Investigating the use of an electronic hand hygiene monitoring and prompt device: influence and acceptability

Judith Dyson and Maurice Madeo

Introduction

Healthcare Practitioner (HCP) compliance with hand hygiene (HH) is considered the primary measure of preventing the transmission of Health Care Associated Infections (HCAIs) with research suggesting that up to 50% of such infections could be avoided with improvements in HH (World Health Organisation (WHO) 2009). Observation is considered the current gold standard for assessing compliance with HH but has a number of limitations particularly the Hawthorne effect (Kohli et al. 2009, Kovace-Litman et al. 2016). As a result of this electronic real-time locating systems have been developed which, as well as monitoring HH, may also improve HH by giving prompts (e.g. a badge worn may change colour or emit a sound). There have been three recent systematic reviews that report the system impact, reliability, implementation challenges and staff design preferences. Srigley et al. (2014) reviewed impact on compliance and found an improvement in HH on entry to or exit from an area. Ward et al. (2014) reviewed all published material relating to HH monitoring and prompt systems and reported challenges to implementation including cost and the need to protect privacy. This review also considered staff preferences relating to systems and found (for example) a preference for vibration rather than audible prompts. The extent of coverage of monitoring systems was also considered in this review according to the World Health Organisation (WHO) (2009) 5 moments and the authors found coverage was largely restricted to moments 1 and 4 (before and after touching a patient). Finally, with regard to reliability, the authors found the accuracy of systems variable. Dawson and Mackrill's (2014) review also investigated the extent of coverage of systems and found that no available system was able to measure moments 2 and 3 (before and after a procedure). These authors cite Vicente (2006) and suggest, when developing optimal HH monitor and prompt systems we need to i) understand what governs human behaviour and ii) understand how HCPs want to be monitored and the personal acceptance of technology.

In relation to i) understanding what governs human behaviour, there is substantial evidence to suggest strategies to enhance clinical practice need to be according to behavioural determinants (Baker et al. 2010) and theoretically underpinned if they are to be effective (Bonetti et al. 2005, Grol et al. 2005, Davies et al. 2010). A recent systematic review of the theoretical underpinnings of HH improvement strategies found addressing behavioural determinants such as knowledge, awareness, action control and facilitation is not enough to improve HH; addressing combinations of different determinants leads to better results (Huis

et al. 2012). Electronic HH prompt and monitor devices are reported to influence by means of reminders or even by way of the Hawthorne effect (Srigley et al. 2014) but there is no evidence of investigation to establish whether or not this is the case or which behavioural determinants these systems might address.

As for ii) understanding how health care practitioners want to be monitored and the personal acceptance of technology, only three relevant studies were identified in the literature that investigate this. Boscart et al. (2008) conducted focus groups to explore the experience of wearing a prototype version of the technology and although practitioners were positive they expressed concerns about who could access the HH data and its intended use. Ellingson et al. (2011) conducted focus groups of practitioners who identified concerns about the accuracy of systems, potential punitive use of the data and they suggested the system indicated a lack of trust in their standards. Levchenko et al. (2010) conducted interviews with nurses who were prompted when they considered it was not necessary.

Aim

Our aims were to investigate:
1. Whether the device improves HH compliance,
2. How devices influence HH (that is, what governs human behaviour within this context?),
3. The experiences and opinions of HCPs of devices (that is, how do practitioners want to be monitored?).

Methods

The device was installed in two units of a large general hospital in the North of England. The specific system worked as follows: a practitioner wearing a badge would enter a bedded area passing a ceiling sensor. If the practitioner failed to clean their hands, after 10 seconds the badge flashed amber and after 15 seconds an audio alert was added. After 20 seconds the badge flashed red and gave a further audio alert. Badges were sensitive to alcohol rub and could be deactivated by the practitioner passing a freshly gelled hand in front of the badge. Sensors were fitted above sinks and when the practitioner was beneath a sink for two minutes (the assumption being cleaning their hands) the badge would be deactivated and return to green.

HH compliance was monitored in one of these two units by observation as per usual practice, through recordings generated by the device and through monitoring the ordering of

alcohol rub. Three HH measures were considered for triangulation purposes each having different strengths and limitations. To assess the possible mechanisms by which the system may influence HH and to establish experiences and opinions regarding the device semi-structured interviews were conducted by an independent researcher with practitioners from both units who had experienced the badge.

Participants

Participants observed for HH monitoring involved all practitioners working on a single medical in-patient unit. This involved 18 practitioners based on the unit (mostly nurses and health care assistants) with approximately 5 visiting practitioners (doctors and allied health professionals e.g. physiotherapists). Observations were by the infection prevention control team and were of approximately 50 opportunities per month. Electronic observation involved all practitioners working on or visiting the unit and monitored opportunities associated with entering and leaving a patient area. Those interviewed were sampled from this and a second unit (accepting emergency patients) within the same NHS trust and were purposively selected from three key job roles; doctors, registered nurses and health care assistants and as these represent the largest proportion of HCPs who had contact with patients. Unit selection was according to convenience. Ethical approval was obtained from the University of Hull, Faculty of Health and Social Care Research Ethics Committee (ref: FHSC-170), Research Governance approval was obtained from the NHS trust involved in the study, participants gave written informed consent to participating in interviews.

Procedure

Semi-structured interviews were undertaken over a six month period from January 2015. Purposive sampling identified a range of participants according to professional role. Recruitment took place through ward managers in each of the two areas. Participants were interviewed in the work place in a private room away from the practice area.

Design

To establish how the system might influence HH behaviour questions were designed using the 11 domains of the Theoretical Domains Framework which offers a comprehensive set of potential behavioural determinants (Michie et al. 2005). To establish practitioners' *experience and opinions* of the system they were simply asked their views and opinions about the system based on their experience of it.

Data analysis

HH observations undertaken by the Infection Prevention and Control (IPC) team were recorded weekly and expressed as a percentage of HH completed as a proportion of HH opportunities. Electronic monitoring was recorded for all (enter/exit) opportunities during the period the system was installed and were also expressed as percentage of HH completed compared with opportunity. The amount of hand gel ordered by the unit was recorded weekly. Interviews were digitally recorded and transcribed verbatim. A thematic analysis (Braun and Clarke 2006) was conducted with themes identified according to the reported mode of influence of the system on HH behaviour and according to experience and opinion about the system.

Results

Participants

Semi-structured interviews (n=12) were conducted with four staff nurses, three charge nurses, two doctors and three nursing assistants. Participants had between three and 21 years of clinical experience. At the time of interview participants had engaged with the system for between 3 and 12 weeks. After interview 9 no new information was offered relating to how devices work or experiences and opinions of the system indicating data saturation.

1. **Do devices influence HH compliance?**

IPC observations ranged from 38 to 100 opportunities per week. Electronic observations monitored between 15 and 20 staff each week. According to IPC team observations HH compliance went from a mean of 73% in the 8 weeks before installation to 83% during the 10 week period the electronic device was installed and went back to 73% after the system was removed (measured over a period of 4 weeks). The electronic monitoring system recorded compliance at between 98% and 100% throughout the period of its installation. The amount of alcohol hand gel ordered went from an average of 4 litres before, 10 during and 2.5 after installation. (Figure 1).

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How do devices influence HH behaviour

Practitioners reported three ways in which they considered the badge influenced HH, i) *prompt* (by the badge flashing and making a sound or by people referring to the badge), ii) *empathy for the patients*, how they might feel if they saw evidence of missed HH and by iii) *increasing awareness* of HH frequency.

i)   Prompt

The electronic system (badge) was reported to prompt HH through its change in colour, the noise it emitted or by other people referring to the badge.

> *"it does prompt you, things like walking in and out of rooms. Definitely prompts then."* (5: Nursing Assistant)

> *"They probably prompt more than anything else."* (9: Charge Nurse)

However, there was also some acknowledgement that people could become desensitised to the prompt.

> *"They just get blind with it."* (12: Nursing Assistant)

> *"Desensitised they are. I saw a lot of people coming into the cubicle and just turning it off."* (6: Doctor)

Not only did the badge prompt HH directly, practitioners also referred to comments made by patients or colleagues. People reported it easier to refer to a flashing or red badge than to ask someone to clean their hands.

> *"It's very visual good for patients and relatives because prior to this last year and the year before we had to wear a badge, please ask me if I have cleaned my hands which is a bit insulting actually. But this is better it gets people talking they say oh what's that? Why is that flashing?."* (9: Charge Nurses)

> *"They* [patients] *say, it is flashing, it is flashing".* (1: Staff Nurse)

> *"They do it in a jokey manner. You know, you might say, you are going in there to do a catheter and look at your badge, it is easier to do it like that."* (7: Staff Nurse)

ii)   Empathy for the patient

The badge offered evidence to patients about whether or not practitioners had cleaned their hands. Practitioners wanted patient to feel confident in the care they were receiving.

> *"I think it does give them [patients] confidence that they know that you are doing it* [HH]." (7: Staff Nurse).

> *"So it does show patients that we are compliant."* (1: Staff Nurse)

> *"It turns different colours and that can make a human-being, a patient, very anxious."* (6: doctor)

iii) Increased awareness

Practitioners reported the electronic system made them more aware of HH and in particular the frequency required.

> *"I think we are all much more conscious of it* [HH].*"* (12: Nursing Assistant)

> *"It does, perhaps it does open your eyes as to how often you go between patient environments."* (5: Nursing Assistant)

> *"I think it does work; you can see them thinking, oh, I should have probably done it a bit more before". (*7: Staff Nurse).

2. What are the experiences and opinions of HCPs of devices

Four themes were identified with regard to the experiences and opinions of the electronic device; these were relating to i) **compliance with HH**, ii) **use of the data generated by systems**, iii) **system accuracy** and iv) **HCPs emotion when using the system**.

i) Compliance with Hand Hygiene

Most practitioners said although their HH practice already good it had improved since the system was installed. Responses were moderate when positive, but no practitioner suggested the system's effect had been detrimental to HH.

> *"We did it* [HH] *anyway; we are more aware of it now"* (1: Staff Nurse)

> *"we are pretty good here anyway, but that said, maybe there was room for improvement, there was a lot more flashing the first week than there is now".* (10: Staff Nurse)

ii) Use of data

This theme relates to how the compliance data generated from the system would or could be used. Some practitioners welcomed the opportunity to see their own data in order to consider their performance and some were concerned that sharing data would lead to criticism or other undesirable outcomes. There was agreement that group data would be more acceptable than individual data and that all data should be presented supportively.

> *"We would use it* [data] *between ourselves to improve hand hygiene on the unit."* (1: Staff Nurse)

> *"People should not be able to see individual level data. . if you do that you are singling out individuals"* (6:Doctor)

> *"They need to find the positives, say how good you are, tell them it that way. If anyone is really bad at hand washing, pull them aside and have a quiet word."* (9: Charge Nurse)

iii) System accuracy

There was a consensus from all practitioners interviewed that the system was not yet accurate. There were four reasons cited for this, the perception that the system was designed to better measure gel than soap, system failure, practitioners gaming or cheating and the limited intelligence of the system. Each of these will be considered in turn.

Gel use

The majority of participants identified that their use of gel had increased but that this was at the cost of using soap and water. Practitioners found that the badges were more responsive to gel than to the sensors by the soap. A small number of practitioners suggested that purpose of the system was to increase alcohol rub sales.

> *"I am using more gel, a lot more gel, I am hand washing less. You have to do it or it won't work* [badge] *so you have no choice you've got to do it. I am gelling more. Our gel use has gone up. Selling gel, that's what this is"*. (4: Nursing Assistant)

> *"I think that is this things major flaw, the badge doesn't really recognise the soap and water so well."* (10: Staff Nurse)

System failure

Participants identified problems with the sensors which sometimes failed to sense a practitioner had cleaned their hands, sometimes HH was prompted by the badges when a practitioner was not near a sensor and a great number of practitioners considered that the time from entering the room to the badge showing red was unreasonably short.

> *They go off without us doing anything at all. So if you are walking down the corridor, I don't know why, it just goes off. . every time I gelled, it was still flashing"* (2: Staff Nurse)

> *"When it flashes red and you have not done anything it does get a bit soul destroying. Things like that, it puts you off. You only get a minute and you're feeling that you have to rush. Sometimes you can go red even when you have washed your hands."* (3: Charge Nurse)

> *"It bleeps randomly"* (4: Nursing Assistant)

Gaming

Some practitioners had thought about manipulating the system, others reported having seen such manipulation and a minority of practitioner reported having engaged in gaming. Often this was linked with system errors or in situations where practitioners believed the system

expected HH unnecessarily. Practitioners said they were unwilling to have inaccurate or unfair data recorded against them.

> *"I want to leave it on top of the trolley. I was going to attach it to a gel dispenser."* (2: Staff Nurse)

> *"I put some gel on the badge for them."* (4: Nursing Assistant)

> *"People will just go and stand near a sink and not necessarily do anything."* (11: Charge Nurse)

> *Intelligence*

Practitioners reported having no faith in the accuracy of data recorded as the system at times expected HH when the practitioner themselves considered it unnecessary.

> *"So you have to get your gloves on and your apron on. You have taken the urine bottle out and then you have to put it down on the floor to step out to gel and . . this doesn't think and it doesn't let me think."* (4: Nursing Assistant)

> *"Even if you didn't do anything, just because you enter an area . . they are only sensors, it doesn't have a brain."* (6: Doctor)

iv) Feelings about the system

Many emotions were expressed when practitioners discussed their experiences of the system; irritation and frustration were the most frequently mentioned. Practitioners acknowledged the value of the system but expressed reluctance in being monitored.

> *"Sometimes it's quite distracting this amber light flashing then starts flashing red, sometimes that is not appropriate. I know there is an emergency button but you get a bit frustrated."* (1: Staff Nurse)

> *"It's like laser quest, you think, oh, stop it."* (3: Charge Nurse)

> *"It's like the big brother show on the tele' I am telling you."* (4: Nursing Assistant)

> *"It bleeps all of the time. It is a nuisance . . irritating at the moment . . it is irritating. It causes concern."* (6: Doctor)

> *"I feel positively about them, I think, overall* [but] *it causes yet another distraction in a stressful situation. When washing your hands is the least of your priorities.*" (8: Doctor)

Discussion

During the period in which the electronic monitoring system was installed, HH practice was improved according to IPC team observations and hand gel usage. According to the electronic system HH compliance was between 98 and 100% during installation.

Practitioners reported the system influenced HH by way of system prompt or other practitioners or patients referring to the badge, so that patients would have confidence in their care and not have to worry and by increased awareness of when and how often HH needed to take place. Opinions and experiences of the electronic system included a general agreement that the system led to improvements, the best use of the HH data was considered including concerns about the possibility of individual level data being shared with others, the accuracy of the system was questioned and practitioners reported finding the system frustrating, irritating and distracting and there was resentment expressed about their HH being monitored.

The findings relating to improved compliance are consistent with previous research (Swoboda et al. 2004, Venkatesh et al. 2008, Edmond et al. 2010, Sahud et al. 2012, Marra et al. 2014) though ours is the only study we are aware of that has taken place in the UK. Of the badge systems that are reported in the literature there is a general assumption that they may be effective through the process of prompt or the Hawthorne effect (created by monitoring) (Strigley et al. 2014). We have found that that the system not only prompts directly but offers an acceptable way for patients and colleagues to ask practitioners to clean their hands.   The UKs National Patient Safety Agency "cleanyourhands" campaign identified that 57% of the public were unlikely to question HCPs, 43% of patients considered practitioners should know to clean their hands and 20% wouldn't want HCPs to think they were questioning their ability to do their job (Pittet et al. 2010). It may be that referring to a changed badge mitigates reluctance to speak up. We have evidence that patients influence practitioners (WHO, 2005). There was indirect reference to the Hawthorne effect within the theme "empathy for patients"; patients observing compliance (though not the behaviour itself) through the colour of the badge. However, practitioners were clear that the influence on their behaviour was protecting patients from worry or giving them confidence in the care being offered rather than through the act of observation. Equally, when HCPs spoke of individual level compliance data they expressed the potential for this to guide improvement or with resentment about being monitored; there was no explicit indication that others being able to see these data influenced their HH but reference to "big brother" suggests practitioners were aware of being monitored which may have influence their practice. There is little reported regarding the practitioners' experiences and opinions of such systems with which to compare our findings. However, previous research reports of systems lacking the "intelligence" to judge the situational context (Boscart et al. 2008, Ellingson et al. 2011) and there is evidence of disparity between human with electronic observations to an extent of 38% (Sharma et al. 2012). Ellingson et al. (2011) also identified a reluctance in being monitored and concerns about compliance data being used unwisely. By contrast none of

the participants in the focus groups conducted by Boscart et al. (2008) expressed any such concerns.

One of the strengths of this study is the explicit investigation of the behavioural determinants addressed by HH monitor and prompt systems and the acceptability of such systems to practitioners. This study is subject also to some limitations. We were only able to monitor and report HH compliance from one of the two areas in which the system was installed. During the study period, in the second unit an unexpected high volume of admissions led to additional and temporary bed spaces being created causing misalignment of the ceiling sensors with the entrances with some bed spaces and having a potential confounding impact on gel usage. Interviews had taken place prior to this change but it was not possible to unpick the HH compliance data sufficiently to report it. Another limiting factor, it was infeasible to measure alcohol rub actual usage and we therefore relied on the stock ordering data to estimate usage. Whilst orders are made according to stock levels and anecdotal evidence dismisses stock-piling it is not possible to be accurate in the amount of alcohol rub used. We did not measure soap usage during the study.

According to the findings of this study further work is required to refine electronic HH monitoring systems. Our participants report irritation and frustration at system failure and lack of "intelligence" (being prompted when HH is not necessary). The findings of this study suggest that electronic HH monitor and prompt systems may improve compliance and that systems appear to impact a range of behavioural determinants. This may be undermined if practitioners have no faith in the accuracy of the system. Consideration needs to be given to most effective and acceptable use of compliance data and the potential and rationale for "gaming" the system.

Conclusion

HH prompt and monitoring systems appear to improve compliance and are multifaceted in their influence however systems are unable to recognise context and therefore prompt when HH is unnecessary. This may lead to practitioner irritation and gaming potentially undermining the positive impact of such systems.

Declaration of conflicting interests: The Authors declare that there is no conflict of interest.

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