International Journal of Nursing and Health Services (IJNHS)
http://ijnhs.net/index.php/ijnhs/home
Volume 3 Issue 2, April 20th 2020, pp 284-296
e-ISSN: 2654-6310

The effect of Electronic Hand Hygiene Monitoring Towards Hand Hygiene Compliance: A Literature Review

Annisa Rahmi Galleryzki[1*], Hanny Handiyani[2*]

[1] Master of Nursing Student, Faculty of Nursing, University of Indonesia, Depok, West Java
[3] Basic Science and Fundamental of Nursing Department, University of Indonesia, Depok, West Java

Article information

***Article history*:**
Received; 10 November 2019
Revised: 25 November 2019
Accepted: 18 December 2029

Correspondence author:
Annisa Rahmi Galleryzki
E-mail:
annisa.rahmi91@ui.ac.id

DOI:
10.35654/ijnhs.v3i2.302

Abstract. Hand Hygiene (HH) is the most effective step to reduce the transmission rate of patient care infections. Attempting to increase HH is carried out by using technology and handwashing compliance as an indicator of its success. The study aimed to describe information on technological developments in HH monitoring in hospitals and their effects on the level of compliance of health workers, especially nurses, in conducting HH. This study uses the literature review method, using the Science Direct, Scopus, Ebsco, and PROQUEST databases. The author uses keywords: "electronic hand hygiene monitoring" and "technology of hand hygiene monitoring" in searching the database. The development of technology in HH monitoring has increased in the last decade. The main goal of its development is to reduce the bias that occurs with control by a human. There are three kinds of HH technology, such as wireless tracking technology, auditing video, and chemical fluid sensor. The use of electronic HH monitoring can increase HH compliance, both assessed in terms of quality and quantity. In contrast, until now, there are no tools that can detect HH compliance in all HH WHO's moments. In its development, the successful use of these tools also experienced obstacles.

Keyword: electronic hand hygiene monitoring, the technology of hand hygiene monitoring

INTRODUCTION

Hand hygiene (HH) is the most effective way to decrease infection (1). Hand hygiene improvement is based on five things, such as 1) Enhancement access of HH facilities; 2) Staff training; 3) Evaluation and feedback; 4) poster or other media for direction individual or group attitude; 5) Upgrading of quality and safety. In the expansion of technology, utilization of technology is used to increase HH, and HH compliant becomes a fruitfulness indicator. Efforts to improve HH were carried out by the use of technology and hand-washing compliance to be an indicator of its success (2).

Evaluation and feedback to improve HH are monitoring HH on human observation and using technology. There are significant differences in HH compliant indirect observation and hidden observation (differences is 30-50%). Therefore, human observation allows a bias results, the appearance of Hawthorne effect, time and cost ineffectiveness, continuous monitoring can not be done, and giving little information from all HH opportunities (3-4).

Whereas technological monitoring can promise, but complete validation not implemented. HH technological monitoring decreases the number of staff involved during an audit and increases accessibility in the room that can not be direct observation (3). Technological monitoring in hand hygiene was conducted in the last decade. The technology is divided into two criteria, such as technology for monitoring specific aspects of HH (HH when entering/leaving a room, using soap dispensers) and technology for monitoring compliance (assessing opportunities & compliance of health workers in conducting HH) (1).

Previous research provided information on the development of electronic HH monitoring in hospitals and their effects on the compliance of health workers, but the results varied. The research is the foundation for writing a literature review to examine the development of technology and its effect on HH compliance. HH compliance is based on WHO guidelines, like compliance with five moments of HH and compliance with HH steps.

OBJECTIVE

This literature review aims to provide information on technological developments in monitoring HH in hospitals and its' effects on the level of compliance of health workers, especially nurses, in conducting HH.

METHOD

Data sources

The author uses various types of research, such as quantitative and qualitative methods, in describing the development of electronic HH monitoring tools and their effects on HH compliance of health workers, both compliance in time and HH rules or steps. The author uses four online databases in literature studies, namely Science Direct, Scopus, Ebsco, and PROQUEST.

Search strategy

The authors conducted several search processes to obtain relevant articles discussing the effect of developing electronic HH monitoring tools on HH compliance. The search process is carried out using keywords: "electronic hand hygiene monitoring" and

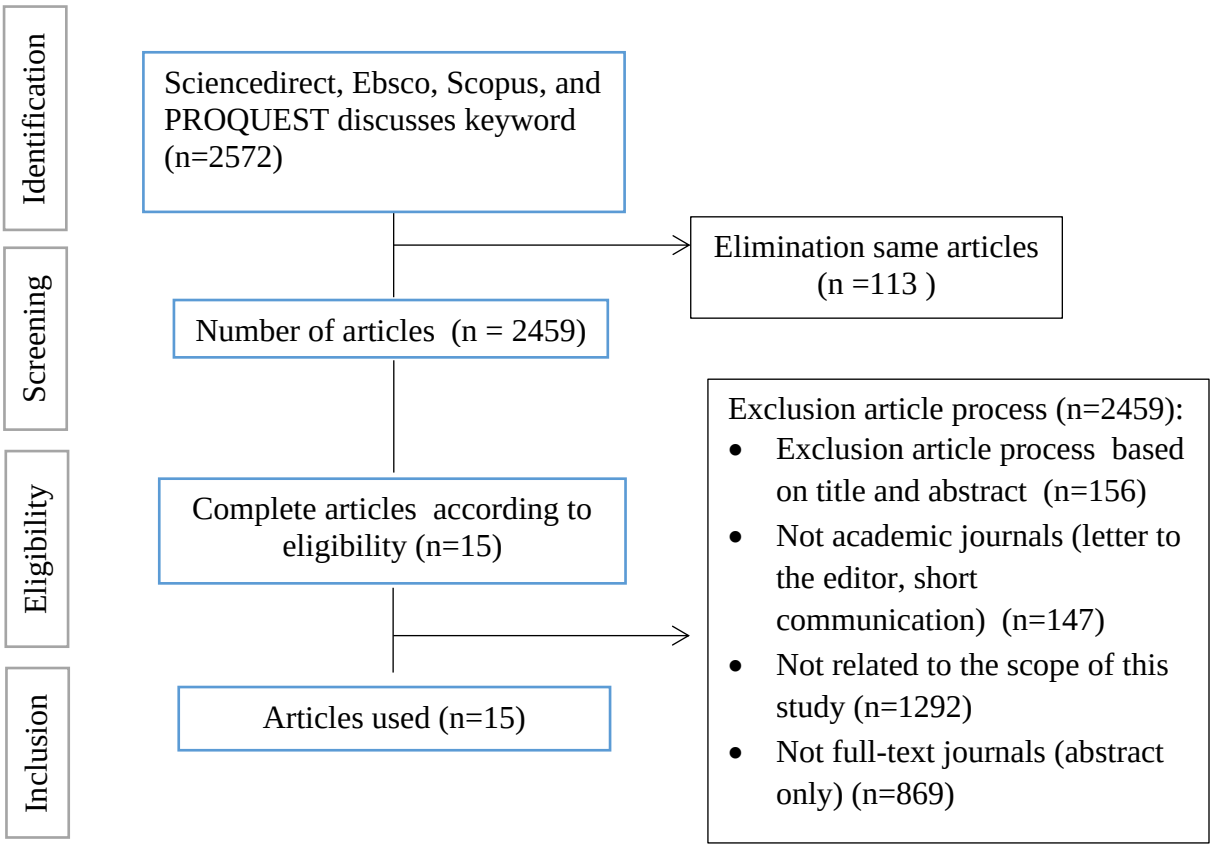

Figure 1. The selection process of literature review uses the PRISMA method

RESULTS

The development of technological hand hygiene monitoring

The technology used in monitoring hand hygiene is increasing continuously. Some studies use wireless tracking technology, such as the use of radio-frequency identity tagging (RIFD), wireless local area networking (Wi-Fi), or using Bluetooth Low Energy (BLE) (1). Also, technological monitoring is handling the development of scanners, videos, and chemical fluid sensors (5–7). Description of HH monitoring development is described as follows:

1) Utilization of wireless tracking technology

The system uses HH status targets inpatient rooms with wireless radio-frequency communication found on employee identification bracelets, patient beds and stretchers, and hand sanitizer dispensers (8). Besides using radio-frequency, technological HH monitoring is also using electronically counted dispenser usage that connected to Wi-Fi

(ingoman weco, ophardt) (9). Information received is linked directly to the central computer (2).

The sensor provided adequate information on implementation time, duration, and steps of the HH, which are assessed, whether following WHO criteria (2,3,8,10). Furthermore, information received on the central server will give rise to different feedback. The feedback system uses two levels, namely real-time feedback and individual, shift, and final department reports. In real-time feedback, the bracelet that the nurse uses provides information about the HH status of the nurse through the color or vibration that appears (3,8,10).

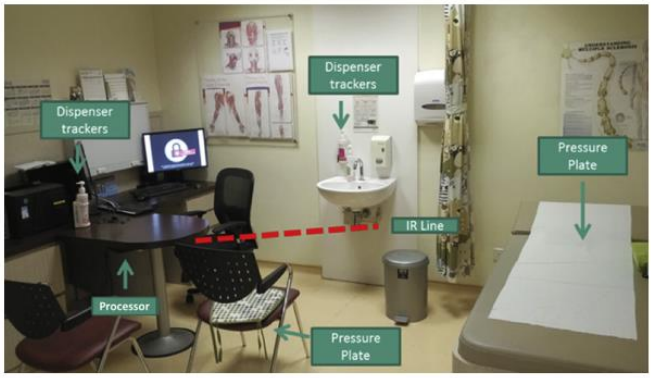

Figure 2 Set-up of the real-time hand hygiene notification machine learning system

2) Utilization of auditing video

Development of a computer vision method using a Kinect camera that produces video and depth images (image 5). This tool can detect the use of Alcohol-based hand rub (ABHR), the adequacy of HH steps, and contact between nurses and patients (11).

One of the purposes of video auditing is using Automatic Video Auditing (AVA) that assess whether HH techniques meet the WHO criteria or not (image 4) (7). One aim to develop monitoring technology is to provide an easy to understand display. The example is how to give real-time feedback on combined risk status (CSR). The CRS was calculated based on a combination of live data from each of the digital systems. A couple of weeks of baseline data were gathered and used from the IPC team to develop rules of red-amber green status. These rules were encoded into a set of finite state machines according to the regulations (image 3). Also, the use of camera-based augmented reality, and gamified learning is also used to teach and assess hand hygiene compliance in hospitals among health care providers (12).

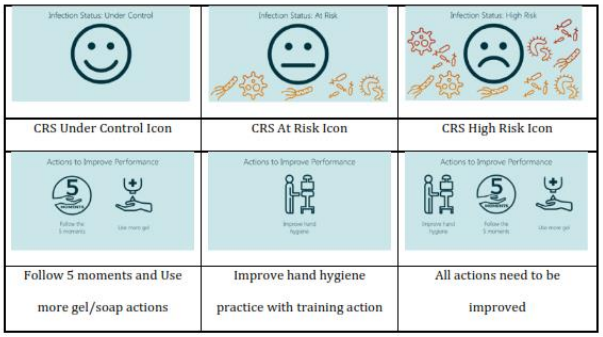

figure 3. Icons used to provide feedback to staff and patients on the combined risk status and the associated actions

Figure 4. Automatic video editing

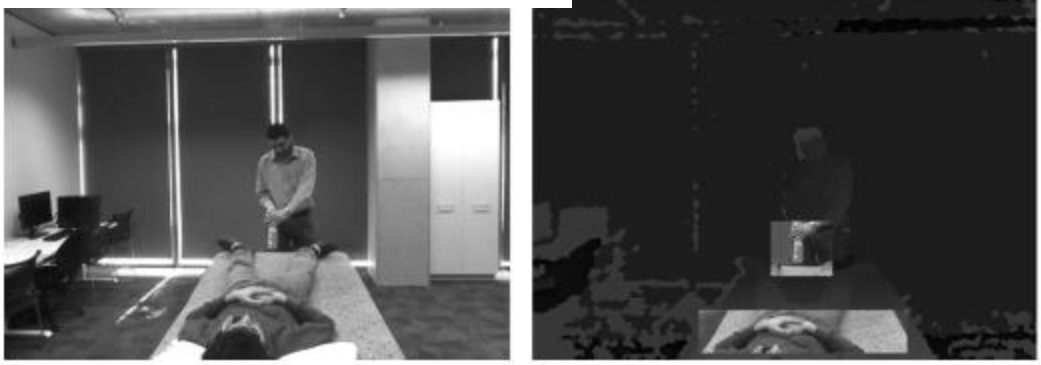

Figure 5. Left: video (RGB) image of the actual scene. Right: processed depth imagery of the same scene.

3) Utilization of chemical fluid sensor

Chemical fluid sensor designs in the form of a ring with two layers printed circuit board (PCB). PCB is the primary sensor as an indicator to see the compliance of HH. Also, this tool can detect different HH agents, monitor the implementation of HH, and report on the process or duration of HH (5).

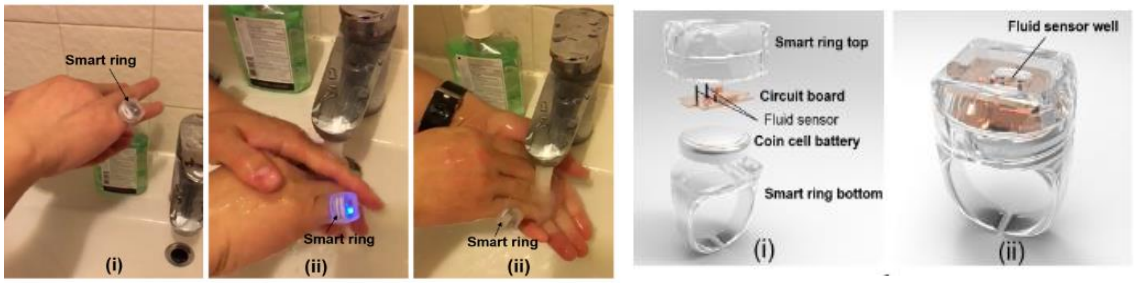

Figure 6. Smart ring design

The compliance of hand hygiene

Two criteria are assessed hand hygiene compliance that is the compliance of hand hygiene timing (five moments of hand hygiene) and compliance of hand hygiene procedures (six-step of hand hygiene)

1) *The compliance of hand hygiene timing*

Quantity evaluation of HH recommended by the World Health Organization is by conducting an assessment of compliance in carrying out "five moments of hand hygiene," namely: 1) Before contact with patients; 2) Before carrying out aseptic procedures; 3) After being exposed to bodily fluids; 4) After contact with patients 5) After contact with the patient's surroundings (7,13). In the studies in this literature review, there are limitations of monitoring only at the first, fourth, and fifth moments (2,4,8).

Research by Edmistren et al. explained a significant increase in compliance with HH implementation by 85% -90%. This research is supported by several other similar studies, that there is a positive effect on the awareness and compliance of HH staff in hospitals (2,7,9). This significant increase is also through a long, gradual process, periodic evaluations, and getting contra from the staff involved (2,14,15). The above research is inversely proportional to that is Dufour et al. , in the review of the use of electronic HH monitoring, the number of HH moments that were not carried out was 3581 moments (77.4%), while 1021 moments (22.6%) were implemented (4).

2) *The compliance of hand hygiene procedures*

The HH quality assessment recommended by the World Health Organization is to evaluate compliance in carrying out the "six steps of hand hygiene"(7,13). An evaluation of compliance with HH steps is carried out by monitoring using a video audit. The use of a video audit can improve the quality of HH by 193%. This tool only provides training to staff, but can also be used as a tool for monitoring every step of the HH. This is because there is direct feedback on the HH step carried out using the green or red color on the screen as an indicator (7).

DISCUSSION

The majority of studies concluded that the use of electronic HH monitoring has a positive effect on the level of HH compliance by hospital staff. The implementation of electronic HH monitoring is a long and complicated process. The success of using this technology requires collaboration and coordination between vendors and hospitals that use services. Careful planning is needed, support from the environment, for example, by setting desired goals and delivered collectively, as well as strong support from the leader (8,9). Training staff gradually also becomes a way to block the potential reduction in HH and the level of staff participation in using tools (14).

None of the existing technological monitoring innovations have been able to assess five HH moments according to WHO guidelines (4). Monitoring can be performed before or after contact with patients. Moreover, it also is done after contact with the environment around the patient. However, the use of electronic monitoring can monitor events and detect changes in needs continuously, reducing the bias caused in human observation and streamlining the time used to collect data. The system also provides data standardization to make it easier to compare at certain times and can provide direct feedback to the staff (8).

In the implementation of technology, the enthusiasm of staff increased. However, it slowly decreases to disappointment and the rejection of staff to continue the system (2). The frustration is based on the inaccurate performance of the tool because it gives the wrong alarm and does not precisely determine the HH moment. Also, the use of wristbands on staff arms is

disturbing, oppressive, and contradictory to the appeal to empty accessories from the arms down (2,3). Battery performance on staff bracelets is also a significant obstacle in the use of electronic HH monitoring with radio transmitters (16). Considering the description of electronic HH monitoring or direct observation can be made based on organizational considerations. Therefore, the selection of HH electronic monitoring equipment in a hospital or related institution needs to pay attention to specific concerns, such as the hospital's physical infrastructure, workflow tools, organizational culture, and costs incurred in starting the use of this tool (17).

CONCLUSION

Utilization of technology in HH monitoring is one way that can be used to improve HH compliance by hospital staff. In the study of compliance in terms of quantity, namely compliance with five moments of handwashing, explain a significant increase in compliance with HH implementation. Also, quality aspects, namely compliance with six steps of washing hands following the standards used by WHO, can improve the quality of HH. In use, electronic HH monitoring has a positive effect on compliance, but staff complaints and dissatisfaction with this tool also need to be considered. Therefore, if hospitals in Indonesia want electronic HH monitoring, primary considerations are required before making a decision, such as agency physical infrastructure, workflow tools, organizational culture, and costs incurred in starting the use of this tool.

STRENGTH AND LIMITATION

This study reviews many previous studies to explore the technology of HH monitoring. The results give information to improve the quantity and quality of the HH staff. This study also offers illustrations about the example of a device so that that reader can imagine those tools. However, these studies have a limitation on quantity HH monitoring. There are no studies in the literature that can assess five HH moments according to WHO guidelines. Therefore, development in HH monitoring remains to be done.

Acknowledgment

The author would like to thank the University of Indonesia for providing the opportunity to access the database, Indonesia Endowment Fund for Education (LPDP), the Ministry of Research and Higher Education (Kemenristek Dikti) for providing facilities and support.

Funding support

No funding has received the performance of these studies

REFERENCES

(1) Geilleit R, Hen ZQ, Chong CY, Loh AP, Pang NL, Peterson GM, et al. Feasibility of a real-time hand hygiene notification machine learning system in outpatient clinics. J

Hosp Infect. 2018;100(2):183–9.
(2) Levin PD, Razon R, Schwartz C, Avidan A, Sprung CL, Moses AE, et al. Obstacles to the successful introduction of an electronic hand hygiene monitoring system, a cohort observational study. Antimicrob Resist Infect Control [Internet]. 2019;8. Available from: https://search.proquest.com/docview/2193658916?accountid=17242
(3) Storey SJ, FitzGerald G, Moore G, Knights E, Atkinson S, Smith S, et al. Effect of a contact monitoring system with immediate visual feedback on hand hygiene compliance. J Hosp Infect. 2014 Oct 1;88(2):84–8.
(4) Dufour J, Reynier P, Boudjema S, Aladro AS. Evaluation of hand hygiene compliance and associated factors with a radio-frequency-identification-based real-time continuous automated monitoring system. J Hosp Infect [Internet]. 2017;95(4):344–51. Available from: http://dx.doi.org/10.1016/j.jhin.2017.02.002
(5) Zhang X, Kadimisetty K, Yin K, Ruiz C, Mauk MG, Liu C. Smart ring: a wearable device for hand hygiene compliance monitoring at the point-of-need. Microsyst Technol [Internet]. 2018;25(8):3105–10. Available from: https://doi.org/10.1007/s00542-018-4268-5
(6) Suen LKP, Wong JWS, Lo KYK, Lai TKH. The use of a hand scanner to enhance hand hygiene practice among nursing students: A single-blinded feasibility study. Nurse Educ Today [Internet]. 76(January):137–47. Available from: https://doi.org/10.1016/j.nedt.2019.01.013
(7) Lacey G, Zhou J, Li X, Craven C, Gush C. The impact of automatic video auditing with real-time feedback on the quality and quantity of handwash events in a hospital setting. Am J Infect Control [Internet]. 2019;000. Available from: https://doi.org/10.1016/j.ajic.2019.06.015
(8) Rn CE, Hall C, Kernizan L, Korwek K, Rn AP, Rhoades E, et al. American Journal of Infection Control Implementing an electronic hand hygiene monitoring system : Lessons learned from community hospitals. AJIC Am J Infect Control [Internet]. 2017;45(8):860–5. Available from: http://dx.doi.org/10.1016/j.ajic.2017.03.033
(9) Diefenbacher S, Fliss PM, Tatzel J, Wenk J, Keller J. A quasi-randomized controlled before e after study using performance feedback and goal setting as elements of hand hygiene promotion. J Hosp Infect [Internet]. 2019;101(4):399–407. Available from: https://doi.org/10.1016/j.jhin.2019.02.001
(10) Benudis A, Stone S, Sait AS, Mahoney I, Price LL, Moreno-Koehler A, et al. Pitfalls and Unexpected Benefits of an Electronic Hand Hygiene Monitoring System. Am J Infect Control. 2019;
(11) Awwad S, Tarvade S, Piccardi M, Gattas DJ. The use of privacy-protected computer vision to measure the quality of healthcare worker hand hygiene. Int J Qual Heal Care. 2019;31(1):36–42.
(12) Thirkell G, Chambers J, Gilbart W, Thornhill K, Arbogast J, Lacey G. American Journal of Infection Control Pilot study of digital tools to support multimodal hand hygiene in a clinical setting. AJIC Am J Infect Control [Internet]. 2018;46(3):261–5. Available from: https://doi.org/10.1016/j.ajic.2017.08.042
(13) Organization WH. WHO guidelines on hand hygiene in healthcare. Geneva, Switzerland: World Health Organization; 2009.
(14) Pong S, Holliday P, Fernie G. American Journal of Infection Control Effect of intermittent deployment of an electronic monitoring system on hand hygiene behaviors

in healthcare workers. AJIC Am J Infect Control [Internet]. 2019;47(4):376–80. Available from: https://doi.org/10.1016/j.ajic.2018.08.029

(15) Pong S, Holliday P, Fernie G. American Journal of Infection Control Effect of real-time electronic prompting on hand hygiene behaviors in health care workers. AJIC Am J Infect Control [Internet]. 2018;46(7):768–74. Available from: https://doi.org/10.1016/j.ajic.2017.12.018

(16) Almeida M, Rn OF, Marra AR, Pereira T, Rn M, Dias R, et al. American Journal of Infection Control Comparison of human and electronic observation for the measurement of compliance with hand hygiene. Am J Infect Control [Internet]. 2014;42(11):1188–92. Available from: http://dx.doi.org/10.1016/j.ajic.2014.07.031

(17) Conway LJ. American Journal of Infection Control Challenges in implementing electronic hand hygiene monitoring systems. AJIC Am J Infect Control [Internet]. 2016;44(5):e7–12. Available from: http://dx.doi.org/10.1016/j.ajic.2015.11.031

(18) Pong S, Holliday P, Fernie G. Secondary measures of hand hygiene performance in health care available with continuous electronic monitoring of individuals. Am J Infect Control. 2019 Jan 1;47(1):38–44.

(19) Brotfain E, Livshiz-riven I, Gushansky A. American Journal of Infection Control Monitoring the hand hygiene compliance of health care workers in a general intensive care unit : Use of continuous closed circle television versus overt observation. AJIC Am J Infect Control [Internet]. 2017;45(8):849–54. Available from: http://dx.doi.org/10.1016/j.ajic.2017.03.015

(20) Dyson J, Madeo M. Investigating the use of an electronic hand hygiene monitoring and prompt device : influence and acceptability. 2017;

Table 1. Development of hand hygiene monitoring technology

Authors	Method	Setting	Objective	Development of technology	ystem-human communication	Findings
Geilleit et al. (2018)(1)	Mixed-method study	Singapore	To assess the effectiveness, user experiences, and costs of implementing a real-time HH notification machine learning system in outpatient clinics.	a multi-disciplinary team co-created an infrared-guided sensor system	Sensor system to automatically notify to perform HH just before first patient contact.	Overall HH performance increased to 100% (P < 0.001). With auditory notifications of a maximum duration of 15 s, HH performance was 80.4% (P < 0.001)
Levin et al. (2019)(2)	Cohort observational study	Israel	Describe the introduction of an electronic HH surveillance and intervention system into the general ICU of a tertiary care teaching hospital, the obstacles to success, and reasons for the system's ultimate failure and removal.	tem was based on radiofrequency transmitters inpatient areas, on HH dispensers, and individual personal bracelets.	Real-time information about whether HH was required or had been performed was then transmitted back to the staff members' bracelet. If HH was needed but had not been presented, the bracelet vibrated and displayed a screen message.	tronic HH system was not accepted by ICU staff principally due to inaccuracy and inconvenience. Direct observations verified inaccuracies. For an automated HH system to succeed, we suggest it must be highly accurate and comfortable to use.
Storey et al. (2014)(3)	Quasi-experimental	London	To establish accuracy and acceptability of an automatic contact monitoring system hand hygiene.	Monitoring equipment was installed across 55 beds and included modified identity badges, bedside furniture, sinks, and alcohol gel dispensers.	Badges were in near-skin contact (through uniform) and could detect alcohol vapor. All devices were linked by wi-fi. A traffic light system on the badge provided immediate feedback to staff and patients on the hand hygiene status of a member of a team on approach to a patient.	Hand hygiene compliance increased from 21% of 97 opportunities to 66% of 197 opportunities during active immediate feedback
Dufour et al. (2017)	Quasi-experimental	France	To assess hand hygiene compliance and associated factors before entering the bedroom (external use) and before entering the patient care zone (inside/bedside use) using an automatic continuous monitoring system.	The radiofrequency-identification-based real-time continuous automated monitoring system in an infectious disease ward		The shorter the duration of the HCW's path, the worse the bedside hand hygiene. Bedside hand hygiene is improved when one or two extra HCWs are present in the room.
Zhang et al. (2019)(5)	Technical paper	Germany		The smart ring was rapidly prototyped by 3D printing technology. The intelligent ring contains an electrochemical fluid sensor. A blue LED indicator and an embedded electronic board	Once the fluid sensor detects fluids, the blue LED indicator starts to flash as an indicator and the ring times the washing process.	We envision that the new wearable smart ring can be used for real-time monitoring hand hygiene compliance of healthcare workers to prevent healthcare-associated infections. Besides healthcare applications, the proposed

Lacey et al. (2019)(7)	Quasi-experimental	Ireland	the impact of automatic video auditing (AVA) with feedback on the quality and quantity of handwashing in a hospital setting.	The AVA systems provided real-time training feedback to each staff on their hand hygiene technique.	The screen showed each step of the WHO protocol, each with a red/green traffic light symbol. As the HCW completed each stage, its associated traffic light changed from red to green. The aim was to get all the traffic lights to turn from red to green. For ensuring anonymity, the AVA camera faced straight down so that only the sink could be seen and the HCW's face or any other identifying information was excluded from view	: AVA with real-time feedback significantly improved the quality and quantity of handwashing. The combination of AVA with electronic monitoring will allow simultaneous auditing of hand hygiene quantity and quality
Edmistren et al. (2017)(8)	Quasi-experimental	Florida	Describe the implementation of an electronic HH monitoring system in 3 community hospitals, including the challenges and drivers of success and the maintenance activities needed for continued improvements in compliance with HH practices.	Using the proximity of the radiofrequency communication-enabled badges about the bed or stretcher beacons and hand sanitizer dispensers, this system monitors 5 HH event opportunities:	All staff are assigned an individual the radiofrequency communication-enabled badge that presents HH compliance status via a series of light-emitting diodes. The badge transmits its current status or change of status to the bed or dispenser beacon	Realizing the full benefit of investments in electronic HH monitoring systems requires careful consideration of implementation strategies, planning for ongoing support and maintenance, and presenting data in a meaningful way to empower and inspire staff.
Diefenbacher et al. (2019)(9)	quasi-randomized controlled before-after study	Germany	To test the potential of goal setting and performance feedback in improving HH.	Hand-disinfectant dispensers' inpatient rooms were replaced with electronic dispensers that counted dispenser usage and transferred data via WiFi (ingo-man Weco, Ophardt).	-	This study suggests that combining goal setting and feedback is a useful approach for improving HH.
Awwad et al. (2019)(11)	Observation	Australia	(i) To demonstrate the feasibility of automated, direct observation and collection of hand hygiene data, (ii) to develop computer visual methods capable of reporting compliance with moment 1 (the performance of hand hygiene before touching a patient), and (iii) to report the diagnostic accuracy of automated, direct observation of moment 1.	Used a Kinect camera (Microsoft Corp) to capture depth images along with RGB images.	-	The diagnostic accuracy of determining that ABHR was dispensed and that the patient was touched was excellent (sensitivity 100%, specificity 100%). The diagnostic accuracy of deciding that the hands were rubbed together after dispensing ABHR was good (sensitivity 83%, specificity 88%).

Thirkell et al. (2018)(12)	Quasi-experimental	Ireland	to evaluate, in a live clinical setting, the ability of integrated digital tools to support a multimodal hand hygiene the program, assess the reaction of staff and patients to real-time feedback of a combined risk status (CRS), and identify the design considerations for a larger-scale rollout.	MEG clinical support tools provide a range of software for front-line HCWs on mobile and tablet devices and provide real-time results and alerts for auditors and managers Surewash: The the system uses camera-based augmented reality and gamified learning to ensure that the muscle memory of hand hygiene is learned correctly The system captures soap and sanitizer dispenses (events) and room entries and exits (opportunities), and can be configured to monitor and measure hand hygiene performance	The final design used an the emoji-type icon on a germ-filled background to indicate risk status. The CRS was followed immediately by a screen indicating actions needed to improve the score; both the CRS states and the action screen	The combined risk status reduced over the pilot period. However, more extensive and more extended duration studies are required to reach statistical significance. Staff and the especially patient reaction was positive in that 70% of the hand hygiene training events were by patients. The digital tools did not negatively impact clinical workflow and received positive engagement from staff and patients. The combination of risk status did not change significantly over the short pilot period because there was also no specific campaign on hand hygiene improvement at the time of the pilot study.
Pong et al. (2018)(15)	Quasi-experimental	Canada	Evaluated the ability of an electronic monitoring system with the real-time prompting capability to change hand hygiene behaviors.	The dispenser activation count is monitored at one maintenance unit before the EMS is installed, during EMS use, and after the system is removed.	The EMS utilizes electronic badges worn by health care staff members that communicate with sensors installed at monitored zone entrances and in all wall-mounted handwash dispensers.	Use of electronic monitoring with real-time prompts of 20 seconds' duration nearly doubles handwashing activity and causes handwashing to occur sooner after entering a patient room. These improvements are sustainable over a year
Pong et al. (2019)(18)	Quasi-experimental	Canada	Investigated an intermittent deployment strategy to overcome potentially declining participation levels.	The dispenser activation count is monitored at one maintenance unit before the EMS is installed, during EMS use, and after the system is removed.	The system uses smart badges worn by staff to collect information about handwashing activity from electronic controllers installed in all soap and alcohol-based hand rub (ABHR) dispensers and on the ceiling, inside, and outside of all monitored zones including all patient rooms	There was a significant increase in aggregate dispenser use with every deployment and a decrease over several weeks following each withdrawal. Participation was high at the beginning of deployment and declined during implementation but was restored to a high level with the start of the next deployment.
Almeida et al. (2014)	Quasi-experimental	Brazil	The purpose of this study was to evaluate hand prospectively hygiene compliance in an adult step-down unit using electronic handwash counters with the application of radiofrequency identification (RFID) (electronic observer) and compare this to direct observation (human observer).	Electronic handwash counters recorded hand hygiene episodes for alcohol gel (PURELL Hand Instant Sanitizer; 62% ethyl alcohol and 4% isopropyl alcohol 1-L bag; Purell, GOJO Industries, Inc., Akron, OH)	This technology uses a wireless identification device (badge) worn by the HCW to sense when an HCW performs hand hygiene with alcohol hand rub using electronic dispensers inside the patient's room	RFID (ZigBee) system showed good accuracy (92%) and is a useful method to monitor hand hygiene compliance.

Brotfain et al. (2017)(19)	Cross-sectional and comparative study	Israel	Compares the hand hygiene compliance rates of HCWs in a general ICU (GICU) using the standard direct observational the method with those recorded using the new covert CCTV observation system.	CCTV is a modern observation system based on online or realtime television camera monitoring.	-	CCTV is an appropriate, reliable, and neutral method for observation of hand hygiene. However, there is no clear basis for incorporating a CCTV observation modality into a health care system that already operates an overt observation program
Dyson et al. (2017)(20)	Mixed-method study	Lincolnshire, UK	To investigate (1) the impact of devices on HH compliance, (2) how devices influence behavior, and (3) the experience and opinions of practitioners on the use of devices.	The badge that was worn by practitioners was a small, light device (approximately 50 g), which they clipped to their tunic breast pocket.	The badge could detect the infrared sensors that were installed above the doors and entrances to a patient's bed space	HH compliance improved during the period the device was installed. Practitioners reported the device increased their awareness, enhancing their empathy for patients, and encouraged patients and colleagues to prompt when HH was needed. Practitioners' said better HH, gaming the system, and feelings of irritation.