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Major Article

Learning to interact with new technology: Health care workers' experiences of using a monitoring system for assessing hand hygiene – a grounded theory study

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Background: Recently, innovative technologies for hand hygiene (HH) monitoring have been developed to improve HH adherence in health care. This study explored health care workers' experiences of using an electronic monitoring system to assess HH adherence.

Methods: An electronic monitoring system with digital feedback was installed on a surgical ward and interviews with health care workers using the system (n = 17) were conducted. The data were analyzed according to grounded theory by Strauss and Corbin.

Results: Health care workers' experiences were expressed in terms of *having trust in the monitoring system, requesting system functionality and ease of use* and *becoming aware of one's own performance.* This resulted in the core category of *learning to interact with new technology*, summarized as the main strategy when using an electronic monitoring system in clinical settings. The system with digital feedback improved the awareness of HH and individual feedback was preferable to group feedback.

Conclusions: Being involved in using and managing a technical innovation for assessing HH adherence in health care is a process of formulating a strategy for *learning to interact with new technology*. The importance of inviting health care workers to participate in the co-design of technical innovations is crucial, as it creates both trust in the innovation per se and trust in the process of learning how to use it.

Adherence to hand hygiene (HH) in health care settings has been highlighted as one of the most effective measures to prevent and control health care-associated infections. It is therefore regarded as a highly important and effective safeguard for patient safety.[1,2] The World Health Organization's "My five moments for hand hygiene"[3] clarify when and how health care workers (HCW) should perform HH in patient care and they have been widely adopted.[4] However, adherence to HH among HCWs is a universal problem.[5] even after the guideline publication by the World Health Organization.[6] To assess adherence to HH, direct observation is regarded as the golden standard, but it has been questioned in recent years due to several limitations, such as the Hawthorne effect.[7,8] As a result of this and to promote a more objective way of assessing HH, new technologies, such as electronic monitoring systems (EMS) with or without digital

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Box 1 Function and implementation process of the electronic monitoring system

Tork Hand Hygiene Compliance Monitoring System

The Tork Hand Hygiene Compliance Monitoring System (Essity AB, Sweden) is a system designed to automatically assess hand hygiene adherence among health care workers.

The system consists of a position system comprising individual small tags worn by the users, antennae installed in the ward ceiling and internet-connected automatic hand disinfection dispensers. These components allow the system to register in real time when health care workers move in and out of virtual zones created on the ward. It also registers the use of hand disinfection from a dispenser before and after entering a zone. Together with a pre-agreed set of adherence guidelines (The World Health Organisation's "My five moments for hand hygiene"), the movement and dispenser usage data allow the measurement of hand hygiene adherence.

Digital feedback to health care workers consists of hand hygiene adherence rates provided by data from the system and it can be provided either at group level or at individual level. Group-level feedback can be seen by the entire staff group, while individual feedback can only be seen by each individual.

Implementation process on the surgical ward

May 2017-Sept 2018	**Oct 2018-Dec 2018**	**Dec 2018-Feb 2019**	**Feb 2019-March 2020**
Phase 1	*Phase 2*	*Phase 3*	*Phase 4*
Tork Hand Hygiene Compliance Monitoring System installed in four patient rooms on the ward	Tork Hand Hygiene Comliance Monitoring System installed on the entire ward	Feedback provided at group level[1]	Feedback provided at individual[2] and group level[1]
2-5 users	20-25 users	20-25 users	20-25 users

[1]Feedback at group level was provided every day in real time via a screen in the nurses' office.

[2]Feedback at individual level was optional and was sent via a personal e-mail or as a text message every week.

feedback and real-time reminders, have been developed.[9-12] These technologies offer the potential to monitor HH events 24 hours a day, 7 days a week and with much less effort than by direct observations.[13] They have attracted attention as an alternative to increase adherence to HH[14] and, in many cases, research has focused on adherence rates when testing and using different EMSs.[15] In recent years, several studies have examined HCWs' attitudes to and perceptions of potential EMSs, highlighting concerns about being monitored, integrity and feedback.[16-20] To our knowledge, only a few studies have investigated HCWs' experiences of using and managing different types of EMS in clinical settings.[20-22] As EMS continue to evolve within health care environments, additional research is needed on aspects where HCWs' opinions are requested and recommended to develop user-friendly products designed to increase adherence to HH.[13] The aim of this study was to explore HCWs' experiences of using an EMS to assess HH adherence, to acquire a new insight into the way HCWs regard technical innovations.

METHOD

Design

This is a qualitative interview study based on a systematic research methodology, grounded theory, (GT) as described by Strauss and Corbin.[23] As GT seeks to identify participants' experiences and develop comprehensive explanations by theory building,[24] it is well suited to this study. GT is useful when it comes to acquiring an insight into new areas that have been unexplored, as it enables researchers to examine areas from different angles.[23]

Setting

In October 2018, an EMS (Tork Hand Hygiene Compliance Monitoring System, Essity AB Sweden) was installed on a surgical ward at a tertiary university hospital in Sweden, involving registered nurses (RNs) and nurse assistants (NAs). The implementation of the EMS was initiated and organized jointly by the hospital ward and the product developer, without any involvement from the researchers in the present study. Prior to the installation, the EMS was tried out as a pilot implementation project in 4 patient rooms during the period 2017-2018 (Box 1).

The hospital ward consists of 22 beds (six 3-bed rooms and 4 single-bed rooms). When the EMS was installed on the entire ward, 37 virtual zones were created, with a total of 21 hand disinfection dispensers evenly distributed on the ward: in patient rooms, corridors, storage rooms, washrooms and the nurses' office. Before installing the EMS, HH had been audited manually on the ward by direct observation every month since 2014, as part of the hospital quality assurance of patient care.

PARTICIPANTS

Data sampling included RNs and NAs working on the ward in patient care who had been using the EMS for at least 1 month. As the data collection and analysis proceeded, the ongoing inclusion and selection of participants was determined by the emerging concepts according to theoretical sampling, as described by Strauss and Corbin.[23] A total of 23 HCWs were users of the EMS (December 2019) and they were all invited to participate in the study. Of these, 17 HCWs were interviewed as a result of the theoretical sampling (Table 1).

DATA COLLECTION

Individual, pair and group interviews, based on the participants' choice, were conducted between December 2019 and November 2020 by the first author (KG). The interviews took place at the participants' convenience and all the interviews were conducted in connection with a working shift on the ward in a quiet, undisturbed room.

Table 1
Characteristics of participants

Profession	n = 17		Median	Range
Registered nurse	8	Age	46	21-62
Nurse assistant	6	Clinical experience (years)	16	2-41
Nurse manager[1]	1	Clinical experience on the surgical ward (years)	6.5	1.5-24
Facilitators[2]	2			
Length of using the EMS				
5 months	1			
1 year	1			
From start (Oct 2018)	15			

[1]The manager on the ward was an RN with a supplementary education in management.

[2]Facilitators were NAs working part time with innovations at the hospital and part time as NAs on the surgical ward. The facilitators had been involved in the initiation of the project and running the project at ward level.

The first 4 interviews were conducted face to face; 2 individual interviews, 1 pair interview and 1 group interview (3 participants). Telephone interviews (n = 10) were then conducted and the participants were able to choose whether they wanted to be interviewed individually or in pairs/groups; all the participants chose individual interviews.

An interview guide, developed within the research team (KG, AEA, LA), was used during the interviews to address different topics related to HCWs' experiences of handling and using the EMS (see supplementary file). The interviews lasted between 20 and 45 minutes and, as in GT, memos were included in the analysis.[23] The memos consisted of data from discussions with participants before and after the recorded interview time and immediate impressions and thoughts after each interview. These memos were written by the interviewer (KG) and discussed within the research team (KG, AEA, LA).

In conjunction with each interview, the participants answered questions related to demographics, which were subsequently included in the analysis to obtain a further understanding of the explored phenomenon (Table 1). The first 6 interviews were transcribed verbatim by KG and the remaining 8 interviews were transcribed by professional transcribers and then scrutinized by KG and discussed within the research team (KG, AEA, LA).

DATA ANALYSIS

A constant comparative method is an iterative process that was used to analyze the data.[23,25] Initially, a pilot interview was conducted with 1 participant. A preliminary analysis was performed (KG, AEA, LA) and the interview questions were refined, in agreement with GT.[23] The pilot interview was subsequently included in the further analysis. Five interviews were then conducted and they were analyzed one by one and the preliminary results were discussed and reflected on by the authors (KG, AEA, LA) before the 8 remaining interviews were conducted.

The analysis was carried out systematically in 3 phases according to GT by Strauss and Corbin,[23] leading to a core category (Table 2). For a detailed step-by-step description of the data analysis, see the supplementary file. Data collection continued until no new dimensions or properties emerged from the data and the constant comparison in the analysis work helped the researchers to determine when categories were saturated. Discrepancies in interpretation were discussed and re-examined among the researchers (KG, AEA, LA) until consensus was reached. To ensure consistency in the application of the categories, the additional researchers within the research group, who are specialized and experts within infection prevention were involved in finalizing the analysis (JK, BL).

As administrative support in the analysis work, a data management program for qualitative data software was used (NVivo 12, QSR International). Quotations were selected and translated from Swedish to English to illustrate the findings and to enable the reader to consider the credibility of the analysis process and the emerging categories.

ETHICS

The study was approved by the Swedish Ethical Review Authority (Dnr: 2019-02574). The participants were informed both in writing and orally about the aim and design of the study and that participation was voluntary and confidential. The participants were informed about the opportunity to withdraw from the study whenever they wanted without explanation. All the participants provided informed consent written or verbally via telephone before the interviews were conducted.

RESULTS

Three interrelated categories reflecting HCWs' experiences of using and handling the EMS were identified during analysis, *having trust in the monitoring system, requesting system functionality and ease of use* and *becoming aware of one's own performance*. By merging these 3 categories in the analysis process, the following core category emerged; *learning to interact with new technology*, defined as the main strategy when using EMS (Fig 1).

The core category and the 3 categories are described and illustrated by the quotations below.

Having trust in the monitoring system

For HCWs, having trust in the monitoring system is important in order to adopt and adapt an EMS in daily work. At the start of the project, several participants were skeptical about interacting with new technology, questioning its use and function, but this changed to a more positive opinion over time. Certain factors continued to be discussed throughout the project; for example, questioning the EMS exclusively to assess the frequency of HH rather than the quality of HH.

> "Well, it assesses that I have applied the disinfectant but not the quality of the application." (I. 5)

Despite this, many participants underlined the importance of collecting data on performed HH and the EMS was considered to be more reliable and consistent than manual direct observations since it registers HH throughout the entire working shift. Any concerns about the accuracy of the system were related to concerns of being correctly registered and being correctly assessed. To obtain a aadherence rate that was considered acceptable to the individual, HCWs tried to adapt to and understand how and when the EMS registered HH events and HCWs' movements. For example, on the ward, nurses often brought a medicine cart when they handed out medicines to the patients and the dispenser for hand disinfection on that cart was not included in the EMS. This meant that nurses often adapted their behavior so they could be registered by the EMS.

Table 2
Example of the coding process according to grounded theory by Strauss and Corbin (23)

Transcript	Initial coding	Axial coding	Selective coding	Core category
" No, it's just that it has also been a little . . . having to change the batteries is a negative aspect. We don't always have time to go and collect batteries and change them. So we have sometimes put a standard bottle of hand disinfectant next to it so we can use that.	Battery time dispensers failing No time to change the batteries Using another hand hygiene product	Managing the monitoring system Adapting and prioritizing tasks	Requesting system functionality and ease of use	Learning to interact with new technology

For a detailed description, see the supplementary file.

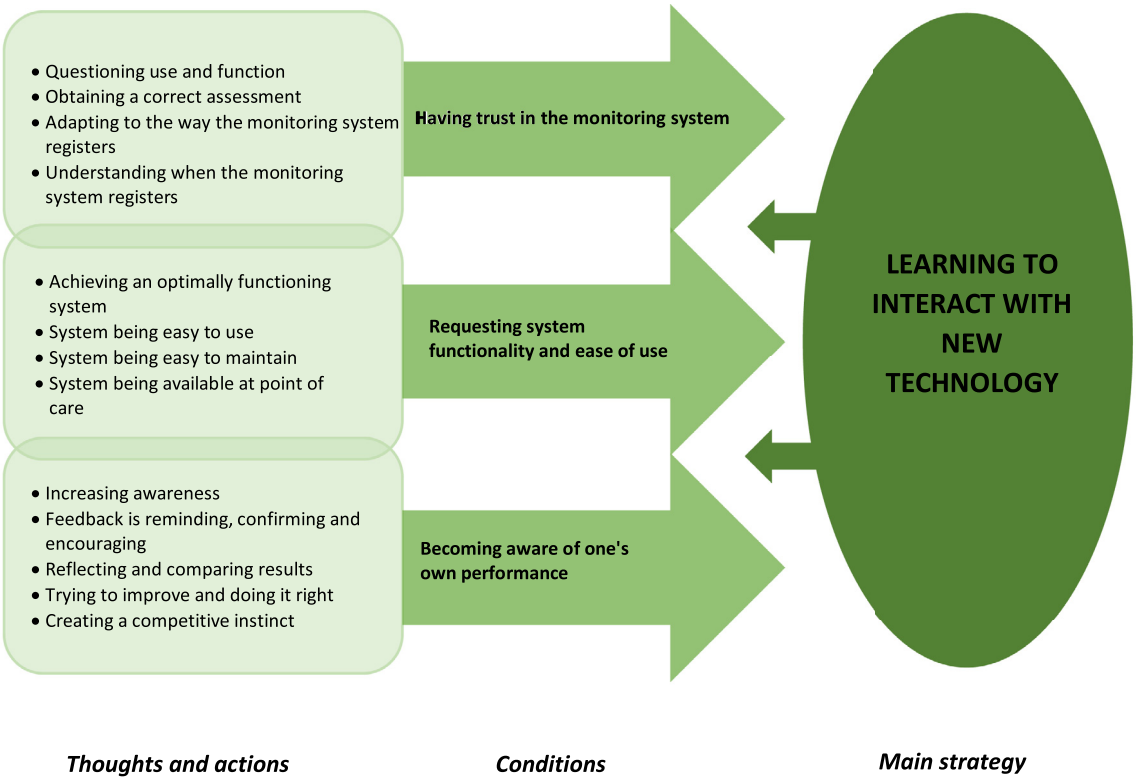

Fig 1. The prerequisite conditions that needed to be fulfilled when learning to interact with new technology, based on the thoughts and actions when using the monitoring system.

> "You make another application, even though you know that you used the disinfectant a moment ago on the cart... and then you go onto the ward and apply the disinfectant again, just to be on the safe side." (I.15).

Wearing a tag every day and being monitored was not regarded as disturbing or bothersome for participants. A few participants addressed concerns of privacy, but only if the EMS were to be used for purposes other than assessing HH.

> "One thing that... isn't negative but could be negative... if this is used for something else. It knows exactly where I am on the ward, how long I am in one place and what that place is." (I.4)

Requesting system functionality and ease of use

Many of the participants felt that the EMS must function in an optimal manner in order to act as a support in the daily work. Several aspects needed to be reviewed and attended to in order to achieve an optimally functioning technology; the battery life of dispensers must improve, changing the container for hand disinfection in the dispensers needs to be easier; the amount of hand disinfection given in every application is too little and the speed of the automatic dispensers is too slow. At the same time, the automatic dispensers were easy to use, simply because it was not necessary to touch the dispenser. Moreover, the EMS must be available in places on the ward where HCWs need to perform HH. If not, HH will be viewed as an extra procedure that risks being omitted.

> "But, first and foremost... I would like dispensers that enable us to get things right..." (I.12)

Moreover, the EMS must not be another piece of equipment that needs to be taken care of and requires too much maintenance from HCWs. If maintenance takes extra time, such as changing batteries in the dispenser, HH will not be given priority.

> "But it's difficult having to change the batteries after a week, we have so much else to do. I can't prioritize the hand disinfectant there, the dispenser." (I.6)

Becoming aware of one's own performance

Feedback acted as a reminder and raised awareness among the participants to perform HH. The group feedback was perceived as good and useful, but the individual feedback was considered even better. Individual feedback addresses only the individual, providing you with an opportunity to study your own improvements or failures, while poor results were difficult to relate to your own performance.

> "When it was brought down to individual level, I think that's when things started to happen and things were actually also more positive. Otherwise, I think it was more overarching, when we were given data, you thought.... It was very clear that 'that doesn't apply to me, that low result'..." (I.5)

The feedback was encouraging and confirming, especially when the results were positive. The results were easy to interpret and understand, confirming that participants performed HH when they were supposed to. In the event of a less positive result, the EMS was questioned and other factors that may have affected the result were examined. Had it been a stressful day? Where did I perform most of

the work today and was the EMS installed there? Where has the EMS failed to register and what could I have done to enable the EMS to register correctly? Feedback increased awareness and the participants reflected on their own actions.

> "When you get data relating to how you disinfect your hands, it can also make you more aware... and you perhaps start wondering 'when don't I use the hand disinfectant?'" (I.12)

The feedback created a competitive instinct. Participants wanted to improve and shape up and remain at a high level in the statistics. They compared themselves with themselves but also with the rest of the group. Participants felt they were good at performing HH before the project was implemented, but the EMS made them even better.

On several occasions, the participants spoke about doing things correctly. Becoming aware of one's own performance of hand hygiene increased the sense of doing things correctly.

> "As long as you know what you're doing, you are aware of when and where you need to apply hand disinfectant. You have done things correctly and you try to do things correctly." (I.15)

Learning to interact with new technology – the core category

Being involved in using and managing a technical innovation for assessing HH adherence in health care is a process of formulating a strategy for *learning to interact with new technology*. The strategy is accomplished by the participants' thoughts and actions which are summarized in 3 major aspects: *having trust in the monitoring system, requesting system functionality and ease of use* and *becoming aware of one's own performance*. These aspects are conditions that need to be fulfilled when learning to interact with new technology. Moreover, learning to interact with new technology cannot be accomplished by these aspects separately, as they interrelate and affect one another.

DISCUSSION

In order to understand HCWs' experiences of using an EMS in a clinical environment, we conducted this study. This study adds more knowledge of the way HCWs interact with new technology to assess HH adherence in their daily work. The analysis revealed that HCWs used several strategies when interacting with a novel technical innovation. The main strategy and core category was *learning to interact with new technology*. The categories highlight 3 crucial conditions in the process of strategy formation: *having trust in the monitoring system, requesting system functionality and ease of use* and *becoming aware of one's own performance*. Strategy formation is a process[26] and the strategies used by HCWs were not expressed as pre-planned or directly verbalized. Instead, they are in line with strategies "as patterns in streams of actions"[26, p. 257] and may develop gradually as the process of learning proceeds.

HCWs stated that there were certain conditions that had to be met when learning to interact with new technology. The conditions were related to the function, accuracy and maintenance of the system; otherwise, the EMS risked not being trusted and not being used. In an increasingly stressful work situation, there was no time for additional work and well-functioning technology was therefore a prerequisite when learning to interact with new technology. We are thus able to strongly recommend that future product developers should involve end users in creating user-friendly products. Earlier studies of ways of creating confidence in using new technology for assessing HH have suggested the same approach.[20,27]

Using the EMS increased the users' awareness of the importance of HH and created a competitive instinct to obtain the best possible results. Feedback has been identified as an important factor to raise awareness of and improve adherence to HH.[28] In the present study, the participants were able to use the EMS over time, initially without feedback on their performance, then by receiving group feedback and finally by receiving both group and individual feedback. Individual feedback was preferable, which is consistent with a previous study by Dyson and Madeo.[21] There are studies that have focused on the acceptance and perceptions of potential EMSs, highlighting concerns relating to feedback and the way feedback is provided.[16-19] The result of the present study implies that, when using and trying out an EMS for a period, users are prone to obtain data on their own results and want to use individual feedback for their own improvement.

Being monitored has been addressed as a concern when interacting with technical innovations to assess HH in health care.[16,18, 21] In this study, the support for this is limited. However, concerns of privacy were mentioned, but only if the system were to be used for purposes other than assessing HH adherence. Previous findings reported concerns about how data produced by a monitoring system might be used, concluding that information should solely be used to report HH.[19]

Increased awareness of HH performance was expressed by HCWs, which has been shown to be an important factor for enabling increased HH adherence.[29] The increased awareness in the present study is the focal point when it comes to HCWs' own progress and their own results as a motivator to improve themselves. It does not, however, address the more profound issue of for whom and why HH is performed in health care, that is, the patient. An improved awareness of HH and a drive to improve the individual results are nevertheless beneficial for the patients. However, we do not know how long this effect will last and further research on sustainability is therefore needed.

Methodological considerations

To achieve credibility and trustworthiness, several measures were implemented before and during the analysis of this study. Initially, the researchers discussed the way in which their clinical background might affect the results of the study. A pilot interview was conducted with 1 participant to examine the reliability of the interview topics and to enable the authors to consider any preconceptions and prejudices that could affect the results. During the analysis process, the researchers focused on the transcriptions, audio recordings and memos and keeping an open mind during data analysis prevented the authors (KG, AEA, LA) from having an impact on their preconceptions. As a result, memo writing and discussions of the memos were helpful in eliminating the risk of information bias. Moreover, any preconceptions or prejudices in general relating to the way HCWs' experiences of using EMS were eliminated by the authors not seeking previous research information before the data analysis. Once the core category was defined, information retrieval started.

To increase the trustworthiness of the analysis, both individual and collective analyses were made. Transcripts and codes were discussed and revised within the wider research team in order to reach consensus. The researchers aimed to achieve high quality by being extremely thorough, careful and strict throughout the analytical process to ensure that the findings were grounded in the data. To increase credibility, contact was made with all the participants after the interviews to clarify data and pose further questions, as in GT.[23] The participants' own words were subsequently used to illustrate the findings.

Although this study implies strengths in its findings, we acknowledge that there are limitations. First, this study was performed on a single surgical ward and the research team had not been involved in implementing the EMS on the ward. This was done by the product developer and the hospital ward before the interview study started, without any involvement of the research group. This process might have caused participants to be in favor of the EMS, as it was only possible to interview the individuals who had volunteered to be users of

the EMS, in this case RNs and NAs. In future studies, additional professions should be involved when trying out and testing the EMS, as several professions are involved in patient care and they are thereby potential users of the EMS. Second, due to the ongoing Covid-19 pandemic, all the interviews could not be conducted face to face but had to take place by telephone. This might have affected the outcome, since GT encourages the inclusion of both verbal and non-verbal aspects during data sampling and analysis.[23] Non-verbal aspects were therefore not included in all the interviews and this could have affected the writing of memos which were included in the analysis. Moreover, the impact of Covid-19 on the overall awareness of HH among participants cannot be excluded. Third, the purpose of GT is to generate a theory through the analysis process.[24] This study identified a core category, linking 3 categories and explaining the experiences of HCWs when interacting with new technology. According to Strauss and Corbin,[23] a core category can be used in further research to produce a general theory of the explored phenomenon.

CONCLUSION

Learning to interact with new technology is a main strategy for HCWs when trying out and using a technical innovation for assessing HH in clinical settings. To be able to implement this strategy successfully, conditions set by HCWs, such as *having trust in the monitoring system, requesting system functionality and ease of use* and *becoming aware of one's own performance*, are needed. Well-functioning technology is a prerequisite for an innovation to be used in clinical settings. Digital feedback increases awareness of HH and individual feedback is preferred by HCWs when it comes to improving their individual results. The importance of inviting HCWs to help in co-designing technical innovations cannot be overrated, as it creates both trust in the innovation per se and trust in the process of learning how to use it. The results of this study can be used when planning and launching the implementation of technical innovations in health care settings.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2021.09.023.

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