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# New technologies to monitor healthcare worker hand hygiene

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## Abstract

Compliance with hand hygiene is a good quality indicator for hospital patient safety programmes. Hand hygiene is a major infection control prevention intervention, but in many medical centres compliance rates are only *c.* 50%. Given the enormous number of hand hygiene opportunities in hospitals, direct observation to monitor compliance is very inefficient. However, technologies are emerging to obviate the need for direct observation. These new technologies for monitoring hand hygiene compliance are discussed in this article.

**Keywords:** Compliance, electronic devices, electronic handwash counters, feedback loop, hand hygiene, innovation, positive deviance, wireless technology, Zigbee

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## Introduction

One hundred and sixty-five years after the publication of Ignaz Semmelwiess' study demonstrating the impact of hand hygiene (HH) in the inpatient setting, hospitals continue to struggle with suboptimal rates of compliance with this basic infection prevention activity, despite widespread agreement that HH is the most important intervention for the prevention of infection [1,2]. The most common reasons given by healthcare workers (HCWs) for non-compliance include insufficient time, work overload, lack of knowledge, scepticism about HH as a prevention method, inconvenient locations of sinks and soap dispensers, and lack of incentives for HH compliance [3]. Studies have confirmed that HH compliance can be affected by the accessibility of products [4] and by the formulations of these products (liquids, gels, and foams) [1,5]. If hands are not visibly soiled, the WHO recommends the use of an alcohol-based hand rub for routine decontamination of hands in all clinical situations [1]. We also know that alcohol-based HH requires less time than washing with soap (plain or medicated) and water, but is as effective for most pathogens [1,5].

## Implementation Science

Implementation science entails the development of strategies and tools that promote the adoption of effective interventions to improve the quality of healthcare. There is often a considerable gap between experimental results for an intervention and its transformation into practice, and implementation science aims to fill this gap [6]. The WHO 'My Five Moments for Hand Hygiene' is a very nice example of implementation science. Although the Five Moments can add value to any HH improvement programme [5,7], in many medical centres where alcohol gel has been made available, HH compliance rates continue to be only approximately 50% [3,8].

## Measuring Compliance

*Observers.* Complicating the problem of suboptimal compliance with HH is our difficulty in measuring compliance. Direct observation is considered to be the reference standard method for evaluating HH compliance [3]. However, it is

generally able to capture only a very small fraction of HH opportunities [9]. There are also issues with validity, including inter-rater reliability, the Hawthorne effect, and concerns regarding patient privacy [10]. Observers can be workers who are primarily assigned to this function, personnel embedded in their own units, or workers from other units who make surreptitious observations (i.e. secret shoppers). Technology can be used to assist direct observation. For example, hand-held personal digital assistants (iPod, Apple) using a free application (iScrub) have been successfully used to record observations and analyse compliance [11,12].

*Electronic counters.* Another option for HH compliance measurement is the use of electronic handwash counters on dispensers of alcohol-based hand rub [9,13]. Generally, studies using observers have employed relatively short observation periods [3,9]; however, electronic counters record continuously for 24 h per day. There is ongoing discussion about the usefulness of electronic HH counters in HH compliance measurement [14]. They can be very useful in counting dispenser activities, but lack utility for determining the appropriateness of HH episodes by the user, and they cannot determine the quality of HH episodes. These are disadvantages as compared with direct observation. It is questionable whether this electronic HH counter can be used as a baseline assessment for HH compliance, given the potential for under-reporting or over-reporting [10]. However, these devices can deliver rapid results without requiring the expenditure of many hours to obtain a small sample of observations. These results can be assessed at short intervals to further encourage the practice of HH among HCWs.

Another interesting study [15] assessed HH compliance through a quasi-experimental design with a duration of 30 weeks, using automated count technology and direct observation by a secret shopper with a feedback intervention. Electronic HH dispenser counts increased significantly in the post-intervention period relative to the pre-intervention period, with the average count per patient-day being increased by 22.7 in the neurological intensive-care unit (ICU) and by 7.3 in the cardiac care ICU (both $p < 0.001$). However, direct observation of HH compliance did not change significantly (percentage compliance increased by 2.9% in the neurological ICU and decreased by 6.7% in the cardiac care ICU (p 0.47 and p 0.07, respectively)). The investigators concluded that passive electronic monitoring of HH dispenser counts does not correlate with direct human observation, and is more responsive than observation to a feedback intervention [15].

*Product utilization measurement.* Handwash product utilization has been used as a proxy for direct observation for determining HH compliance [9]. Typically, the total volume of product used (alcohol gel or chlorhexidine) is expressed in litres per 1000 patient-days. Although data collection is relatively simple, and trends may be useful over time, this method provides less detail about HH compliance than direct observation. Although measuring product use is less resource-intensive and less expensive than direct observation, it can be inaccurate and produce misleading results [14,16].

One reason for not finding a strict correlation between three HH compliance measurement methods (direct observation, electronic handwash counters, and product volume measurement) was that patients and their families inside the rooms also use alcohol gel for HH [17]. As the patient is taught about the importance of using alcohol gel for HH to prevent infections, but not taught about the quality of hand disinfection, or the way to use the electronic handwash device, it is possible that patients and family members, and even HCWs, pushed the dispenser multiple times in a short time period (although the product will be dispensed on demand, only one episode of HH is recorded for every 2-s time period), or pushed the dispenser once suboptimally, resulting in a small dispensed volume [13,17].

## New Electronic Systems for Monitoring HH

More recently, electronic HH systems have emerged to not only record compliance but also promote it. These systems are designed to ensure that HCWs perform HH before approaching the patient's bedside, and issue an alert to do so. They can use sensors that detect alcohol vapours [18], or radiofrequency identification to determine whether HH has occurred [13]. In one study, each nurse wore a credit card-sized badge containing a solid-state metal oxide semiconductor that detects alcohol vapours [18]. The alcohol sensor in the badge is activated at the doorway to the patient room by a sensor on the doorframe. Following the performance of HH with an alcohol-based product, the HCW places their hand near the badge sensor. If alcohol is detected within 8 s of room entry or exit, the badge light turns green, and it emits a 'ping' sound. If alcohol is not detected, the badge light turns red, and the badge beeps. The HH compliance data for each badge are instantaneously transmitted via wireless telemetry to a centralized database, where individual compliance data can be monitored. In this trial of alcohol vapour sensor badges, HH compliance for all HCWs before the intervention was 66%. During the intervention, HH compliance was driven to a median compliance of 92%, which is a likely underestimate of the potential impact of the device, given that no feedback was given to HCWs on their individual compli-