk of cross-contamination, and scepticism about the effectiveness of HH in reducing HAIs have been identified as determinants of poor HH among doctors [7]; a lack of time and forgetfulness have been identified as barriers to good HH among nurses [8]. Nurses not only demonstrate higher HHC than doctors, but also have more HH moments during their shifts caring for patients [9]. It has been estimated that nurses are responsible for 71% of patient contacts, while the corresponding proportion for doctors is 10% [10]. Therefore, nurses' HHC rates can be expected to have a major impact on the prevention of HAIs, especially in the wards.

To obtain robust information on HAIs, the incidence studies based on patient- or device-days are generally used. An alternative approach is to use prevalence studies, which describe the percentage of the infections at a certain time-point or period. They are easier to perform, but they are not so precise for monitoring, for example, HHC [11].

Our previous longitudinal study, which covered 2013–2019, demonstrated that HHC among healthcare workers improved at a hospital level following the use of direct observations and feedback [12]. Moreover, the incidence of HAIs decreased when the monthly HHC had surpassed 80% for two years. The purpose of this study was to explore how direct observation and feedback influences HHC among nurses and doctors in medical and surgical wards. We were also interested in determining whether any HHC changes in these wards would impact the incidence of HAIs.

Methods

Study design and setting

This longitudinal observational study was conducted at Oulu University Hospital, a tertiary care centre in northern Finland, between May 2013 and December 2020. The 607-bed hospital provided 159,828 patient-days of care (excluding psychiatry) in 2020. A total of 2841 nursing staff and 653 doctors work in the somatic area, including 784 nursing staff and 179 doctors in the medical area and 1492 nursing staff and 356 doctors in the surgical area. The six medical wards, which include a total of 172 beds, are for cardiac, neurological, lung, cancer, and haematological patients, as well as patients with infections. The seven surgical wards consist of cardiovascular and vascular surgery, gastrointestinal surgery, neurosurgery, orthopaedics, plastic surgery and urology, rheumatic orthopaedics, artificial joint surgery, thyroid surgery, and ear, nose, and throat diseases, with total of 201 beds.

Since 2013, 42 trained infection control link nurses have made regular direct observations of HHC in these 13 wards to improve HHC among healthcare workers. Variables recorded in the eRub database during each observation include the duration of hand rubbing (seconds), the observed moment(s) of WHO's five moments for HH, i.e. #1 before touching a patient, #2 before a clean or aseptic procedure, #3 after body fluid exposure risk, #4 after touching a patient, and #5 after touching patient surroundings, the job description of the person observed (nurse or doctor), and the ward. This process is described in more detail in our previous study [12].

Hand hygiene compliance data

Hand hygiene observational data were captured from the eRub database [1,2]. These data were summarized according to the type of healthcare worker (nurse or doctor), the ward location, and the moment(s) of WHO's five moments for HH. HHC was calculated on a quarterly or annual level as the number of correct HH opportunities divided by the total of opportunities observed. The patient ward was described as either a medical or surgical ward.

The incidence of healthcare-associated infections

The incidence of HAIs was determined by analysing the hospital's medical records system. The study hospital has a semi-automatic electronic incidence control programme that is linked to all of the hospital's electronic databases [13]. Thus, when a patient is started on an antibiotic, the programme automatically opens a questionnaire that the doctor(s) must complete. The key question to be answered is whether the antimicrobial agent(s) is/are being prescribed for the treatment of an HAI that has started at the study hospital or for an infection that has started in outpatient care. Each ward has two nurses who act as infection control link nurses; as such, they have been trained to check all registered initiations of antibiotic treatment after the patient has been discharged. In this study, HAIs were classified according to a modified version of the criteria of the US Centers for Disease Control and Prevention (CDC) [14]. The incidence of HAIs was analysed per 1000 patient-days. The incidence of HAIs was then calculated on annual, quarterly, and monthly bases.

Statistical analysis

A Poisson regression model was used to calculate the rate ratios (RRs), including the 95% confidence interval, for the change in incidence. The natural logarithms of patient-years were included as offset parameters when calculating the RRs for incidence. Multivariable logistic regression analysis was performed to calculate adjusted odds ratios (ORs) for the HHC. Hand disinfection (yes/no) was assigned as the dependent variable. Independent variables were type of opportunity according to WHO (moments 1–5; M2 reference), profession (nurse or doctor; reference), year (2013–2020; 2013 reference) and type of ward (medical or surgical; reference). Ward was set as a cluster effect, i.e. it was assumed that within the wards the HHC changes were smaller than between the wards. All variables were included in the model. Odds ratios, 95%

confidence intervals (CIs) and *P*-values are presented as a result for logistic regression analysis. Pearson correlation coefficient (*r*) was calculated, while two-tailed *P*-values are reported in the text. The statistical programmes SAS (version 9.4, SAS Institute Inc., Cary, NC, USA) and SPSS (Version 26.0, IBM Corp., Armonk, NY, USA) were used in the analyses.

Ethical considerations

According to the Medical Research Act (488/1999), approval from the local ethics committee is not required in a register-based study that does not process identifiable information.

Results

Between 2013 and 2020, a total of 31,010 HH events were recorded in the studied medical and surgical wards (24,614 and 6396 events for nurses and doctors, respectively). Among nurses, 8496 of the events occurred in medical wards and 16,118 events occurred in surgical wards. The corresponding numbers for doctors were 1950 and 4446, respectively. Concerning WHO's five moments, moment 4 (after touching a patient) was the most observed HH event among nurses in medical ($N = 2201$) and surgical wards ($N = 4341$), as well as among doctors in medical wards ($N = 796$); by contrast, moment 1 (before touching a patient) was the most observed event for doctors in surgical wards ($N = 1524$).

An improvement in HHC was observed in both medical and surgical wards (Table I, Figures 1 and 2): in medical wards HHC rates increased 10.8%, from 86.2% (95% CI: 84.0–88.1) in 2013 to 95.5% (94.1–96.6) in 2020; and in surgical wards 32.7%, from 67.6% (65.3–69.9) to 89.7% (88.3–90.9). The median annual hand-rubbing time decreased from the baseline 25 s (interquartile range: 16–31) in 2013 to 18 s (15–23) in medical wards, and from the baseline 20 s (12–30) in 2013 to 19 s (15–25) in surgical wards (Table I).

When the wards were compared using the HHC of 2013 as a reference (Table II), both in medical and surgical wards the HHC increased significantly over the next seven years (ORs: 1.52–3.71 in medical wards and 1.52–5.21 in surgical wards) (Table II). When moment 2 (before clean/aseptic procedure) was used as a reference, only after moment 5 (after touching patient surroundings) was the HHC significantly better in both wards (OR: 1.31 for medical wards and 1.49 for surgical wards). The HHC was clearly better in both wards among nurses than doctors (OR: 3.36 for medical and 9.85 for surgical wards).

The overall HHC among nurses increased 17.8%, from 2013 (81.6% of 2194 moments) to 2020 (96.1% of 2637 moments) and among doctors 65.8%, from 2013 (43.8% of 459 moments) to 2020 (72.6% of 634 moments). When the professions were compared using the HHC of 2013 as a reference (Table III), both nurses' and doctors' HHC increased significantly in the next seven years (OR from 1.64 to 6.25 for nurses and 1.74 to 4.71 for doctors). Also, within the professions, the HHC in all five moments increased significantly among nurses and doctors from 2015 onwards (Supplementary Tables S1 and S2). When moment 2 (before clean/aseptic procedure) was used as a reference (Table III), the HHC was significantly better after moment 3 (after body fluid exposure risk) for both nurses (OR: 1.64) and doctors (OR: 1.61) and after moment 5 (after touching patient surroundings; OR for nurses: 1.44; and OR for doctors: 1.96). Only doctors' HHC was significantly higher than reference after moment 4 (after touching a patient; OR: 1.47) (Table III). On the other hand, after moment 1 (before touching a patient), the OR was significantly lower than the reference (OR for nurses: 0.59; OR for doctors: 0.80). When the HHCs of two professions in medical and surgical wards were compared, the OR for nurses was not significant (1.69), whereas in medical wards doctors' HHC was significantly better than in surgical wards (OR: 3.83).

Table I
Hand hygiene observations, compliance, and hand rubbing time in medical and surgical wards between 2013 and 2020 in a Finnish university hospital

Wards/year	No. of observations	No. of observations where compliance with hand hygiene was recorded	Median (IQR) hand-rubbing time (s)	Hand-hygiene compliance, % (95% CI)
Medical				
2013	1069	921	25 (16–31)	86.16 (83.96–88.10)
2014	1544	1369	30 (20–34)	88.67 (86.99–90.15)
2015	1293	1213	30 (22–32)	93.81 (92.37–95.00)
2016	1740	1532	28 (20–32)	88.05 (86.44–89.49)
2017	1213	1073	26 (18–31)	88.46 (86.54–90.14)
2018	1489	1325	21 (16–28)	88.99 (87.29–90.48)
2019	1035	941	18 (15–23)	90.92 (89.01–92.52)
2020	1063	1015	18 (15–23)	95.48 (94.06–96.58)
Surgical				
2013	1584	1071	20 (12–30)	67.61 (65.27–69.87)
2014	2346	1810	24 (15–31)	77.15 (75.41–78.81)
2015	2827	2336	24 (16–32)	82.63 (81.19–83.98)
2016	3057	2571	26 (18–32)	84.10 (82.76–85.36)
2017	2979	2585	25 (18–33)	86.77 (85.51–87.94)
2018	3072	2719	22 (17–30)	88.51 (87.33–89.59)
2019	2491	2189	20 (15–26)	87.88 (86.54–89.10)
2020	2208	1980	19 (15–25)	89.67 (88.33–90.88)

IQR, interquartile range; CI, confidence interval.

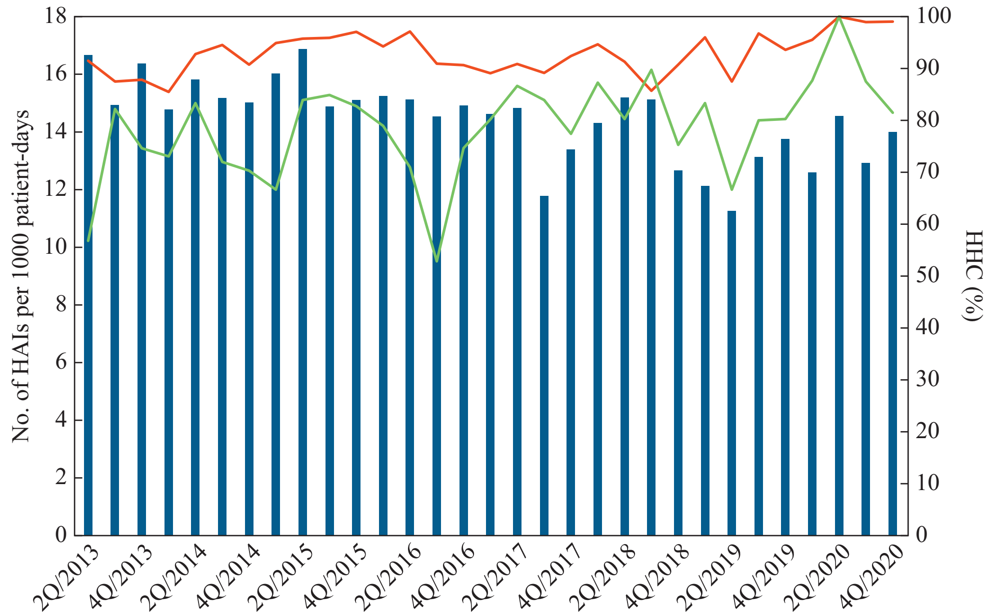

Figure 1. Quarterly (Q) incidence of healthcare-associated infections per 1000 patient-days (blue bars) and percentage hand hygiene compliance (HHC) for nurses (red line) and doctors (green line) in medical wards.

As Table IV shows, the annual incidence of HAIs in medical wards decreased from 15.9 per 1000 patient-days in 2013 to 13.5 per 1000 patient-days in 2020 (RR: 0.970; 95% CI: 0.959—0.981; $P < 0.0001$). In surgical wards, the annual incidence of HAIs decreased from 13.7 to 12.0 per 1000 patient-days (RR: 0.974; 95% CI: 0.963—0.985; $P < 0.0001$) (Table IV). In medical wards, relatively clear fluctuations in quarterly HHC rates among nurses and doctors were apparent during the eight-year study period (Figure 1). On the other hand, quarterly HHC among nurses working in surgical wards increased more steadily across the study period and showed only minor fluctuations (Figure 2). Among doctors, HHC during the third quarter of 2013 was as low as 18.4%, but thereafter increased to 61.5% in the fourth quarter of 2020 (Figure 2). There was a low negative correlation between the quarterly incidence of HAI and HHC ($r = -0.35$, $P = 0.052$) in surgical wards. A negligible negative correlation between quarterly HAI incidence and HHC was observed in medical wards ($r = -0.043$, $P = 0.82$). The discrepancies in HAI incidence between medical and surgical wards may be explained by distinct patient populations

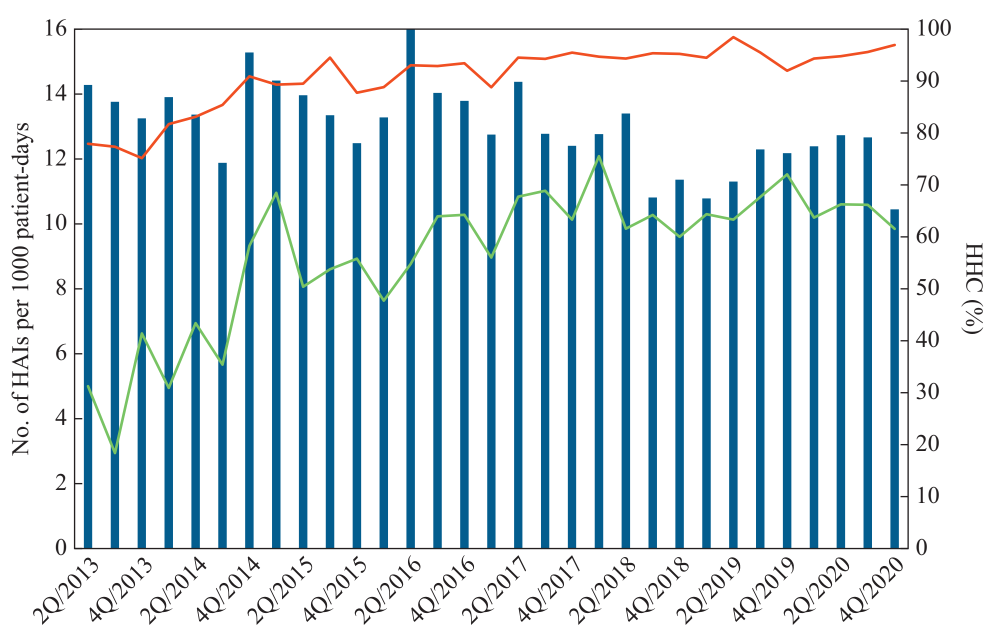

Figure 2. Quarterly incidence of healthcare-associated infections per 1000 patient-days and hand hygiene compliance (HHC) for nurses and doctors in surgical wards.

Table II
Comparison of hand hygiene compliance changes during 2013 and 2020 between medical and surgical wards as well as between nurses and doctors (logistic regression analyses)

Variable		Medical wards			Surgical wards		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
Year	2014	1.52	1.18–1.96	0.001	1.73	1.48–2.04	<0.001
	2015	2.53	1.87–3.41	<0.001	3.01	2.56–3.55	<0.001
	2016	1.81	1.41–2.33	<0.001	3.62	3.07–4.26	<0.001
	2017	1.52	1.15–1.99	0.003	4.71	3.97–5.59	<0.001
	2018	1.59	1.23–2.05	<0.001	6.19	5.20–7.38	<0.001
	2019	1.86	1.38–2.50	<0.001	6.16	5.12–7.40	<0.001
	2020	3.71	2.59–5.31	<0.001	6.33	5.21–7.69	<0.001
	2013	1.0			1.0		
Moment	1	0.66	0.53–0.83	<0.001	0.58	0.50–0.67	<0.001
	3	1.29	0.95–1.76	0.11	1.88	1.58–2.24	<0.001
	4	0.67	0.53–0.85	0.001	0.89	0.77–1.04	0.14
	5	1.31	1.03–1.66	0.028	1.49	1.29–1.73	<0.001
	2	1.0			1.0		
Profession	Nurse	3.36	2.90–3.90	<0.001	9.85	8.97–10.8	<0.001
	Doctor	1.0			1.0		

OR, odds ratio; CI, confidence interval.

(Supplementary Table S3). There were large between-ward differences in the prevalence of various types of HAI; however, three types of HAI showed similar prevalence: pneumonia was the second most prevalent infection in both wards; urinary tract infection was the third most prevalent infection; and other general infections ranked number ten.

Discussion

The results of this study show that continuous HH observations and feedback led to a sustained, significant improvement in overall HHC in medical and especially in surgical wards over an eight-year period. Overall HHC increased significantly among both nurses and doctors. Moreover, the incidence of HAI decreased significantly in both wards over the study period.

Earlier studies have predominantly reported two typical findings. First, nurses demonstrate higher HHC than doctors [4,6]. The present research agreed with those previous findings. Also, in our study HHC was higher among nurses than doctors (OR in medical wards: 3.4; in surgical wards: 9.9). Second, HHC rates are usually lowest before aseptic/clean procedures (moment 2) [15]. In our series this held true only for doctors, whereas nurses had contrary results. Their HHC was poorer before (moment 1) and after touching a patient (moment 4), when HHC rates before aseptic/clean procedures (moment 2) were used as a reference (OR for moment 1: 0.59; for moment 4: 0.58). Since 2015, both nurses and doctors had statistically significant increases across all five moments, when

Table III
Comparison of hand hygiene compliance change during 2013 and 2020 between nurses and doctors (logistic regression analyses)

Variable		Nurse			Doctor		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
Year	2014	1.64	1.40–1.92	<0.001	1.74	1.33–2.28	<0.001
	2015	2.74	2.31–3.26	<0.001	2.83	2.18–3.68	<0.001
	2016	3.12	2.63–3.70	<0.001	2.78	2.18–3.56	<0.001
	2017	3.08	2.58–3.68	<0.001	3.98	3.07–5.15	<0.001
	2018	3.78	3.17–4.52	<0.001	4.60	3.53–5.98	<0.001
	2019	4.36	3.55–5.35	<0.001	4.71	3.60–6.16	<0.001
	2020	6.25	4.95–7.89	<0.001	4.71	3.53–6.27	<0.001
	2013	1.0			1.0		
Moment	1	0.59	0.51–0.68	<0.001	0.80	0.63–1.01	0.064
	3	1.64	1.36–1.98	<0.001	2.14	1.61–2.85	<0.001
	4	0.68	0.58–0.78	<0.001	1.47	1.12–1.92	0.005
	5	1.44	1.23–1.68	<0.001	1.96	1.53–2.50	<0.001
	2	1.0			1.0		
Ward	Medical	1.69	0.73–3.93	0.20	3.83	1.56–9.41	0.006
	Surgical	1.0			1.0		

OR, odds ratio; CI, confidence interval.

Table IV

Number of infections, total patient-days, and incidence of HAIs per 1000 patient-days in the medical and surgical wards of a Finnish university hospital between 2013 and 2020

Wards/year	No. of HAIs	No. of patient-days	No. of HAIs per 1000 patient-days (95% CI)
Medical			
2013	584	36,748	15.89 (14.63–17.24)
2014	840	55,283	15.19 (14.18–16.26)
2015	857	54,490	15.73 (14.69–16.82)
2016	801	53,551	14.95 (13.94–16.03)
2017	739	54,048	13.67 (12.70–14.70)
2018	775	54,198	14.30 (13.31–15.34)
2019	678	53,993	12.56 (11.63–13,54)
2020	663	49,198	13.48 (12.47–14.54)
			RR (95% CI): 0.970 (0.959–0.981); $P < 0.0001$
Surgical			
2013	602	43,958	13.69 (12.62–14.83)
2014	835	61,236	13.64 (12.73–14.59)
2015	836	61,676	13.54 (12.65–14.51)
2016	891	62,369	14.29 (13.36–15.26)
2017	843	64,491	13.07 (12.20–13.98)
2018	804	66,497	12.09 (11.27–12.96)
2019	723	61,985	11.66 (10.78–12.50)
2020	680	56,472	12.04 (11.15–12.98)
			RR (95% CI): 0.974 (0.963–0.985) $P < 0.0001$

HAI, healthcare-associated infection; RR, rate ratio; CI, confidence interval.

we used the year 2013 as a reference. During the last year of the present study, doctors' HHC was at a similar level (72.6%) as was reported in a large, nationwide, eight-year-long Australian study (71.7%) [16]. Other research has also demonstrated that targeted feedback can significantly improve doctors' HHC [17]. According to a four-year study from a teaching hospital in China, direct observations and immediate feedback increased doctors' monthly HHC to levels as high as 92.2% [18]. Hence, continuous observations and feedback may dispel resistance among doctors and change their HH behaviour.

The high HHC rates reported in this study may be explained in several ways. First, we highlighted all five components of the WHO multi-modal promotion strategy [19]. Previous literature has identified two bundles that are associated with HHC improvements [20]. The first bundle includes feedback, education, and reminders, whereas the second bundle comprises interventions, improved access to alcohol-based hand rub, and administrative support. All these elements are in use in the medical and surgical wards of the study hospital.

The overall HHC was clearly higher in medical than in surgical wards during the first three observation years (2013: 27.4%; 2014: 14.9%; 2015: 13.5%). The differences may be explained by the fact that the chief medical and nursing managers of the medical wards commissioned a systematic evaluation of HH practices the year before the study (2012). It is notable that a survey concerning managers' attitudes towards HH and their role in improving HH was conducted in 2016. According to the survey, managers are committed to using various methods to promote HH [21]. Since 2016, the differences in HHC between these two units has decreased, being only 0.5% in 2018 and 3.5% in 2019. However, during the first COVID-19 year (2020), the HHC in medical wards, including the ward for infections, was clearly higher (6.5%) than what was observed in surgical wards; the difference between these wards was still the same (6.3%) in the second year of the COVID-19 pandemic in 2021 (data not shown). Also, our results suggest that a manager's active role in the organization is important for sustaining high HHC [22,23].

According to a previous systematic review, a decrease in the incidence of HAIs can be expected when HHC exceeds 60% [24]. However, it should be noted that some of the included publications had methodological problems; for example, they were not originally designed to evaluate the impact of HHC on HAI incidence. It is also important to remember that we cannot reliably determine how HHC impacts different types of HAI. Although many studies have reported an association between HHC and device-associated infections, in these cases a patient's endogenous flora can also increase the risk of infection [25]. For this reason, various aseptic measures, and specific infection control practices, should be implemented in addition to HH if the risk of infection is to be minimized [24].

Only a few studies including high baseline HHC also demonstrated a decrease in the incidence of HAI [12,16,25]. A study with an exceptionally high initial HHC (82.6%) reported that HHC further increased to 95.9% and that HAI incidence decreased by 6.0% over the 17-month study period [25]. In a nationwide Australian study, an increase in overall HHC from 63.6% to 84.3% over eight years was associated with a decrease in healthcare-associated *Staphylococcus aureus* bacteraemia; more specifically, a 10% increase in HHC led to a 15% decrease in the incidence of bacteraemia [16]. It has earlier been reported that the incidence of HAIs begins to decrease on the hospital level once monthly HHC exceeds 80% for two years [9]. In a recent four-year longitudinal Chinese study, HHC increased from 64.8% to 90.5% as a result of direct observations and immediate feedback [18]. They observed a weak but statistically significant negative correlation ($r = -0.27$) between monthly HHC and HAI incidence.

In the present study, HAI incidence decreased in medical and surgical wards when HHC increased from 86.2% to 95.5% in medical wards and from 67.6% to 89.7% in surgical wards. We did not find a clear correlation between HHC and HAI incidence in medical wards, which could be explained by the small increase in HHC (10.8%). In surgical wards, the notable increase of 32.7% in HHC showed a weak negative correlation with the incidence of HAIs; however, the r^2 for the relationship was only 0.12, i.e. an increase in HHC only explains 12% of the change in HAI incidence. This means that several factors other than a change in HHC explained the observed decrease in HAI incidence; we are not aware of these factors as the research was designed to measure changes in HHC and HAI. Taken together, sustained improvements in HHC can be achieved by continuous direct observations and feedback – even when the baseline HHC is high – with empirical evidence from ward, hospital, and national levels across four continents.

The present study had several notable strengths. First, we followed all HAIs when tracking the prevalence of HAIs. The infections were classified according to a modified version of the criteria presented by the CDC [14]. Most earlier studies that have investigated the association between HHC and infections have typically focused on device-associated infections in the ICU or throughout the entire hospital. By contrast, we prospectively identified all of the possible HAIs that could affect patients following the initiation of antibiotics. Following discharge, patient data were checked by link nurses. Furthermore, surgical site infections and bloodstream infections were checked once again by the infection control practitioners. This approach has been shown to be reliable [13]. Second, HH observations were made in an identical manner throughout the study period. HH results for different wards can also be accessed via the hospital intranet. Third, HH observations were made by co-workers in the wards, which may decrease the need for behaviour change during the observation period. In addition, we analysed hand-rubbing time, which has not always been reported in prior research. During the study period, the median rubbing time decreased to a median of 18 s in medical wards and 19 s in surgical ward (2020). Because the incidence of HAIs did not increase during the study period, our results suggest that a hand-rubbing time of 15–20 s may be sufficient for preventing HAIs; this result concurs with other recent suggestions [26,27].

Nevertheless, the present study has several limitations. First, it is a non-randomized, internal observational study carried out in a single tertiary hospital in Finland. Further studies are needed to determine whether the results are generalizable to other types of hospitals or countries with high baseline HHC. Second, we do not have a baseline HHC value for the period preceding the study; this is because the follow-up was started during this observational study. However, during the first six months the HHC varied between 73.7% and 78.2% at the hospital level [12]. Third, individual patient data were not collected, which makes it impossible to detect changes in the underlying diseases of patients. However, it should be stated that the investigated tertiary hospital serves a large region, and no marked changes in treatment protocols, practices or reasons for admission occurred during the study period. Moreover, the Hawthorne effect, i.e. a change in behaviour under the knowledge that one is being followed or monitored, is most likely a factor in the present as well as in previous studies [28]. Notably, an Australian study found that the Hawthorne effect for HHC was more pronounced in cases of direct human auditing than automated surveillance [29]. It has even been suggested that direct observations should not be used when evaluating compliance [30]. We considered this in our study, with the same trained link nurses and co-workers in each ward making observations over the eight-year study period; it may lead to the Hawthorne effect becoming less pronounced. It is important to state that the HH observations were made during day shifts on regular weekdays. As this represents a minority of the daily HH opportunities in wards, the observation method may have biased the results. However, it is interesting to note that covert electronic HH observations found HHC to be highest during night-time [31]. In a recent study in the geriatric hospital, the use of a novel electronic wearable device did not change the HHC among healthcare workers. However, the use of the device increased the median duration of hand rubbing (from 6.5 to 8 s) and the volume of alcohol-based hand rub (from 1.12 to 1.71 mL) [32]. Although electronic surveillance systems seem to be free of the Hawthorne effect, further studies are needed to determine standardized metrics for quantifying system performance differences among electronic HH monitoring systems [33]. As has been the case in earlier studies, there were far fewer HH observations among doctors than among nurses in the present study; data for doctors only represent one-fifth of the total observations. Furthermore, among medical doctors, the proportion of total observations was only 30.5% of the 6396 events, potentially explaining the high fluctuation seen in Figure 2. Another limitation was that our HH analysis concentrated only on rubbing time without any emphasis on technical aspects. Furthermore, although Oulu University Hospital uses fully electronic medical records, the presence of devices (e.g. catheters) or catheter-days is not recorded systematically in the wards [13]. For this reason, it was impossible to state how the study hospital compared to other organizations in terms of the incidence of device-associated infections per device-days. Finally, the HAI monitoring system required the link nurses to manually review antibiotic treatment after the discharge of patients once every three weeks for each ward [13]. This was associated with some costs, and the efficacy was not reported, as has been the case in some other studies [16].

In conclusion, our eight-year project in a tertiary hospital showed that continuous observations and feedback can significantly increase HHC in medical and surgical wards. A significant positive change in HH and across all five moments for HH was seen among both nurses and doctors. During the same period, the incidence of HAIs significantly decreased in both medical and surgical wards.

Conflict of interest statement
None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.06.007.

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