Clean work, the pursuit of increased adherence to hand hygiene routines

a descriptive study

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Abstract
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Healthcare-associated infections (HAI) are a problem in health care worldwide. In Sweden 7-8% of all patients treated in hospital suffer from an adverse event of varying severity, of which approximately 60,000 from a HAI. Proper hand hygiene is considered the single most important measure to reduce HAI. Despite the importance, adherence to correct hand hygiene routines are lacking among healthcare workers (HCWs). The World Health Organizations (WHO) multimodal promotion strategy promotes areas that need to be addressed in order to change the behaviour of individual HCWs to optimise adherence to hand hygiene and to improve patient safety. These areas include feedback, education, reminders at the workplace and institutional safety climate.

The overall aim of this study was to examine the possibility of adherence to hand hygiene routines and to explore factors that might influence the HCWs adherence.

The study used a descriptive research design made through qualitative method, with focus group interviews, and quantitative method, using a questionnaire survey. Eight focus group interviews were conducted with assistant nurses (n=18), nurses (n=15) and physicians (n=5) and analysed with abductive qualitative content analysis. The questionnaire survey was answered by nurses (n=84) and nursing students in their first semester (n=71) and last semester (n=46) and the data was statistically analysed.

The main findings show that there are barriers to hand hygiene adherence and measures to improve these. HCWs highlighted discrepancies regarding how the organisation was supposed to give feedback and how it actually was at the workplace and expressed needs for more direct feedback to improve adherence. The study also found that hygienic knowledge gaps exists among nurses and nursing students regarding causes of HAI and how the risk of contamination of patients and HCWs can be minimized among others. Students at the beginning of the education had a lower level of knowledge than last semester students and registered nurses. The last semester students tended to have the highest level of hand hygiene knowledge.

In conclusion, the key areas presented by WHO's multimodal promotion strategy to improve adherence all lack the appropriate measures, in some extent. The use of an electronic reminder system could give the means to improve a behaviour as long as the individual integrity is protected and development of curriculums for nursing students and continuing education of nurses is needed to further develop and maintaining knowledge.

Keywords: Healthcare Associated Infection, Healthcare Workers, Hygiene, Knowledge, Perception, Students

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List of studies

This report is based on the following studies:

I. P.-O. Blomgren, B. Lytsy, K. Hjelm, C.L. Swenne. (2021). Healthcare workers' perceptions and acceptance of an electronic reminder system for hand hygiene, *Journal of Hospital Infection*, Volume 108, 2021, Pages 197-204, ISSN 0195-6701, https://doi.org/10.1016/j.jhin.2020.12.005.

II. P.-O. Blomgren, B. Lytsy, C.L. Swenne, K. Hjelm. (2022). Hand hygiene knowledge among nurses and nursing students -A descriptive cross-sectional comparative survey using the WHO's "Hand Hygiene Knowledge Questionnaire". *Submitted*

Contents

Abbreviations

HAI	Healthcare-associated infection
HCW	Healthcare worker
IPC	Infection Prevention and Control
PI	Principal investigator
RN	Registered nurse
SALAR	Swedish Association of Local Authorities and Regions
TPB	The theory of planned behaviour
WHO	World Health Organization

Introduction

Healthcare-associated infections

Every year, 4 million EU citizens suffer from a healthcare-associated infection (HAI), of which more than 90,000 people die (1). The cost of this is estimated at 7 billion Euros due to extended treatment times, reoperations and expensive medications (2). In Sweden, calculations from the Swedish Association of Local Authorities and Regions (SALAR) show that 7–8% of all patients treated in hospital suffer from an adverse event of varying severity, which means that 100,000 patients suffer annually, of which approximately 60,000 (4.5%) from a HAI. Annually, approximately 1,300 patients die as a direct or indirect result of a HAI, an average of three to four patients per day. The costs are estimated at approximately SEK 8 billion per year, which is 12% of the total cost of somatic care. In addition to costs for care, this also causes a lot of mental and physical suffering as well as financial losses for the patient (3).

A HAI is defined, according to the National Board of Health and Welfare, as an infection that occurs during inpatient care or as a result of diagnostics, treatment or nursing in other care and social care. It can occur during any part of the patient's chain of care, which can be connected through several instances, such as inpatient care, primary care, municipal care and social care (4).

HAIs, such as catheter-caused urinary tract infections, pneumonias, postoperative wound infections and bacteremias, can be reduced by a third (5). To prevent HAIs, there are scientifically based guidelines and action packages. In all action programmes, hand hygiene has a central role and is considered the single most important measure to reduce HAIs and the spread of resistant bacteria between patients (5–7). Either by endogenous infections from the patient's own flora, i.e. *Clostridoides difficile*; by exogenous cross-infections through direct contact; or droplets between patients or staff, i.e. SARS-CoV-2 (COVID-19), or indirectly from the environmental floras, i.e. *Pseudomonas aeruginosa*. The survival of these bacterial types on decontaminated surfaces varies between four to 16 months (8).

Organization of infection prevention and control

Sweden has three administrative levels, which are involved in the health system: national, regional and local (9). At the national level, the Ministry of Social Affairs is responsible for health care policies and has an international collaboration with e.g. the European Union and World Health Organisation (WHO). The Public Health Agency and the National Board of Health and Welfare that ensure implementation of laws and regulation work under the Ministry of Social Affairs. How health care shall be conducted in Sweden is regulated in the Health Care Act (HSL 2017:30). It specifies that the care shall be of good quality with a good hygienic standard. According to the National Board of Health and Welfare, a good hygienic standard covers four areas for the care provider; healthcare hygiene competence, care facilities, equipment in care as well as the organisation and planning of care. Under healthcare hygiene competence, it states that all healthcare personnel must have basic knowledge of healthcare hygiene as well as access to healthcare hygiene expertise regarding preventive work and acute problems (10).

At the regional level, healthcare is divided into 21 regions, where every region is responsible for providing publicly funded healthcare services and the operational infection control work.

Lastly, the local level, including the 290 municipalities that follow the infection control guidelines from their region, is responsible for public health through social services and care for the elderly (9).

In SALAR, all municipalities and regions are represented, and they collaborate, e.g. with issues concerning promotion of good hand hygiene in healthcare. Direct observations are made annually to check for adherence to hand hygiene routines within healthcare and social care; these observations are based on a standardised protocol issued by SALAR (11).

At the hospital level, the organisation can differ; the studied university hospital organized the infection prevention and control (IPC) by WHOs Multimodal Hand Hygiene Improvement Strategy (12,13). The department of IPC consists of a medical specialist in IPC and nurse specialist in infection control. Yearly the healthcare workers (HCWs) at the hospital have education in IPC, both through an interactive education program and 1-2 times through facilitators. Monthly, all wards perform direct observations of 10 HCWs' adherence to hygiene routines; the results are reported centrally and made available to the HCWs. All departments have a quality manager with the ultimate responsibility for the IPC, and each ward has a facilitator in IPC who works together with the assistant nurses and nurses.

Adherence to hand hygiene recommendations

Adherence is similar to compliance, referring to the extent to which a behaviour matches agreed guidelines or recommendations. Adherence has been adopted in an attempt to emphasise that an individual is free to decide whether to adopt the recommended behaviour, while the term compliance lacks the emphasis on the individual (14). In this study, the term adherence will be used.

Despite the importance of good hand hygiene, the routines are poorly followed among healthcare personnel according to national observational measurements by SALAR (11). The results from the observations during the spring of 2022 show an adherence to hand hygiene routines at approximately 80% within the regions and 70% in the municipalities (11). The weaknesses of direct observation are that they are carried out by people with varying experience in carrying out observations, which can lead to observational bias, as well as through the staff's awareness that they are being observed, so-called the “Hawthorne effect”, which can result in higher adherence with good hand disinfection during observation sessions (15). With the help of electronic observations, either through counters in the alcohol dispenser (16–22) or through video surveillance (23,24), it has been possible to check for adherence without having to perform direct observations. These passive electronic observations do not correlate with the direct observations and give a more accurate picture of the actual adherence (16,19,23,24). Based on the passive observation possibility, studies have also been carried out with a focus on how interventions can affect adherence. The interventions have taken place via direct feedback through digital voice reminders (18–21), sound signals (17,18) and flashing lights (17–19) in connection with hand disinfection situations, all of which have improved staff adherence. Important factors influencing adherence were attitude (self-interest), knowledge, subjective norms (social influence) and perceived control (16–25).

A strategy on how to improve hand hygiene within healthcare settings has been produced by the WHO titled “A guide to the implementation of the WHO multimodal hand hygiene improvement strategy” (12). The strategy has been designed and based on scientific literature on implementation, behavioural change, diffusion methodology, diffusion of innovation and impact assessment (26). It is based on five parts; 1) the infrastructure at the workplace must enable good hand hygiene, 2) education and practical training of "My 5 Moments for Hand Hygiene", 3) evaluation and feedback, 4) encouragement and reminder and 5) safety culture among the healthcare staff (12). According to the WHO’s “My 5 Moments for Hand

Hygiene", hand disinfection should be carried out: 1) before patient contact, 2) before clean or aseptic work, 3) after unclean work, 4) after patient contact and 5) after contact with the patient's immediate environment (27). An improvement in hand hygiene correlates with knowledge about infection transmission, and in order to assess the level of knowledge about hand hygiene, the WHO has designed a questionnaire that assesses the basic knowledge about infection transmission and hand hygiene (12,28). Regarding knowledge, several studies have shown that the knowledge level about hand hygiene among nursing students (29–37) and nurses (38–40) can be low to moderate in several areas. However, no previous studies have been revealed comparing nursing students and registered nurses.

Theoretical framework

Promoting health is the goal of and key concept in nursing; however, HAIs inflict harm on the patient's health. A transition from health to illness and/or changes in the patient's environment, due to poor hand hygiene, may leave the patient vulnerable to risks that affect their well-being and/or health (41). In order to increase adherence and reduce the risk of HAIs, behavioural modifications are needed, both at the individual and organisational level.

In order to investigate human behaviour and how to affect it, cognitive and psychosocial theoretical perspectives may be taken into account. Plenty of overlapping theories and models have been used explaining behavioural change, whereas the "Theory of Planned Behaviour" (TPB) is a theory that performs well in predicting behaviour (42). It has attracted considerable attention from social psychologists in identifying beliefs forming the basis for behaviour that may be amenable to change (43). According to the TPB (44), the individual's behaviour is the result of attitudes, subjective norms and the perceived behavioural control. The attitude is formed by the appraisal or evaluation the individual expects from his/her behaviour. The subjective norm is the perceived social pressure to perform the behaviour and lastly, the perceived behavioural control is associated with the difficulty or ease of performing the behaviour.

Another important factor to consider is the HCWs individual beliefs, which constitute attitudes towards their behaviour (e.g. hand hygiene practice) which they guide and thus, determine (45). Beliefs are influenced and learned by socialisation in contact with other groups (e.g. co-workers, friends) and institutions in society (e.g. healthcare institutions, universities). Still, the foundation of the individuals' beliefs lies in their knowledge

on the subject. Thus, filling in knowledge gaps influences their beliefs and attitudes towards a previously mismanaged behaviour (45).

Therefore, this thesis will rely on a theoretical framework focusing on behaviour and knowledge, which are also key factors in the WHOs strategies on how to improve and promote good hand hygiene within healthcare settings (12).

Rationale

HAI has an economic burden on the society and involves great physical and mental suffering for the affected patient and relatives. Studies with direct observation (46,47) have shown a lack of adherence to hand hygiene according to the World Health Organisation's recommendations (48) to prevent contact infection via the hands. Other studies also provide information about knowledge gaps among nursing students (29–37) and nurses (38–40), where the knowledge level has been moderate to low in several areas. No studies have focused on the HCW's perceptions of having a reminder system, nor examined the knowledge level in nursing students over different semesters compared to registered nurses. Therefore, in this study, the focus will be on the perceptions of an electronic reminder system for reminding and encouraging good hand hygiene, and to examine the knowledge level of nursing students and nurses.

Aims

The overall aim

To examine the adherence to basic hygiene routines and explore factors that influence it in HCWs in order to reduce the risk and prevent the occurrence of HAIs.

Specific aims of included studies

Study I

To investigate healthcare workers' perceptions of infection prevention in the healthcare organization and perceptions and acceptance of an electronic reminder system that encourages good hand hygiene.

Study II

To explore the difference and determine the level of knowledge regarding hand hygiene aspects in accordance with the WHO Hand hygiene Knowledge Questionnaire between nursing students and RNs in Sweden. We assumed that 1st year students' knowledge would differ from last year students so therefore this difference is to be explored as well.

Method

Design

Both studies used a descriptive research design made through qualitative and quantitative methods to provide a more complete understanding of the research problem (49). Study I was a qualitative study using semi-structured focus group interviews for data collection, exploring a field not previously explored. Interviews were conducted through focus groups to elucidate both shared and individual views on the subject as well as gather rich information (50). Study II was performed with a cross-sectional comparative survey to describe the knowledge in the studied groups (49). The knowledge data were collected through the WHOs "Hand hygiene Knowledge Questionnaire for Health-Care Workers" (28) from nursing students and registered nurses. The studies are presented in Table 1.

Table 1. Overview of study design, background data and method of Studies I-II

Study	Study design	Study area	Study population	Method for data collection	Method of data analysis
I	Qualitative and descriptive study	University hospital -Cardiology ward -Cardio thoracic theatre -Central intensive care unit -Thoracic intensive care unit -Central operating theatre	Total N= 38 -18 assitant nurses -15 nurses -5 physicians 65% had worked more than 2 years at their current position	8 focus-group interviews using a semi-structured interview guide	Qualitative abductive content analysis.
II	Quantitative cross-sectional comparative and descriptive survey	Nursing training programmes first and last semester University hospital at the departments of geriatrics, medicine and surgery	Total N= 201 117 from the nursing training programme 84 nurses from the university hospital.	A digital survey with WHO's "Hand Hygiene Knowledge Questionnaire for Health-Care Workers" consisting of 25 questions: 12 "yes" or "no" 4 "true" or "false" 9 multiple-choice	Descriptive statistics were used. Comparison between groups with Fisher's exact test with post-hoc Pairwise Z-Tests to determine group difference. ANOVA for continuous variables with post-hoc test Tukey HSD to determine location of dissimilarities.

Setting

Study I

The study took place at a university hospital where the interviews were conducted at a cardiology ward, a cardio thoracic theatre, a central- or cardio thoracic intensive care unit and a central operating theatre. The hospital organised the Infection Prevention and Control (IPC) using the Multimodal Hand Hygiene Improvement Strategy (12). This included an infrastructure for hand hygiene improvement, tools for training, evaluation and feedback, reminders and ongoing work on patient safety issues at the hospital

Study II

The study was conducted in a nursing training programme at a university and a university hospital.

The nursing programme is a three-year (two semesters/ year) education at the university, leading to a bachelor's degree in nursing. Students have IPC education and receive the basic IPC knowledge before they work hands-on with patients, in various health facilities, from the middle of the first semester and onwards.

Table 2. IPC content in the different years at the nursing training programme.

1st year	**2nd year**	**3rd year**
Routes of transmission Hand hygiene and dress code Cleaning and disinfection of surfaces and medical equipment Sterilization Waste management	Prevention of transmission of microorganisms in health-care environments Health-care associated infections Repetition on 1st year teachings including airborne infections	All earlier IPC practices with a focus on work management and qualitative perspectives

This study was conducted during the end of the first and last semester.

At the university hospital, the survey was conducted at the departments of geriatrics, medicine and surgery. The IPC unit at the university hospital operates in accordance with the WHO's Multimodal Hand Hygiene Improvement Strategy (12).

Participants

Study I

There were 38 participants, whereof 18 were assistant nurses, 15 nurses and 5 physicians. The majority had worked for more than 2 years, and 20% stated they had not received any education about hand hygiene since they started at the workplace; furthermore, 53% had not received any such education within the last year.

Study II

A total of 487 participants were sent the survey, including nursing students in their first semester (n= 128), last semester (n= 81) and clinically active RNs (n= 278) in the departments of geriatrics (n= 43), medicine (n= 132) and surgery (n= 103). The response rate was 71 (56%) from the first semester students, 46 (57%) from the last semester students and 84 (30%) from the RN.

The majority of the respondents were females aged between 19–64 years, with a mean age of 31±11 years. Approximately half of the nursing students had experience of working as an assistant nurse. The mean time of working as a RN was 10±9.5 years. The majority answered that they had received formal training in hand hygiene in the last three years, and almost all routinely used alcohol-based hand disinfectant for HH within healthcare settings (See table 3).

Table 3. Characteristics of the study population in study II. First semester students (NSS1), last semester students (NSS6), and nurses (RNs).

Variable	**NSS1 (n= 71)**	**NSS6 (n= 46)**	**RN (n= 84)**
Age (year) Mean± SD	24.1± 6.7	27.8± 6.4	37.8± 11.76
Female n (%)	56 (78.9%)	40 (87%)	73 (86.9%)
Male n (%)	15 (21.1%)	6 (13%)	11 (13.1%)
Experience of work as an assistant nurse, n (%)	29 (40.8%)	34 (73.9%)	
Years of working experience as a nurse, mean ±SD	-	-	10.4± 9.5
Formal training in hand hygiene in the last three years, n (%)	48 (67.6%)	39 (84.7%)	51 (60.7%)
Routinely used an alcohol-based hand disinfectant for hand hygiene within healthcare settings, n (%)	64 (90.1%)	46 (100%)	84 (100%)

Procedure

Study I

In a collaborative project between the Department of Public Health and Caring Sciences at Uppsala University and Industrial Design Engineering at Chalmers University, Gothenburg, a concept for an electronic reminder system was developed, with the function to collect and present statistics on hand disinfection and give direct feedback to the staff (51).

A convenient sampling procedure was used, where the participants were asked in person by the principal investigator (PI) or co-author, or had the opportunity to sign up for the focus groups on a list placed at the ward (15). Between September 2016 and March 2018, the data were collected from eight focus groups. The focus groups were divided as: three with assistant nurses, three with nurses and two with physicians. The groups included two to eight participants. The composition of the groups was based on the participants' similar professions, roles and experiences of the same issue (52). The recruitment of participants continued until no new data emerged and no further depth of insight was given (15).

A semi-structured interview guide was developed which covered opening questions, introductory-, transition-, key- and ending questions. The key questions were based on the TPB (44). One experienced moderator conducted all focus groups interviews, and the assistant moderator took notes and summarised the interview afterwards so the participants had the opportunity to reflect and comment. The interview guide was pilot tested with the first focus group interview (50), no changes were made, and the interview was included in the data collection.

Each focus group session lasted between 25–40 minutes (mean 30 minutes) and was audio recorded. All participants were active during the interviews, which were conducted at the university hospital, mainly at the participant's ward. It was a round table seating where everyone could see one another, including the moderators. During each session, a film was shown about the concept of the electronic reminder system and an article from the newspaper about a patient's experience of having a wound infection after surgery to stimulate discussion and interaction in the group to get a deeper understanding of the phenomenon investigated.

A professional secretary then transcribed the interviews verbatim.

Study II

A questionnaire was developed based on the WHO's "Hand Hygiene Knowledge Questionnaire for Health-Care Workers" (28). It comprised 25 questions to assess knowledge of all essential aspects of HH, focusing on

transmission routes for bacteria and how to prevent transmission between healthcare workers, patients and the environment. Twelve questions were to be answered with a "yes" or "no" alternative, four with "true" or "false" statements, and nine were multiple-choice questions. The questionnaire was translated into Swedish based on the WHO's guidelines on Translation and Adaptation of Instruments (53). Two authorized professional translators translated the original questionnaire in English through "forward- backward translation" into Swedish. Between the forward and backward translations, the research team acted as an expert panel by reviewing the translated version to identify and resolve inadequate expressions in the translation. The questionnaire was then pilot tested on 10 nursing students and 10 RNs, resulting in minor phrasing changes.

The chief nurse and the research and development manager at the university hospital were contacted, and they gave their consent for further contacts to be made at the hospital. Thereafter, the principal investigator (PI) received contact information for the heads of the departments at the hospital and informed them about the study. Also, the chair of the programme committee for the nursing training programme was contacted by the first and last author at the university and was provided with the same information. After the approval of the study, an information letter was sent out one week before the start of the data collection, by secretaries at the hospital to the RNs at the different departments and by the PI to all students.

At a specific date, the digital questionnaire was made available, and information was sent out to HCWs. The students received a digital bulletin reminding them to answer the questionnaire. The questionnaire was accessible for 1 month, and one reminder was sent out halfway through the month. The nursing students received their information through their student e-mails, and the RNs received their information through secretaries and department heads who forwarded the information by e-mail. At the start of the data collection, the nursing students in semester 1 and 6 received oral information during one of their online lectures, to encourage them to answer the questionnaire.

Data analysis

Study I

The analysis was conducted according to the method described by Krueger and Casey for analysing focus-group interviews (50), searching in the content for patterns, themes and contradictions in the respondents' statements. By reviewing each line of the text, topics were identified, and then the material was extracted and coded; thereafter, these were studied concerning similarities and dissimilarities, and categories were then formulated. Thus, categories were

developed inductively and given titles as close to the original text as possible (see example in Table 4).

Table 4. Example from inductive data analysis.

Quote	Code	Category
No, I can't remember any time in the last year that we have received feed-back on hand hygiene. (physician) Once … I started a year and a half ago. (nurse)	No feed-back	Feedback

Also introduced to the data were categories from a theoretical model: the TPB, where the data were deductively placed in the categories: attitude, subjective norms and perceived behavioural control (44,52) (see example in Table 5).

Table 5. Example from deductive data analysis based on the theory of planned behaviour.

Quote	Code	Category
I like the concept that it can be registered at group level, but I do not know … it will be a bit like this Big Brother watching over it all. (physician)	Mixed appraisal	Attitude

All transcripts were analysed independently by the PI and co-researcher and discussed until consensus was reached (52).

Study II

Descriptive statistics were used to analyse data and values were given as numbers, percentages, means and standard deviation (±SD). Comparisons were made between the groups, with Fisher's exact test for categorical variables to study significant differences. Post-hoc Pairwise Z-Tests were used to determine which of the groups differed from the other. Further, one-way analysis of variance (ANOVA) was made for continuous variables, followed by a post-hoc test Tukey HSD to compare groups and determine the location of dissimilarities. In all calculations, $p < 0.05$ was considered as the level of significance (54).

The level of knowledge was analysed in accordance with previous studies using the WHO Hand Hygiene Knowledge Questionnaire, where the

knowledge level was divided into three groups. Good, where the total correct score is 75% or higher, moderate with a score between 50 and 74%, and poor with a score below 50% (29–32)

Rigour

Study I

In order to assure a good quality of data several steps were made to increase trustworthiness, the dimensions of credibility, confirmability, dependability and transferability were applied (52).

To strengthen credibility (52) data triangulation was used by interviewing different professions (assistant nurses, nurses and physicians) at different healthcare areas (cardiology ward, cardio thoracic theatre, central intensive care unit, thoracic intensive care unit and central operating theatre). The interview guide was pilot tested with the first focus group interview with no changes made. The analysis of the data was made through both analyst triangulation and theory triangulation. The analyst triangulation was made in a research seminar by four groups of senior researchers at the department focusing on analysing one of the transcribed interviews, whereas their results were similar to those found by the PI. By also introducing the TPB to analyse the data deductively, the theory triangulation gave the ability to cast the findings in a different perspective.

Confirmability (52) was ensured by developing codes and categories labelled as closed to the text as possible. Illuminative quotations was used, representing different professions and wards, to show how the data was linked to the original source and provide several perspectives about a theme.

The dependability (52) was secured by a detailed description of the steps taken in the study with a particular focus on data collection and analysis process, “the decision trail”. It was also confirmed by a description of the credibility of the researchers and thus the PI. To ensure traceability, the transcripts were coded for each individual. All transcripts were analysed independently by the PI and co-researcher and discussed until a consensus was reached. The independently derived coding was also presented to the other co-researchers for cross-checking, and the coding was in agreement, as with the analyst triangulation made in the research seminar mentioned above.

Transferability (52) was favoured by giving a description of the settings and context used with the information about what wards were participants recruited from, the number of participants and professions and their work experience at the current ward. Presenting the findings with as much detail as possible, including the illuminating quotations, gives a possibility to make transferability judgements by the reader.

Study II

The WHO Hand hygiene Knowledge Questionnaire for Health-care Workers (28) is used to assess knowledge on the essential aspects of hand hygiene (12). The questionnaire had been validated and reliability tested in 8 pilot sites representing all WHO regions: Africa, America, South-East Asia, Europe, Eastern Mediterranean and Western Pacific (26). In order to maintain content validity, two authorised professional translators translated the questionnaire through "forward- backward translation" into Swedish (49) based on the translation recommendations by WHO (53). The research team evaluating the translation between the forward- backward translations consisted of a physician with extensive knowledge in IPC and three experienced nurses with IPC knowledge. The Swedish translated questionnaire was then pilot tested on 10 nursing students and 10 nurses to make sure the participants did not have any difficulties understanding the questions. The pilot test resulted in some minor phrasings changes.

Ethics

Ethical standards for scientific work were followed and based on the Declaration of Helsinki (55) and Swedish law (56). All participation in the studies was voluntary, and the participants received information about the study and were informed that they could withdraw at any time.

Study I was approved by the Regional Ethical Review Board (Reg. no. 216/211 and 2016/11/1). Study II did not require an approval by the research ethics committee as it posed no mental or physical risk to the participants' health, and no personal data were handled. The web-based questionnaire included the purpose and design of the study, and the voluntary nature of participation, including assurance of confidentiality. The return of a questionnaire implied the respondents' consent to participate. De-identified data were used. An approval was obtained from the heads of the departments at the hospital and the programme leaders for the nursing training programme.

Findings

Study I

The findings of the HCWs' perceptions of the healthcare organisation were inductively categorised into: knowledge, feedback and barriers. The facilitators at the wards trained all new employees and students in IPC at the start of their employment, and they were available for questions regarding hygiene matters. During all the interviews, discrepancies were raised regarding how the organisation was supposed to give feedback and how it actually was at the workplace by the HCWs. Although monthly observations were made, the results were rarely given to the HCWs in person; rather, they were available on the intranet for them to find themselves. Moreover, they received correctional feedback through other HCWs because of an open work climate. Difficulties could arise with personal feedback between employees because of hierarchy between their professions. Barriers found were that it is a personal responsibility to work according to established procedures, making some participants feel that feedback from the organisation is unnecessary. Stressful situations and certain tasks also hindered the possibility of adherence.

There were mixed opinions about the acceptance and perception of an electronic reminder system. Several of the HCWs in the study were positive about receiving feedback as well as statistics from the electronic reminder system, as long as it is not set up in the areas aimed for relaxation, i.e. staff rooms. The HCWs expressed unease with the thought of the head of the department having information about their hand hygiene at the workplace, and the risk they could use it for their own purposes. Receiving an evaluation in accordance with adherence on an individual level was not something that the HCWs were interested in because of the possibility of a Big Brother society at the workplace. Having the data collected and presented on a group level was considered a better solution to address the risk of personal infringement.

The deductive analysis in accordance with TPB (44) thus showed that the HCWs' attitudes were mainly favourable towards the electronic reminder system as long as it did not register on an individual level or imply any negative effects on the personal side of the workplace. Moreover, as they perceived reminders to improve hand hygiene as a way to remind those who had bad adherence, it worked as a social pressure in a positive way. Further, it gave them a feeling of perceived behavioural control.

Study II

All three groups, consisting of nursing students in semester 1 (NSS1), nursing students in their sixth and last semester (NSS6) and RNs, had varying levels of knowledge on the 25 questions (Table 4).

Table 4. Number of questions (n) from the 25 questions in the WHO Hand Hygiene Knowledge Questionnaire, with the knowledge scoring level divided by the first semester students (NSS1), last semester students (NSS6), and nurses (RN). The knowledge level was determined as good (>75% correct answers), moderate (50-74%) and poor (<50%).

Knowledge level	**NSS1** **n**	**NSS6** **n**	**RN** **n**
Good (>75% correct)	11	18	17
Moderate (50–74% correct)	8	2	2
Poor (<50% correct)	5	6	5

A good knowledge level was found in 11 out of the 25 questions among all groups. These questions regarded microorganisms'(entitled germs in the questionnaire) route for transmission and how to prevent the transmission to the patient using hand disinfectant before touching or doing a clean/ aseptic procedure on the patient. Other questions for which there was good knowledge included: how to protect the HCWs by using hand disinfectant after touching the patient, being exposed by the patient's surroundings or after the risk of contact with body fluids. The groups also excelled in their knowledge regarding the importance of avoiding artificial fingernails, avoiding jewellery and knowing that damaged skin increases the likelihood of colonisation of harmful microorganisms on the hands. Regarding the required hand hygiene method in specific situations, the groups knew to use hand disinfectant before giving an injection and after removing the examination gloves.

NSS6 and RN showed good knowledge for an additional six questions, mainly regarding methods for correct HH. Lastly, NSS6 had good knowledge on correct hygiene method after emptying a bedpan.

However, poor knowledge was also found in all groups. NSS6 had poor knowledge regarding six questions, and NSS1 and RNs for five questions. It was found that all groups had poor knowledge about microorganisms present on or within the patient, being the most frequent source of microorganisms responsible for HAI. They also had poor knowledge that hand hygiene actions after exposure to bodily fluids or after exposure to the patients' immediate surrounding would not prevent transmission of microorganisms to the patient. Poor knowledge was found regarding how to protect the HCWs from microorganisms using hand hygiene actions before a clean/ aseptic procedure, and

knowing that it does not help since the microorganisms will be transmitted after the clean/ aseptic procedure.

When it came to what hand hygiene method that was required in specific situations, there was also poor knowledge among the groups about handwashing and the use of hand disinfectant in sequence. These actions are not recommended to be performed in sequence. The NSS6 group also claimed that alcohol-based hand disinfectant was more effective against microorganisms than handwashing.

Comparing the knowledge between the groups shows that the mean score (±SD) between the groups differed; specifically, the NSS1 group's score was significantly lower (17.1±2.1) than the NSS6 group (18.8±1.7) and the RN group (18.4±2.2) ($p= 0.000$). The NSS6 group had the highest level of good scores, with 34.7% of the participants scoring 75% points or above; the NSS1 group had the lowest number of good scores, with 8.5%; and the RN group scored lower than the NSS6, with 26.2%.

Therefore, this study highlights that there are knowledge gaps among the nursing students and RNs, mainly the source of microorganisms causing HAI and how to prevent transmission of microorganisms to patients and HCWs.

Discussion

The study is unique as it is the first to explore and describe HCWs' perceptions of having an electronic reminder system and comparing the hand hygiene knowledge over different semesters among nursing students and registered nurses. The main findings from the study highlight behavioural and knowledge aspects, previously presented (12,26) as key aspects to focus on for improvement in hand hygiene within healthcare.

Study I

Studies have shown the positive effects of increasing adherence to hand hygiene practices by using electronic reminder systems (18–21). The HCWs in this study were positive towards an electronic reminder system regarding feedback and statistics. Feedback is necessary to explicate procedures and gives the means to improve awareness of the importance of hand hygiene and adherence to recommendations for good hand hygiene. A cornerstone of the guidelines to the implementation of the WHO multimodal hand hygiene improvement strategy is feedback (12). Several HCWs also expressed an unease if the head of the department had the information about their personal data regarding the adherence to hand hygiene. Thus, the electronic reminder system seemed to allow for a possibility of facilitating development of a behavioural change towards a better HH and infection control.

Based on the results, there is a need for developing the organisation to give continuous feedback, focusing on data at a group level. Making the feedback data easily accessible or by giving performance feedback directly to the HCWs is an effective strategy for improving adherence rates for good hand hygiene.

Methological considerations

The recruitment of informants continued until no new data were presented in the analysis and no further depth of insight was given (15). The number of participants from the three different professions representing a ward (assistant nurses, nurses and physicians) contributed to a variation and wealth of data. The interviews were conducted using a semi-structured interview guide (50) for opening-, introductory-, transition-, key- and ending questions. The questions were open-ended and stimulated interaction and the opportunity to talk

freely about their experiences, providing rich data. The interviews were also moderated; moreover, at the end, the assistant moderator summarised the findings to the group, which gave the opportunity to add or clarify what had been said. The group interactions were lively regardless of the number of respondents in each group, which provided high quality data to reach individual beliefs. These aspects have strengthened the study (52).

A main limitation of qualitative studies is the difficulty in generalising the data. However, the aim of this study was to explore and understand; thus, by describing the context and findings thoroughly, transferability may be enabled, however decided by the reader (52).

Study II

Earlier studies have shown knowledge to be lacking in some areas among nursing students (29–37) and nurses (38–40). This study provided the opportunity to compare the nursing students in different semesters to show that there might be a progression in ICP knowledge during the education, where the first semester students scored having a lower knowledge than the latter. There was no significant difference between the last semester students and the RNs but a tendency to lower score by the RN. This indicates that the knowledge level not seem to improve further. Still, there are knowledge gaps that need to be addressed in order to avoid HAIs. Thus, this might provide one answer to why HAIs still occur within healthcare, namely lack of knowledge (26).

Currently, two separate organisations provide education on IPC at the graduate/post graduate level in the university and in the continuous education delivered by the hospital. Continuous education of HCWs has been proven to be a key element (26,57,58) and needs to be developed, as studies have shown that cooperation and development of joint training of students together with HCWs may yield greater improvements in individual knowledge and adherence (59,60). Both organisations strive to minimise the risk of HAIs, and the benefits of combining continuous education for the nurses with the nursing students might lead to developing a hygienic consensus. This enables a better patient safety climate by influencing HCW's individual attitudes (44) and beliefs (45) towards hand hygiene by being supported by the organisation. The result will be a reduction in the risk of HAIs and, therefore, risk of harm to the patients.

Methological considerations

A strength of the study is the use of an existing questionnaire developed by the WHO that has been validity and reliability tested to investigate hand hygiene knowledge among HCWs (26). Following the steps for translation recommended by the WHO (53), including forward, backward translation, input from an expert panel and pilot testing, content validity in the translation was considered preserved. Still, a limitation with questionnaire surveys is that the

thought process behind the respondents' answers is unable to be presented and one reason for low knowledge scores in the questionnaire could be the WHO methodology. Hand hygiene procedures taught at the studied training program for the nursing students and the continuous education for the RNs differ from the 5 Moments for Hand Hygiene presented by the WHO since the same terminology is not used. This might have caused some confusion answering some questions since of phrasing and preconceptions made by the participants. This could have been solved by using personal interviews which is considered to be the most respected method for obtaining information about peoples knowledge (15), however in a situation when you want to reach many respondents and in the presence of an ongoing pandemic it was not possible to conduct an interview study.

The secretaries at the wards forwarded the survey, information and the reminder from the PI to all presumptive, clinically active RNs. Since the study was conducted in the midst of the COVID-19 pandemic, the workload and well-being of the RNs might have affected the response rate, which was limited (30%) as studies have shown that the HCWs' well-being and mental health have been affected because of the COVID-19 pandemic (61). Studies have also shown that lack of time is a commonly discussed reason for low response rates, where 30–40% response rate is common. Response rate may also have been affected by the fact that the participants could have been exposed to an extensive amount of other evaluations and questionnaire surveys (62,63). Regarding reminders to achieve a higher response rate, three meta-analyses showed no difference in response rate, beyond 1–2 reminders sent (64), whereas this study sent two. Information about sick leave or if the participants had seen the survey in their inbox was not available; hence, the response rate could be higher than reported here.

The internal dropout was negligible (1%), which supports that the instrument was valid to screen for knowledge.

Conclusion

The results from this study revealed that there are barriers to hand hygiene adherence and measures to improve these. HCWs have expressed needs for more direct feedback to improve adherence (study I), and nursing students and nurses show knowledge gaps within the area of hand hygiene (study II). The WHO's multimodal promotion strategy promotes areas that need to be addressed in order to change the behaviour of individual HCWs to optimise adherence to hand hygiene and to improve patient safety. These areas include feedback, education, reminders at the workplace and institutional safety climate. The studies conducted show that all these areas, to some extent, lack the appropriate measures in order to improve the adherence. Feedback and education are lacking; reminders can be given directly, and the institutional safety climate shows deficiencies from the organisation, with regard to providing necessary actions. Deficiencies also existed between HCWs regarding the subjective norms based on their individual beliefs, underpinned by their knowledge, which constitute their attitudes and guides their hand hygiene related behaviour.

Study 1 showed that there is a positive acceptance of the electronic reminder system, and the respondents perceived it as having the ability to change behaviour. However, the concept has to be further developed to protect the individual integrity, and it needs to be used with continuous feedback on a group level.

Study 2 showed that there were knowledge gaps within all groups, where the optimal aim is to know all aspects of hand hygiene in accordance with the WHO's guidelines,. This calls for action with an educational programme that does not separate the groups but combines them to deliver continuing education, since the students will someday be influencing future hand hygiene knowledge as a peer with the registered nurses. Furthermore, it may be necessary to review curriculums and education programmes in order to ensure that they are consistent with the recommendations in the international guidelines provided by the WHO.

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