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Short Report

Effectiveness of an electronic hand hygiene monitoring system in increasing compliance and reducing healthcare-associated infections

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SUMMARY

During an interventional study in a nephrology department, we investigated the effect of an electronic hand hygiene monitoring system on the hand hygiene compliance of healthcare workers ($N = 99$) and hospital-acquired bloodstream infections. The hand hygiene compliance of the doctors and nurses improved significantly during the intervention phase when they received group and individual feedback based on actionable insights from the electronic hand hygiene monitoring system. The improvements in hand hygiene compliance were associated with a significant reduction in the number of hospital-acquired bloodstream infections.

Introduction

Hand hygiene (HH) is a key part of infection prevention and control (IPC) in all healthcare facilities to reduce healthcare-associated infections (HCAIs). HH compliance (HHC) is therefore considered one of the most important measures of patient and HCW safety [1]. Unfortunately, HHC remains suboptimal [2], even during the COVID-19 pandemic [3], and effective long-term strategies are needed.

Electronic HH monitoring systems (EHHMSs) may be of help in identifying the most effective methods of improving HHC among various professional groups and in documenting the associated changes in HCAIs [4].

Hospital-acquired bloodstream infections (HA-BSIs) have been chosen by the Danish Ministry of Health as a national indicator for the overall development of HCAIs. Thus, we aimed to investigate the impact of an EHHMS on the HHC of front-line HCWs and HA-BSIs. We hypothesized that the data-driven feedback interventions associated with the use of the EHHMS

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are more effective than present routine practices to directly increase the HHC and thereby reduce the incidence of HA-BSI.

Methods

Study design and setting

We conducted an investigator-initiated quality-improvement project designed as a prospective interventional trial in an in-patient nephrology department with 800—900 admissions per year.

The study consisted of three phases: Phase 1 was considered a baseline registration (February 2020—July 2020) which was interrupted for two months due to the COVID-19 pandemic (department temporarily relocated). The baseline HHC did not change between pre- and post-lockdown (Figure 1).

Phase 2 was an intervention period (July 2020—November 2020) with a presentation of aggregated HHC data at staff meetings one to two times per month and in monthly newsletters. Focused feedback was given on the areas with low HHC and followed a three-step process: (1) summary of the results from the previous weeks to generate awareness and to ensure a continuous follow-up; (2) open discussion to facilitate knowledge distribution; (3) guided practice to focus on the most relevant areas of improvement.

Phase 3 was an intervention period (November 2020—February 2021) with individual feedback. Staff signed up via a mobile application (app) to receive their own HHC information via a weekly e-mail report.

Study participants

Doctors and nurses were eligible to participate if they had regular patient contact in the department. Participation was voluntary, and study participants had to keep the same sensor affixed to their name badge throughout the study period.

Data collection

We focused on alcohol-based hand rub based on the WHO's "My 5 Moments for Hand Hygiene" and collected the data using an EHHMS (sani nudge™; see the Supplementary data) [5]. The HHC data were accessible to the head nurse, chief physician, and IPC professionals via an online dashboard. Visuals and graphics were printed and shown to the study participants at feedback meetings and afterwards posted on bulletin boards in places frequently visited.

The EHHMS measured HHC in relation to 'before patient contact' when entering the patient zone, 'after patient contact' when leaving the patient zone, before 'clean tasks' and after 'unclean tasks' to reflect the clinical work. Clean tasks were defined as moments for HH measured by the system in rooms where clean procedures take place (medication rooms and clean utility rooms), and unclean tasks as moments for HH

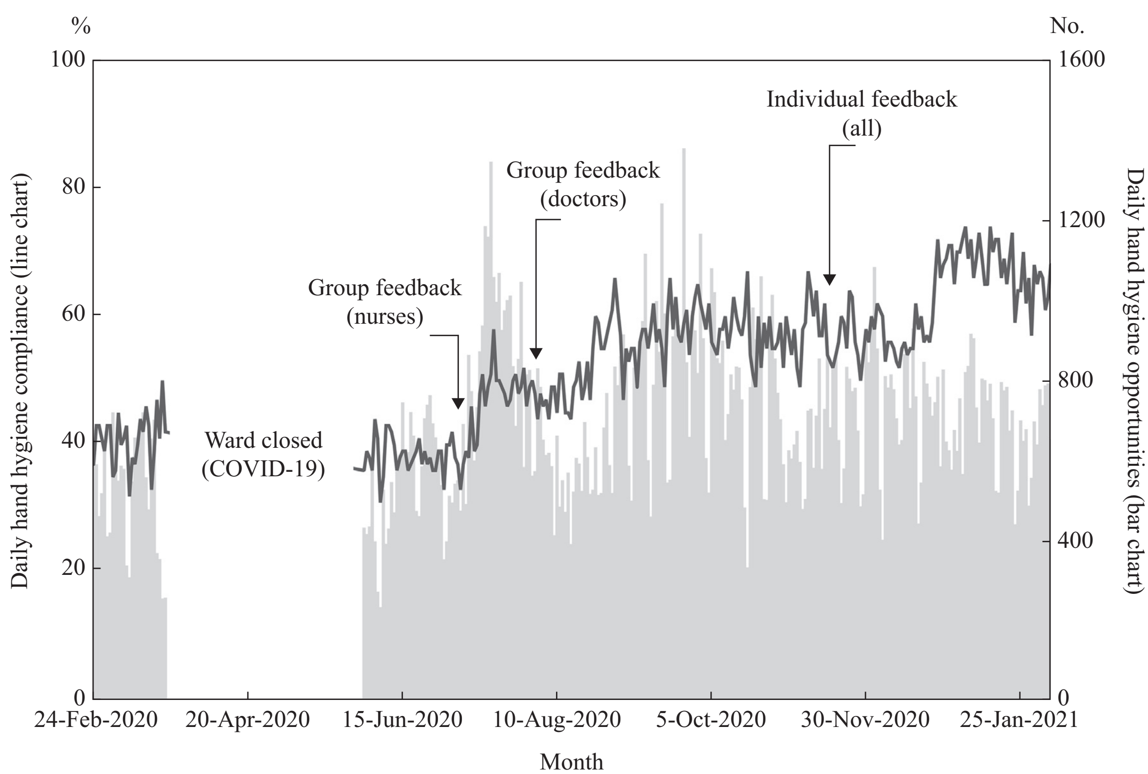

Figure 1. Hand hygiene compliance and opportunities. Daily hand hygiene compliance (line) and hand hygiene opportunities (bars) of nurses and doctors during the study period. The ward was closed during April and May 2020 because of the COVID-19 lockdown. Group feedback was initiated for the nurses before the doctors. The sign up for individual feedback via the mobile application was initiated simultaneously for both groups but took a month before all had signed up and started to receive their weekly performance data.

in rooms where unclean procedures take place (staff toilets and unclean utility rooms).

Classification of HA-BSIs

We routinely cultured blood samples on suspicion of clinical sepsis. BSIs were defined by the presence of a significant BSI pathogen (bacteria or fungi) and an appropriate concomitant antimicrobial treatment [6]. Information about BSIs in patients admitted to the department was retrieved from an electronic hospital infection monitoring system [6]. We defined HA-BSI as a BSI in a patient hospitalized for more than 48 h at the time of discovery. Subsequently, the authors (A.R.K. and J.K.M.) manually audited the classification of the cases by reading the electronic medical record of the patients.

Ethics

The Hospital Review Board approved the study (no. 21/478).

Process and outcome effects

The primary outcome was the overall HHC of the doctors and nurses, as measured by the EHHMS. We compared the averaged HHC of the nurses and doctors at department level between Phase 1, Phase 2 and Phase 3. The secondary outcome focused on the effects of changed HHC measured by the incidence of HA-BSI.

Statistical analysis

Continuous variables were reported as means with standard error of mean or 95% confidence intervals (CIs). The parametric distribution of data was confirmed by the Shapiro–Wilk normality test. We assessed the differences between HHC means with the Student's *t*-test. Differences in infection incidence rates between the HH intervention period and two control periods (same period during the previous two years) were assessed using the log-rank test.

Two-sided *P*-values <0.05 were considered statistically significant. All analyses were performed using GraphPad Prism (version 9.1.0) and STATA (version 16).

Results

We enrolled 77 nurses and 22 doctors. The system measured an average of 550 HH opportunities per HCW per month. The HHC gradually increased over time (Figure 1).

HHC of doctors

The doctors' HHC before patient contact increased significantly from baseline once they received group feedback (16% vs 27%, P=0.001) and more than doubled from baseline to the period when they received individual feedback (16% vs 37%, P<0.0001) (Supplementary data). In addition, the HHC increased significantly from group feedback to individual feedback (27% vs 37%, P=0.009). HHC after patient contact increased significantly from the baseline period compared with the group feedback period (25% vs 37%, P=0.01) and the individual feedback period (25% vs 38%, P=0.002). The same pattern was observed for the HHC before clean and after unclean tasks.

HHC of nurses

The nurses' HHC before patient contact increased significantly from the baseline once they received group feedback (22% vs 37%, P<0.0001) and more than doubled during the period with individual feedback (22% vs 56%, P<0.0001) (Supplementary data). HHC also increased significantly after patient contact, before clean tasks and after unclean tasks. As with the doctors, the nurses' HHC was lowest in the patient rooms, lower before than after patient contact, and highest in the rooms related to unclean tasks.

Infection rates

Patient characteristics were comparable during the control and intervention periods (Table I and Supplementary data). The two control periods had a significantly higher number of HA-BSI cases (control period 1: 14.7 cases per 10,000 patient days, 95% CI 7.0–30.9, P=0.008) (control period 2: 19.1 cases per 10,000 patient days, 95% CI 9.9–36.8, P=0.003) compared with the intervention period (0 cases) (Table I).

Discussion

We tested the effect of an EHHMS on HHC and HA-BSI and found that the EHHMS significantly increased the HHC of the HCWs and reduced the rate of HA-BSIs. Other studies have found similar correlations between implementation of EHHMSs, improved HHC and reductions in HCAIs [7]. Only a few studies reported on HA-BSI even though it is a common HCAI with serious implications for the affected patients indicated by an increase in the case fatality rate from 33% to 49% in the elderly [8] and excess length of hospital stay for survivors [9].

Table I
Patient characteristics in the department and number of HA-BSI for the control and intervention periods

Period	Control 1 Jul 2018–Jan 2019	Control 2 Jul 2019–Jan 2020	Intervention Jul 2020–Jan 2021
Mean age (years) (SD)	68 (17)	66 (18)	69 (16)
Female sex (%)	41	44	41
Patients treated	815	877	823
Patient days	4752	4700	4745
HA-BSI	7	9	0
Incidence rates per 10,000 patient days	14.7	19.1	0
P	0.008*	0.003**	Ref.

HA-BSI = hospital-acquired bloodstream infection, SD = standard deviation.
* Comparison between control period 1 and intervention.
** Comparison between control period 2 and intervention.

Guest *et al*. suggested that to be cost-effective, an IPC intervention related to the implementation of EHHMSs must reduce the HCAI incidence by $\geq$15% [10] which was achieved in this study. While cost is only one incentive to reduce HCAIs, the primary focus for HCWs should always be on patient safety. HHC constitutes an important patient safety indicator that is useful for monitoring and training purposes. In our study, we found that the doctors had the lowest baseline but reached almost the same high HHC level related to clean and unclean tasks after the interventions as the nurses. In the patient rooms, however, the doctors merely reached 38% compared with 61% for the nurses. One potential explanation could be that the doctors did not receive the full benefit of the individual data because individual data reports required at least five patient visits per week to ensure enough statistical power. Some of the doctors had periods of other tasks (ambulatory service, administrative work, etc.) resulting in weeks without individual data reports and less HH feedback compared with the nurses.

There were several limitations to this study. This was an observational study which increases the risk of being subject to potential bias. Other factors might have influenced the reduction in HA-BSI. However, the type of patient admitted was comparable in the control and intervention periods (Table I and Supplementary data), and environmental cleaning or antibiotic stewardship standards did not change during the study period. Not all HCWs were equally exposed to the group feedback because of variation in meeting attendance which makes it difficult to estimate the highest potential effect of the intervention. However, approximately 60% of the HCWs opened the individual data reports each week which may indicate possibilities to improve HHC even further if feedback exposure is ensured consistently. Although it was a small-scale study, we did collect a large amount of data compared with HH studies using manual direct observations, which provides statistical power to the analyses.

In conclusion, the implementation of an EHHMS to provide group and individual feedback significantly improved the HHC of doctors and nurses, which was associated with a significant reduction in HA-BSI. This study adds to the growing evidence on the value of EHHMSs and aids IPC professionals and clinical departments in making evidence-based assessments of HHC.

Acknowledgements

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Conflict of interest statement

M.B.H. works at Konduto ApS which has developed sani nudge™. The other authors declare that they have no competing interests.

Funding sources

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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.2021.05.011.

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Appendix A

The sani nudge system.

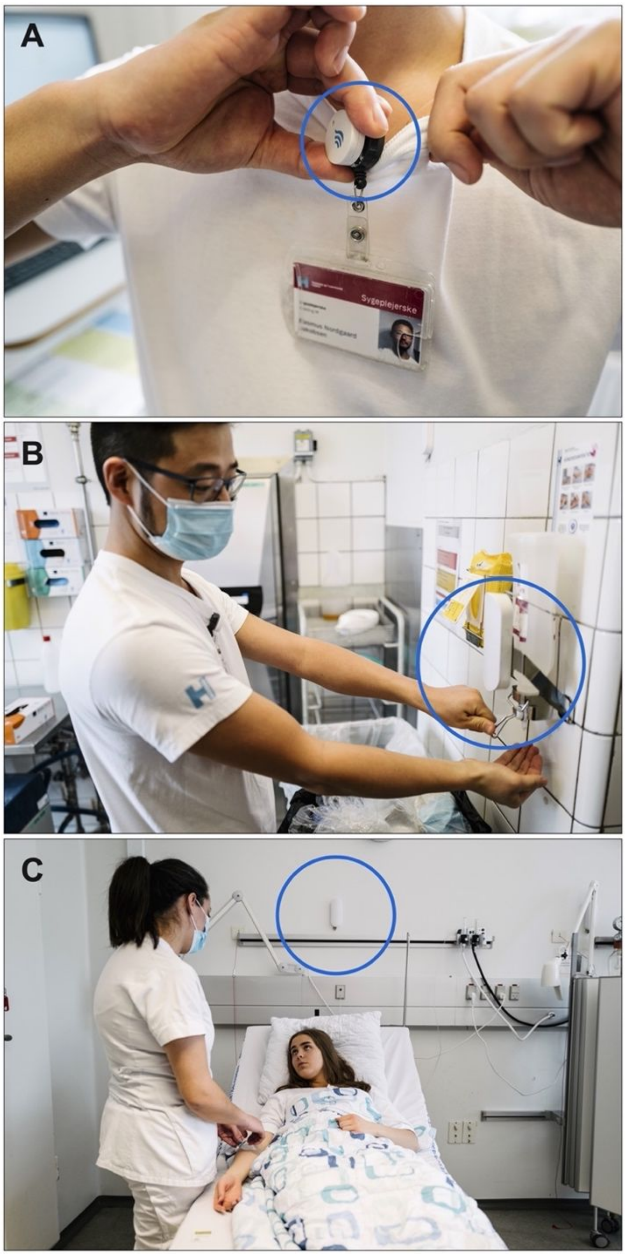
The sani nudge system is a validated, real-time location system measuring hand hygiene compliance 24/7. The sensors are placed on the existing name badges of the healthcare workers and connect with sensors on existing alcohol-based hand rub dispensers and on the wall near the patient's bed to create a patient zone (proxy measure for patient contact). The network of sensors allows the system to detect hand hygiene opportunities and hand hygiene events (alcohol-based hand rub related to each hand hygiene opportunity):

A) Sani IDs placed on the name badges of the healthcare workers and coded according to staff group (doctors or nurses).

B) Sani sensors placed on an alcohol-based hand rub dispenser which measure hand hygiene events (dispenses) and connect the events to the sani ID closest to the Sani sensor.

C) Sani sensors placed in the patient room to measure hand hygiene opportunities around the patient by creating a patient zone according to WHO's guidelines. This allows the system to be used as a proxy for monitoring WHO moments 1 (before touching a patient), 4 (after touching a patient), and 5 (after touching patient surroundings). In the other room types (staff toilets, medication rooms, utility rooms), the Sani sensors created work zones which enabled them to detect whether hand hygiene was performed before clean procedures and after unclean procedures.

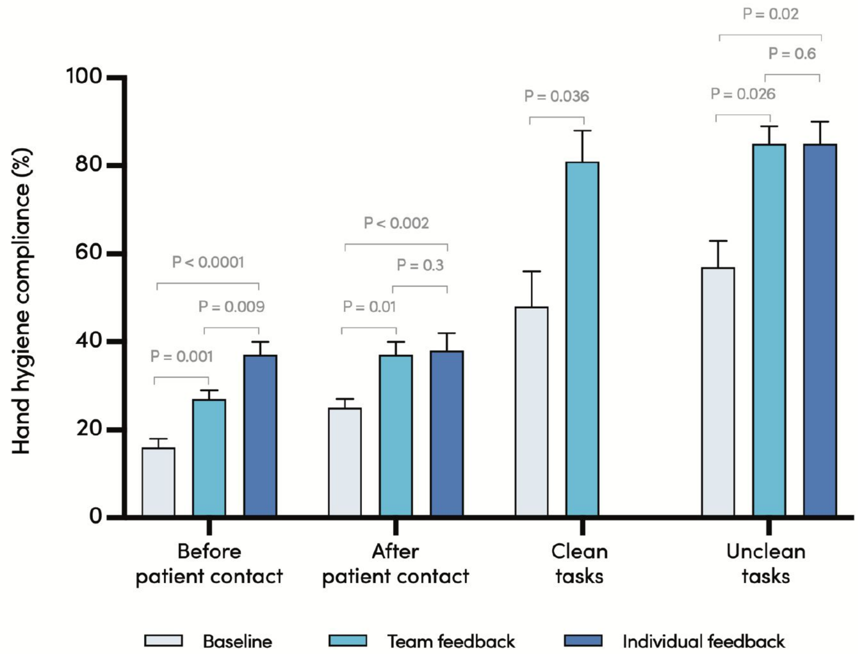
Written informed consent to use the pictures for publication in print and electronic has been obtained by the healthcare workers and the patient.



Appendix B

Doctors' hand hygiene compliance.

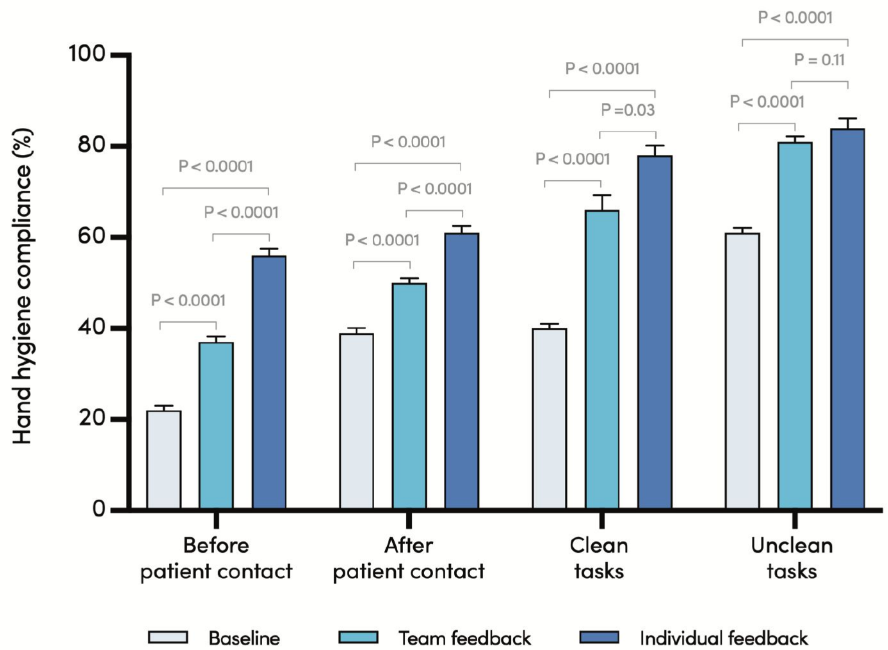
Hand hygiene compliance of the doctors before and after the interventions.



It was not possible to calculate HHC levels anonymously for the doctors during the individual feedback period in the rooms related to the clean tasks (medication rooms and clean utility rooms) because less than five doctors assessed these places and in an insufficient number of times to ensure that the doctors could not be individually identified.

Nurses' hand hygiene compliance.

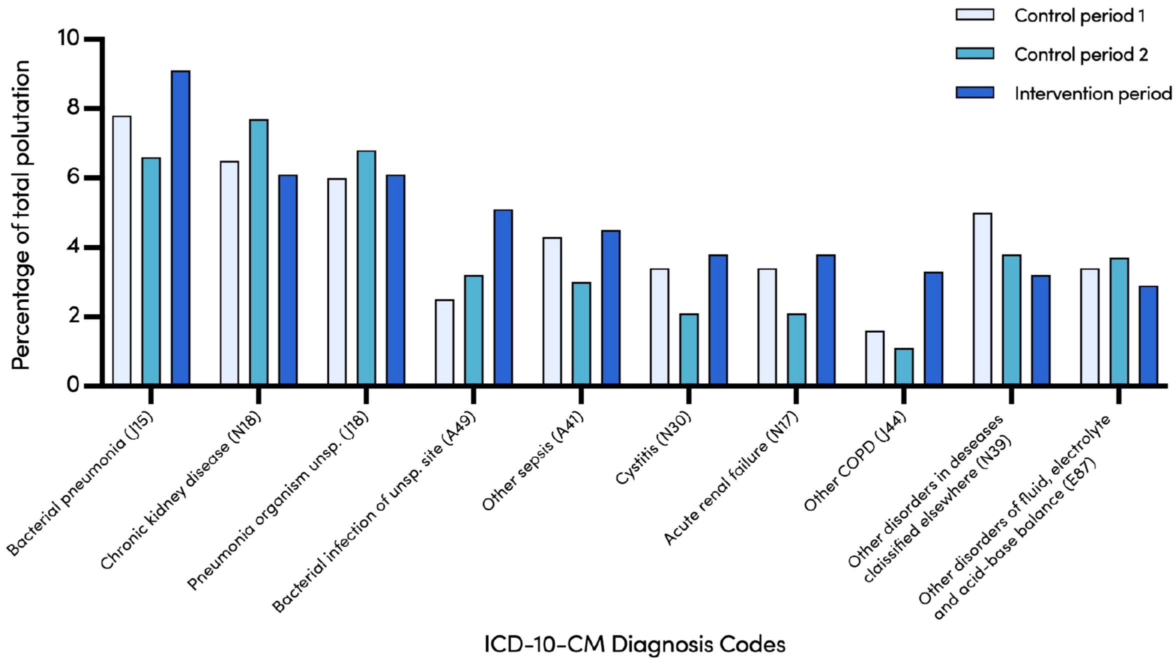
Hand hygiene compliance of the nurses before and after the interventions.



Appendix C

Patient population.

Top 10 most frequent diagnoses made in the department during the two control periods and the intervention period. Control period 1 (Jul 2018 – Jan 2019), Control period 2 (Jul 2019 – Jan 2020), Intervention period (Jul 2020 – Jan 2021).



Unsp.= unspecified, *COPD* = chronic obstructive pulmonary disease.
Cystitis (N30) more broadly register all types of urinary tract infections.