Hand Hygiene Compliance Monitoring Systems for Reducing Healthcare-associated Infections

Hand hygiene compliance monitoring systems (HHCMSs) automatically monitor hand hygiene (HH) compliance rates—that is, the number of HH events (i.e., activation of or proximity to a hand soap or sanitizer dispenser) divided by the number of HH opportunities (i.e., times when an individual should clean his/her hands, such as when entering a patient’s room) or similar compliance metric. HHCMSs can be broadly categorized as group-level or individual-level. Group-level HHCMSs use monitored dispensers to count HH events and either care area sensors or proprietary algorithms to assess HH opportunities. Group-level HHCMSs provide aggregate HH compliance rates of staff, outside vendors, caregivers, visitors, and patients who used monitored dispensers within a care area during a certain time period (i.e., hour, day, week, or month).

The Evidence Bar™

Evidence is inconclusive — too few data

Although limited evidence suggests that some HHCMSs can accurately collect data and/or improve HH compliance, whether they lead to reduced healthcare-associated infections (HAIs) is unclear because most studies did not report on HAIs. The one study that did report a reduced *Staphylococcus aureus* infection rate after implementing a hand hygiene (HH) monitoring technology did not control for other variables that could have affected the infection rate. Controlled studies are needed to further assess these systems’ impact on patient outcomes and the costs of different systems.

**Evidence limitations.** Only 1 small randomized controlled trial (RCT) of short duration and at high risk of bias was available. Most of the other seven studies were single-center; all were at high risk of bias, especially studies that compared HH monitoring systems with direct observation.
Executive Summary

Conclusions

Hand hygiene compliance assessed in studies of various designs that reported clinical utility or validity

— 1 small RCT (Rodriguez-Aldrete et al. 2016) of 10-hour duration reported that an electronic visual reminder increased HH compliance of 20 staff who entered the operating room.

— 1 nonrandomized comparison study (Vaidotas et al. 2015) found higher HH compliance rates at 2 hospital entrances over 33 weeks using GOJO SMARTLINK electronic sensor (17%, 7.1%, respectively) than with direct observation (24-hour surveillance) (2.2%, 1.7%, respectively).

— 1 report of 2 single-site pre-/postintervention studies (Michael et al. 2017) found automatic observation with BioVigil increased HH compliance from 54% to 87% in an organ transplant unit and from 52% to 97% in a cardiothoracic surgery intensive care unit (ICU).

— 1 pre-/postintervention study (Kelly et al. 2016) found that use of the DebMed System improved HH compliance in 21/23 inpatient units (median improvement 9.7% over 33 months); MRSA infection rates were lower, but the device use's contribution to this lower rate was unclear.

— 1 pre-/postintervention study (Arai et al. 2016) reported HH compliance increased from 10.0% to 18.2% three months after installing electronic HH counting devices in 28 clinical departments and giving physicians feedback.

— 3 studies reported accuracy for identifying HH: GOJO SMARTLINK (sensitivity 92.7%, positive predictive value 84.4%); MediHand Trace (sensitivity 95.65%, specificity 100%); nGage™ (accuracy 88.5% in simulated validation setting and 52.4% in real-life clinical setting).

Evidence

Search dates: January 1, 2013, through September 5, 2018. We reviewed full text of 8 studies.

— 1 single-center RCT with a crossover design (Rodriguez-Aldrete et al. 2016; n = 20 residents) compared electronic visual reminders plus direct observation with direct observation alone and reported on HH compliance upon entry into the operating room during two 10-hour periods.

— 1 single-center, prospective, nonrandomized comparison study (Vaidotas et al. 2015) compared electronic observer (GOJO SMARTLINK) and direct observation through video surveillance and reported on HH compliance at 2 hospital entrances over a 33-week period.

— 1 single-center accuracy study (Limper et al. 2017) of GOJO SMARTLINK compared direct observation to GOJO monitoring across 3 buildings and reported accuracy.

— 1 report (Michael et al. 2017) of 2 single-center, prospective pre-/postintervention studies assessed electronic badges that sensed volatile alcohol on HH compliance for 12 weeks in an organ transplant unit and for 8 weeks in a cardiothoracic surgery ICU.

— 1 single-center, retrospective pre-/postintervention study (Kelly et al. 2016) assessed the DebMed system in 23 inpatient units regarding HH compliance and MRSA infection rates over 33 months.

— 1 single-center, prospective pre-/postintervention study (Arai et al. 2016) assessed electronic HH counting devices plus feedback on HH compliance of 280 physicians in 28 clinical units over 3 months.

— 1 multicenter accuracy study of the nGage radiofrequency identification (RFID) system (Pineles et al. 2014) in a simulated validation setting and a real-life clinical setting.

— 1 single-center accuracy study (Boudjema et al. 2014) GojOof the MediHandTrace® RFID-based real-time automated continuous recording system.

Guidelines


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Background

This report focuses on automated and electronically assisted HHCMSs that track HH compliance in healthcare settings.

Healthcare-associated Infections

The U.S. Centers for Disease Control and Prevention (CDC) defines HAIs as “infections patients can get while receiving medical treatment in a healthcare facility.” Patients’ flora and the healthcare environment are the main sources of HAIs. Infection spread is believed to occur through healthcare workers’ contaminated hands and contaminated items or medical equipment. These infections can happen anywhere healthcare is delivered: hospitals, outpatient settings such as ambulatory surgical centers and dialysis facilities, and long-term care facilities such as nursing homes and rehabilitation centers. They may be caused by any infectious agent, although most are caused by bacteria and viruses. HAIs cause increased morbidity and mortality, extended hospital stays, and increased medical costs.

Hand Hygiene/Compliance

According to CDC, proper HH by healthcare workers is the most important practice for preventing HAIs. Healthcare workers have long known that clean hands reduce infection risk, and a variety of organizations have issued recommendations on how and when to perform HH. Long-standing clinical guidelines (e.g., from CDC, WHO, Occupational Safety and Health Administration, Centers for Medicare and Medicaid Services, Veterans Affairs) provide recommendations on routine HH with alcohol-based handrubs and handwashing with plain or antimicrobial soap and water in cases in which hands are visibly soiled. WHO has identified five important “moments” when healthcare workers should employ HH practices: 1) before touching a patient, 2) before a clean/aesthetic procedure, 3) after body fluid exposure risk, 4) after touching a patient, and 5) after touching patient surroundings. (See “Clean Care Is Safer Care.”)

However, despite the focus on HH as an important patient safety practice, compliance is often low, and studies report compliance rates among healthcare workers hovering at or below 50%. In 2016, ECRI Institute published the following recommendations for healthcare facilities to monitor and improve HH compliance (see “Hand Hygiene in the Healthcare Setting”):

- Establish a multidisciplinary hand hygiene team to ensure administrative support and promote hand hygiene compliance, including implementing multimodal strategies for behavior change.
- Assess the organization’s hand hygiene program to ensure it uses multimodal strategies to achieve and maintain high rates of hand hygiene compliance.
- Measure hand hygiene compliance to determine organization and department baselines.
- Determine the reasons for noncompliance, and develop remedial measures to address them.
- Provide ongoing training for HCWs [healthcare workers] on when and how to clean hands.
- Educate patients and their visitors on the need for hand hygiene by HCWs, as well as themselves.
- Provide evaluation and feedback to HCWs on hand-hygiene performance in multiple formats and on more than one occasion.

Direct observation of HH compliance by a validated observer is considered the gold standard in compliance monitoring. While this method can potentially detect all HH opportunities, it is time-consuming, relies on skilled observers, and is vulnerable to observation bias. This approach is also unable to identify individuals with consistently poor or outstanding HH compliance.

Hand Hygiene Compliance Monitoring Systems

The primary purpose of an HHCMS is to automatically monitor HH compliance rates—that is, the number of HH events (i.e., activation of or proximity to a hand soap or sanitizer dispenser) divided by the number of HH
opportunities (i.e., times when an individual should clean his/her hands, such as when entering a patient's room) or similar compliance metric.

Defining characteristics of HHCMSs include:

- A means of measuring HH events
- A means of collecting or estimating HH opportunities
- Availability of reports for viewing HH compliance information calculated from event and opportunity data

FDA does not classify HHCMSs. The technology is new and has undergone many changes in systems and manufacturers in recent years. Manufacturers continue to add advanced features that may help with the following: system customization to meet facility needs (e.g., configurable care areas, alert types, report type and report e-mail frequency); system and web portal ease of use; data analysis services; integration with a facility's existing hand soap and alcohol sanitizer products and/or dispensers; identification of patient isolation rooms for active or suspected infections; reducing or eliminating user-required maintenance; and battery management and recycling.

HHCMSs can be broadly categorized as group-level or individual-level. Group-level HHCMSs use monitored dispensers to count HH events and either care area sensors or proprietary algorithms to assess HH opportunities. Group-level HHCMSs provide aggregate HH compliance rates of staff, outside vendors, caregivers, visitors, and patients who used monitored dispensers within a care area during a certain time period (i.e., hour, day, week, month).

Individual-level HHCMSs have the capabilities of group-level HHCMSs, plus the ability to track the HH compliance of individuals wearing system tags (i.e., badges, badge holders, bracelets). Monitored dispensers or chemical sensors within the badges count HH events, and a network of sensors within a care area measures HH opportunities of tagged users. Some of these systems provide real-time alerting at the point of care regarding tagged users' HH compliance. A web portal allows certain users to view HH compliance rates for tagged individuals (e.g., staff, outside vendors, caregivers, visitors, patients) during a specified time period per individual, unit, or across entire facilities.

Individual-level HHCMSs can be further divided into two categories: systems that continuously track staff (and sometimes patient) location and systems that do not. Real-time locating systems (RTLSs) are a multipurpose technology that can be used to locate and track tagged users, equipment, patients, or other items of interest in near real time within an area defined by the system configuration. This location information is collected by hardware installed within the facility, aggregated, and presented to end users through a web portal. HH compliance is identified through applying rules to both clinician location and dispenser sensor information. For example, a nurse may be considered noncompliant if he/she enters a patient room and approaches the patient's bed without performing HH, but a nurse who enters a patient room and uses the hand soap or sanitizer dispenser on his/her way to the patient bed is considered compliant. HH compliance is just one application of an RTLS; most facilities considering an RTLS-based HHCMS will also consider using the RTLS for other purposes, such as equipment or nurse tracking. Adoption of this technology requires clinicians to consent to continuous monitoring of their movement and location within a trackable area, which may be controversial.

Non-RTLS HHCMSs, on the other hand, do not continuously track clinician movement; instead they determine HH compliance through user tags' interaction with sensors within, on, or near dispensers and with sensors near a care area, above a care area entrance, or within a care area (i.e., on beds, stretchers, chairs, or walls). For example, a nurse is considered noncompliant if he/she interacts with two patients without using a soap or alcohol sanitizer dispenser in between. One important differentiator from RTLS systems is that non-RTLS systems cannot locate a user tag that is outside the detection range of a dispenser or care area sensor, thus eliminating concerns about continuous monitoring of clinician movement and location.

Major components of a typical group-level HHCMS include:

- Either sensors above a care area entrance or within a care area to detect entry, movement within, and exit from a care area or an algorithm for estimating the number of HH opportunities
- Integrated or retrofitted radiofrequency (RF) or RFID sensors in manual and automatic dispensers to detect and report HH events
CLINICAL EVIDENCE ASSESSMENT
Hand Hygiene Compliance Monitoring Systems for Reducing Healthcare-associated Infections

- Web portal for users to access and analyze HH compliance rates for a care area, unit, group, ward, or possibly facility during a certain time period (e.g., day, week, month)

Major components of a typical individual-level HHCMS include:

- Badges, badge holders, or wristbands with an integrated active RF, RFID, infrared, or ultrasound tag that is worn by clinicians, outside vendors, caregivers, or patients
- Either RTLS hardware (e.g., readers, exciters) distributed within a care area operating with RF, RFID, ultrasound, Bluetooth, Wi-Fi, ZigBee, or ultra-wideband platforms that track user location and movement in patient care areas, in real time or sensors near a care area, above a care area entrance, or within a care area; these sensors detect when user badges enter and exit a care area
- RF, RFID, infrared, or ultrasound sensors within, on, or near manual and automatic hand soap or alcohol sanitizer dispensers to detect and report HH events
- A network (wired or wireless) composed of badge stations, hubs, modems, bridges, and/or gateways, or else an RTLS, either of which
  - Tracks the proximity of tagged users to, or their activation of, monitored soap or alcohol sanitizer dispensers when they are within the range of a care area sensor (i.e., to assess HH compliance) and
  - Transmits data to servers or cloud storage; networks and RTLSs may use facility Ethernet or proprietary systems that do not require facility networks.
- Web portal for users to access and analyze HH compliance rates for a specific individual, care area, unit, group, ward, or possibly facility during a certain time period (e.g., day, week, month)

Clinical applications of HHCMSs include:

- Monitoring HH compliance rates of clinical staff, outside vendors, caregivers, and patients in a care area, unit, department, ward, or possibly facility.
- Providing administrator users access to HH compliance rate data and advanced reporting features; data are shown in customizable reports for a specific individual, care area, unit, department, group, ward, or possibly facility per shift, week, month, or year.
- Automatically sending customized HH compliance rate reports to specified users via e-mail once a shift, day, week, or month.

All hospital departments could potentially implement these systems. Facilities should confirm with individual-level HHCMS vendors that they support facility-wide system implementation, if they consider that important.

For more information, see the Selected Web Resources section for links to manufacturers of various HHCMSs identified in our searches and the ECRI Health Devices Guidance on Hand Hygiene Compliance Monitoring Systems.

Clinical Guidelines

Searches of PubMed, EMBASE, and other web-based resources identified one relevant guideline published in 2009, titled WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge, Clean Care Is Safer Care. These guidelines include a table that compares the advantages and disadvantages of various monitoring approaches; direct observations by expert observers self-reported by healthcare workers, direct observations by patients, and consumption of hygiene products and automated monitoring systems. Specifically, automated monitoring systems “may potentially produce valuable detailed information about hand hygiene behavior and infectious risks plus the absence of an observer may reduce observation bias,” according to the guidelines.

Disadvantages include “potential ethical issues with tracking of individual behavior, the unknown impact on staff and patient behavior, and systems may be costly and failure-prone.”

Many advances in HH monitoring technology have occurred since publication of this 2009 guideline.
Clinical Literature

We searched PubMed, EMBASE, the Cochrane Library, and selected web-based resources for documents relevant to this topic and published between January 1, 2013, and September 5, 2018. We excluded studies that assessed bundled interventions to reduce HAIs, those that assessed HH monitoring system prototypes, and those that assessed systems without active websites. We identified eight relevant publications: one RCT(2), one nonrandomized comparison study(3), three pre-/postintervention studies(4-6), and three accuracy studies.(7-9) We review full text of articles available through open access or our library subscriptions and abstracts of the remaining articles. We reviewed full text of the eight studies (seven available through open access and one available by subscription).

- 1 single-center RCT with a crossover design (20 anesthesiology residents) compared an electronic visual reminder plus direct observation with direct observation alone and reported on HH compliance upon entry into the operating room during two 10-hour periods.(2)
- 1 single-center, prospective, nonrandomized comparison study compared electronic observer (GOJO SMARTLINK) and direct observation through video surveillance and reported on HH compliance at 2 hospital entrances over a 33-week period.(3)
- 1 report of 2 single-center, prospective pre-/postintervention studies assessed the impact of using electronic badges that sensed volatile alcohol on HH compliance during 12 weeks in an organ transplant unit and during 8 weeks in an cardiothoracic surgery ICU.(4)
- 1 single-center, retrospective pre-/postintervention study assessed the impact of implementing the DebMed (DebMed, Charlotte, NC, USA) system in 23 inpatient units on HH compliance and MRSA infection rates over a 33-month period.(5)
- 1 single-center, prospective pre-/postintervention study (Arai et al. 2016) (280 physicians) assessed the impact of electronic HH counting devices plus feedback on HH compliance in 28 clinical departments over a 3-month period.(6)
- 1 single-center accuracy study compared the GOJO SMARTLINK electronic monitoring system with direct observation in 3 hospital buildings.(7)
- 1 multicenter accuracy study compared the nGage RFID system in a simulated validation setting and a real-life clinical setting with direct observation in two hospitals.(8)
- 1 single-center accuracy study compared the MediHandTrace RFID-based real-time automated continuous recording system (MediHandTrace SAS, La Garde, France) with video recording.(9)

Table 1 provides summaries of the clinical studies we reviewed.

We also identified two articles regarding the challenges of implementing automatic/electronic HH monitoring systems.(10,11)

Evidence Limitations

Evidence regarding automated and electronically assisted HH monitoring systems is limited. The only RCT was small and excluded data from the second group that crossed over due to a substantial carryover effect. Seven of the eight studies were single-center assessments of different HH monitoring methods, and findings may not be generalizable. Authors of the one pre-/postintervention study that reported a lower MRSA infection rate after implementing the DebMed System also reported an inability to control for other institutional initiatives that may have affected this rate.

Studies that compare HH monitoring systems with direct observation may be at risk of bias due to the Hawthorne effect; the caregivers' desire to please observers may inaccurately inflate HH compliance rates.

We did not identify any studies that compared different commercially available systems or studies that addressed the costs associated with implementing these systems.

Additional studies (preferably multicenter RCTs) are needed to further assess the possible advantages and disadvantages of using these systems and to compare different commercially available systems and costs.
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<tr>
<th>Reference Site</th>
<th>Number of Participants</th>
<th>Setting</th>
<th>Intervention</th>
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<th>Conclusions</th>
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<tr>
<td>Rodriguez-Aldrete et al. 2016(2)</td>
<td>20 anesthesia residents (10 in each group). Crossover within 1 to 5 days Entry into operating room</td>
<td>Jackson Memorial Hospital (Miami, FL, USA)</td>
<td>Electronic visual reminder stating: “Please sanitize your hands,” plus direct observation vs. Direct observation</td>
<td>“The group that started in the control arm had a total of 2 hand hygiene events during 10 hours of observation and 21 hand hygiene events during the intervention (0.2±0.1 vs 2.1±0.6 [mean±standard error], respectively; P=.05). The group that started with the intervention first had a total of 21 hand hygiene events during 10 hours of intervention and 23 hand hygiene events as the subsequent control group. Given the substantial carryover effect, the second group was not included in the final analysis; thus, the advantage of a crossover trial was lost.”</td>
<td>“We implemented an electronic reminder that was successful at increasing the hand hygiene rate. Interestingly, when used initially, the reminders produced a behavioral effect in the subsequent observation. Future trials could use a longer washout period to account for the carryover effect.”</td>
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<tr>
<td>Randomized Controlled Trial</td>
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<td>Vaitotas et al. 2015(3)</td>
<td>2 hospital entrances of a tertiary care private hospital</td>
<td>Hospital Israelita Albert Einstein (Sao Paulo, Brazil)</td>
<td>Electronic handwash counters with the application of radiofrequency identification (RFID) (GOJO SMARTLINK) (electronic observer) vs. Direct observation (DO) (human observer) through 24-hour surveillance 33-week study</td>
<td>“We found low hand hygiene compliance rates of 2.2% (99/4,412) and 1.7% (140/8,277), respectively, at reception areas A and D, detected by direct observation. Using the electronic observer, we measured rates of 17% (15,624/91,724) and 7.1% (51,605/730,357) at reception areas A and D, respectively. For the overall time period of simultaneous electronic and human observation, the human observer captured 1% of the hand hygiene episodes detected by the electronic observer.”</td>
<td>“Our study showed very low hand hygiene compliance in hospital reception areas, and we found an electronic hand hygiene system to be a useful method to monitor hand hygiene compliance.”</td>
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<tr>
<td>Nonrandomized Comparison Studies</td>
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**Table 1. Clinical Trials**

Hand Hygiene Compliance Monitoring Systems for Reducing Healthcare-associated Infections

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<tr>
<td>Michael et al. 2017(4) Reviewed full text Cleveland Clinic, (Cleveland, OH, USA)</td>
<td>Study 1: conducted for 12 weeks between January 28 and April 23, 2014, on a nursing unit for solid organ transplant patients with 34 beds. Study 2: conducted for 8 weeks between February 2 and March 30, 2015, on a cardiothoracic surgery intensive care unit with 14 beds.</td>
<td>DO before intervention vs. Automatic observation (AO) using electronic badges with a mechanism for sensing volatile alcohol (BioVigil LLC, Santa Rosa, CA, USA)</td>
<td>“On unit 1, baseline and hygiene (HH) compliance was 54% based on 88 DOs made over 12 months. During the 12-week pilot, 75 healthcare workers (HCWs) participated and HH compliance averaged 98% based on 140,000 AOs. Compliance based on DO during pilot 1 was 93% based on 27 observations. Postpilot compliance by DO was 100% (44 DOs) at 6 months and 87% (150 DOs) at 1 year. On unit 2, prepilot HH compliance was 52% of 104 DOs in 12 months. During the 8-week pilot study 45 HCWs participated, and compliance by AO was 97% based on 27,566 measurements. Compliance by DO during the pilot study 2 was 99% based on 68 observations. Postpilot compliance based on DO was 92% (185 DOs), and 86% (290 DOs) at 6 and 12 months, respectively.”</td>
<td>“As an infection prevention strategy, the AO system resulted in substantial increase in HH compliance compared with baseline during both pilot studies. …. Future studies should address the optimal design and cost-effectiveness of an infection prevention strategy that uses an AO system, keeping in mind implications about behavior change and learning.”</td>
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<td>Kelly et al. 2016(5)</td>
<td>23 inpatient units over a 33-month period</td>
<td>Implementation of DebMed System</td>
<td>&quot;A statistically significant negative correlation was found between unit-specific change in HH compliance and the corresponding MRSA [methicillin-resistant Staphylococcus aureus] rate ($r = -0.373$, $P &lt; .001$). Increased HH compliance resulted in lower rates of MRSA infection. Of the 225 unit quarters analyzed, 111 (49.3%) showed improvement in HH compliance; the median difference was -0.11 (interquartile range, -7.5 to 7.4). Overall, 21 of the 23 units (91.3%) showed improvement from the baseline quarter to the most recent quarter; the median absolute improvement was 9.7% (interquartile range, 7.6-20.2).&quot;</td>
<td>&quot;Our study showed that improved hand hygiene compliance (HH compliance) after the introduction of an electronic monitoring system was associated with decreased rates of healthcare-associated MRSA infections. Across the entire hospital, periods of improved HH compliance led to lower infection rates. We believe the monitoring system aided nursing leadership's ability to drive change and improve staff performance, by providing real-time reliable HH compliance data. Continuing feedback allowed for ongoing conversation with frontline nursing staff, and unit-level data allowed for unit-level solutions because staff engagement with the data led to strategic decisions, which resulted in consistent, sustained improvement in [HH] performance.&quot;</td>
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<td>Arai et al. 2016(6)</td>
<td>280 physicians 28 clinical units</td>
<td>Electronic HH counting devices and feedback for 3 months</td>
<td>&quot;The overall [HH] adherence rate was 10.7% at baseline, which improved significantly after feedback to 18.2% in the third month. Of the clinical departments, 78.6% demonstrated significant improvement in hand hygiene compliance. The change in the percentage of physicians in each category before and after feedback were as follows: very low (84.3% to 72.1%), low (8.6% to 14.3%), moderate (2.9% to 8.9%), and high (4.3% to 4.6%), from the first to third month, respectively. Based on category assessment, 17.1% of physicians were classified as responders.&quot;</td>
<td>&quot;Physicians' adherence to [HH] practices during outpatient examinations was successfully monitored remotely using electronic counting devices. Audit and feedback of adherence data may have a positive impact on physicians' [HH] compliance.&quot;</td>
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### Clinical Validity/Accuracy Studies

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<tr>
<td>Limper et al. 2017(7) Reviewed full text University of Chicago Medicine (IL, USA)</td>
<td>3 hospital buildings</td>
<td>GOJO SMARTLINK electronic monitoring system comprised 5 main components: activity counters, dispenser actuation counters, data receivers, a secure server, and a digital monitor. Trained observers used DO to document room activity and compared this data to raw data collected by the electronic monitoring system.</td>
<td>“During the planned path phase, investigators performed 4,872 unique events across 3 distinct hospital buildings varying in size and age since construction. Overall sensitivity across the medical center was 88.7% with a PPV [positive predictive value] of 99.2%. During the behavioral validation phase, trained direct observers recorded 5,539 unique events across 3 distinct hospital buildings. Overall sensitivity across the medical center was 92.7% and PPV was 84.4%.”</td>
<td>“Objective measures of sensitivity and PPV indicate the promise of the benefit of this and other hand hygiene monitoring technologies to capture basic behaviors associated with [HH].”</td>
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<tr>
<td>Pineles et al. 2014(8) Reviewed full text (available only be subscription) 2 U.S. hospitals</td>
<td>31 healthcare workers 2 hospitals</td>
<td>DO vs. Data collected by the nGage RFID system in a simulated validation setting and to a real-life clinical setting</td>
<td>“A total of 1,554 and hygiene (HH) events were observed. Accuracy for identifying HH events was high in the simulated validation setting (88.5%) but relatively low in the real-life clinical setting (52.4%). This difference was significant (P &lt; .01). Accuracy for detecting health care personnel movement into and out of patient rooms was also high in the simulated setting but not in the real-life clinical setting (100% on entry and exit in simulated setting vs. 54.3% entry and 49.5% exit in real-life clinical setting, P &lt; .01).”</td>
<td>“We found the system was very accurate in an idealized setting but correctly attributed one half of HCP [healthcare practitioners] [HH] events during routine clinical activities. Validation of automated systems for hand hygiene compliance must be tested in actual clinical practice. Otherwise, estimates of accuracy will overestimate accuracy in real world clinical settings. Infection preventionists and hospital epidemiologists must understand the limitations of using technology as a monitoring tool. Continued study is necessary to determine if such systems can be used to monitor hand hygiene compliance and whether they can improve overall HH compliance.”</td>
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<td>Boudjema et al. 2014(9) Reviewed full text Aix Marseille University (Marseille, France)</td>
<td>17-bed infectious disease ward</td>
<td>RFID-based real-time automated continuous recording system (MediHandTrace) vs. Video recording</td>
<td>“We report here a [RFID]-based real-time automated continuous recording system (MediHandTrace) that permits the tracking of hand hygiene opportunities and the disinfection compliance of HCWs [healthcare workers] that we evaluated against videorecordings as being accurate (99.02%), sensitive (95.65%) and specific (100%).”</td>
<td>“MediHandTrace is capable of studying compliance over time (day/ week/night); it can calculate sanitizer consumption (by room or by HCW), the HCW compliance by patient (type/ disease), the HCW compliance and workflow (number of HCWs in the room, mean duration of stay in the room) and many other variables, revealing factors that may influence compliance.... MediHandTrace is a tool that is able to replace direct observational monitoring.”</td>
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### Selected References and Resources

**References Reviewed (PubMed and EMBASE search dates were January 1, 2013, through September 5, 2018)**


**Search Summaries**

The following databases were used to identify the literature and related materials.

**ECRI Institute Resources [searched January 1, 2013, through September 5, 2018]**

Search Strategy:

hand AND (cleans* OR disinfect* OR hygiene OR sanitat* OR sanitize* OR wash*) AND (monitor* OR radio* OR track* OR rfid)

Results: We identified four related reports.

- **Hand Hygiene**. [Clinical Risk Management Services]. 2012 Dec 1.
- **Hand Hygiene in the Healthcare Setting**. 2016 Mar 15. [Healthcare Risk Control].

Search Strategy:

- S3  aeroscout OR airista OR biovigil OR centrak OR debmed OR gojo OR "hand-in-scan" OR handgiene OR hygreen OR intelligentM OR medsense OR ngage OR "patient safeguard system" OR proventix OR sprixx OR stanley OR "stery-hand" OR surewash OR swipesense OR ultracenz OR (versus AND hand AND hygiene)
- S4  (S1 AND S2) OR S3

Results: We identified 54 records.


Search Strategy:

- S1 'hand washing'/mj OR (hand:ti OR hands:ti AND (hygiene:ti OR disinfect*:ti OR clean*:ti OR cleansing:ti OR wash:ti OR washing:ti OR sanitiz*:ti OR sanitat*:ti))
- S2  automat*:ti OR electrom*:ti OR feedback:ti OR radio*:ti OR radiofrequency/mj OR radiofrequency:ab,ti OR 'radio-frequency':ab,ti OR rfid/mj OR realtime:ti OR 'real time':ti OR rfid:ti OR 'smart phone':ti OR smartphone:ti OR wifi:ti OR "wi-fi":ti OR wireless:ti OR system*:ti
- S3  aeroscout OR airista OR biovigil OR centrak OR debmed OR gojo OR 'hand-in-scan' OR handgiene OR hygreen OR intelligentM OR medsense OR ngage OR 'patient safeguard system' OR proventix OR sprixx OR stanley OR 'stery-hand' OR surewash OR swipesense OR ultracenz OR (versus AND hand AND hygiene)
- S4  (S1 AND S2) OR S3

Results: We identified 17 records.


Search Strategy:

- S1  (hand OR hands) AND (hygiene OR disinfect* OR clean* OR cleansing OR wash OR washing OR sanitiz* OR sanitat*)
- S2  automat* OR electrom* OR feedback OR radio* OR radiofrequency OR radio-frequency OR "real time" OR realtime OR RFID OR wifi OR "wi-fi" OR "smart phone" OR smartphone OR system* OR wireless
- S3  aeroscout OR airista OR biovigil OR centrak OR debmed OR gojo OR "hand-in-scan" OR handgiene OR hygreen OR intelligentM OR medsense OR ngage OR "patient safeguard system" OR proventix OR sprixx OR stanley OR "stery-hand" OR surewash OR swipesense OR ultracenz OR (versus AND hand AND hygiene)
- S4  (S1 AND S2) OR S3

Results: We did not identify any relevant publications.

Guidelines and Standards [searched January 1, 2009, through September 5, 2018]

Search Strategy:

(hand OR hands) AND (hygiene OR disinfect* OR clean* OR cleansing OR wash OR washing OR sanitiz* OR sanitat*) AND (automat* OR radiofrequency OR radio-frequency OR RFID OR wifi OR "wi-fi" OR monitor* OR...
surveillance OR device* OR system OR systems); (hand OR hands) AND (hygiene OR disinfect* OR cleanse* OR cleansing OR wash OR washing OR sanitiz* OR sanitat*) AND (guideline* OR guidance)

Results: We identified one relevant guideline

Selected Standards and Guidelines

Selected Web Resources. [searched September 5, 2018]

Manufacturers
- Airista. Hand hygiene compliance monitoring solution. [cited 2018 Sep 5].
- Biovigil Hygiene Technologies, LLC. Hand hygiene solutions. [cited 2018 Sep 5].
- Budapest University of Technology and Economics. Semmelweis System. [cited 2018 Sep 5].
- CenTrak, Inc. Hand Hygiene Compliance. [cited 2018 Sep 5].
- Clean Hands Safe Hands. Reduce Infections by Improving Hand Hygiene. [cited 2018 Sep 5].
- Deb Group, LLC. DebMed Electronic Hand Hygiene Compliance System. [cited 2018 Sep 5].
- Ecolab. Hand Hygiene Program Compliance Monitoring System. [cited 2018 Sep 5].
- General Sensing. MedSense. [cited 2018 Sep 5].
- GE Healthcare. AgileTrac Hand Hygiene Monitoring. [cited 2018 Sep 5].
- GLANTA. SureWash. [cited 2018 Sep 5].
- GOJO Industries. GOJO Smartlink. [cited 2018 Sep 5].
- HyGreen, Inc. Hand Hygiene Recording and Reminding System. [cited 2015 Sep 5].
- MediHandtrace. MHT Kit. [cited 2015 Sep 5].
- Midmark Corp. (formerly Versus). RTLS Safety Solutions. [cited 2015 Sep 5].
- Proventix Systems, Inc. nGage. [cited 2015 Sep 5].
- Swipesense. Swipesense. [cited 2015 Sep 5].
- Tyco International. Elpas Hand Hygiene. [cited 2015 Sep 5].

Other selected web resources
- Centers for Disease Control and Prevention. Hand hygiene in healthcare settings. [updated 2018 May 3]
The Evidence Bar™

ECRI developed The Evidence Bar™ to provide a visualization of our judgment about the balance of benefits and harms of the technology after assessing the available published clinical evidence in light of key outcomes and comparisons of interest. The Evidence Bar™ rubric shows five possible choices for our expert judgment. After review and analysis of evidence identified through literature searches conducted by master's level medical librarians, ECRI research analysts, extensively trained in methods of evidence assessment, weigh potential benefits and harms of a technology to arrive at their expert judgment.

| Balance of evidence unfavorable | - | - | - | - | + |
| Balance of evidence raises concerns | - | - | - | - | + |
| Balance of evidence inconclusive because of no available evidence, mixed results, or too few data | - | - | - | - | + |
| Balance of evidence somewhat favorable | - | - | - | - | + |
| Balance of evidence very favorable | - | - | - | - | + |

Policy Statement

The information presented in this Clinical Evidence Assessment is highly perishable and reflects the state of the literature on this topic at the time at which searches were conducted and the Clinical Evidence Assessment was prepared. Clinical Evidence Assessments provide a guide to the published clinical literature and other information about a topic on which we received a client inquiry. The scope is customized to address the specific information needs of the requestor. The content reflects the information identified from searches of the available, published, peer-reviewed scientific literature, gray literature, and websites at the time the searches were conducted. Publications referenced in this Clinical Evidence Assessment are generally limited to the English language. Clinical Evidence Assessments are developed by a multidisciplinary staff of doctoral level research analysts, clinicians, and medical librarian information specialists. For quality assurance, all reports are subject to review within ECRI before publication. Neither ECRI nor its employees accept gifts, grants, or contributions from, or consult for medical device or pharmaceutical manufacturers. The Clinical Evidence Assessment may be based on review of abstracts of published articles as well as full text articles. Abstracts do not always accurately reflect the methods and findings of full-length articles and limit full interpretation of published data. This Clinical Evidence Assessment is not intended to provide specific guidance for the care of individual patients. ECRI implies no warranty and assumes no liability for the information contained in the Clinical Evidence Assessment.

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