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State of the Science Review

Current issues in hand hygiene

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Although substantial improvements in hand hygiene practices have occurred in recent years, many health care facilities continue to encounter challenges in achieving and maintaining high levels of hand hygiene compliance. Issues of current interest include the optimum dose of alcohol-based handrub (ABHR) that should be applied, the impact of hand size and alcohol-based handrub dry times have on efficacy, and ideal hand hygiene technique. There is a need to determine which additional promotional activities can augment improvements in hand hygiene that are achieved by implementing the multimodal improvement strategy recommended by the World Health Organization. Monitoring hand hygiene performance and providing personnel with feedback on their performance are essential elements of successful improvement programs. Further research is needed to establish the most effective methods of providing feedback. Additional studies are needed to optimize strategies for performing direct observation of hand hygiene compliance, and to determine the role of supplementing direct observations using automated monitoring systems.

Achieving and maintaining optimal hand hygiene practices continue to be a challenge in most health care facilities. Issues that facilities continue to face include questions regarding hand hygiene technique, the most effective strategies for promoting improved hand hygiene, and challenges associated with monitoring hand hygiene compliance. The purpose of this review is to briefly discuss these issues.

HAND HYGIENE DURATION, PRODUCT VOLUME, HAND SIZE, DRY TIMES, AND TECHNIQUE

In recent years, questions have been raised regarding the appropriate duration (number of seconds) that hand hygiene should be performed, and the volume of alcohol-based handrub (ABHR) that should be applied to the hands of health care personnel (HCP). The 2002 Guideline for Hand Hygiene in Healthcare Settings from the Centers for Diseases Control and Prevention (CDC) did not make a recommendation on how long hands need to be rubbed together when using an ABHR, but the text states that if hands feel dry after rubbing together for 10-15 seconds, an insufficient volume of product has likely been applied.[1] The 2009 World Health Organization (WHO) Guideline For Hand Hygiene in Healthcare recommended that hands be rubbed together for 20-30 seconds when using an ABHR, or 40-60 seconds when washing with soap and water.[2] Some studies have found that the WHO 6-step technique for ABHR disinfection may require 39-45 seconds.[3] One ward-based survey of ABHR antisepsis found that the median time to rub hands together until they felt dry (dry time) was only 4-10 seconds.[4] Several other studies have reported mean handrub durations of <15 seconds.[5-7] One recent study found that rubbing hands together for 15 seconds was nearly as effective as 30 seconds.[8]

In 2 small studies in which HCP were given the opportunity to select the volume of ABHR to apply to their hands during routine nursing activities, the mean volume of product applied ranged from 0.73-1.09 mL per application.[9,10] A Scottish observational study that used a different method for estimating the mean volume of ABHR applied per hand hygiene event reported that the mean volume was 1 mL, rather than the 3 mL that were recommended.[11] The earlier mentioned findings suggest that HCP apply small volumes of ABHR to their hands to achieve short dry times that allow them to return quickly to their duties.

Factors that may affect dry times include the volume of ABHR applied, product formulation, and perhaps HCP hand size. Studies have found that the greater the amount of ABHR applied, the longer the dry time.[12-14] Although some experts in Europe have recommended that HCP apply 3 mL of ABHR to their hands, the volume of ABHR delivered by some dispensers in the United States and Europe may be only 0.6-1.75 mL.[15,16] Products with a higher concentration of alcohol yield faster dry times than lower concentrations, and other ingredients included in product formulation may also affect

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Table 1
Relationship between volume of ABHR applied and mean $\log_{10}$ reductions achieved

Volume of ABHR applied	Mean Log_{10} reduction
1 mL	1.99
2 mL	2.96
3 mL	3.28

Modified from Suchomel et al[20]
ABHR, alcohol-based handrub.

Table 2
World Health Organization multimodal hand hygiene improvement strategy

1A. System change: alcohol-based handrub
1B. System change: access to safe continuous water supply and towels
2. Training and education
3. Observation and feedback
4. Reminders in the workplace
5. Institutional safety culture

dry times.[13] As a result, applying the same amount of 2 different products may yield significantly different dry times.[12,13] One study found that if at least 1 mL of ABHR is applied, volunteers had to rub their hands together for 17-26 seconds before they felt dry.[15]

Several studies have reported that the microbiological efficacy of ABHRs may be affected by the size of HCPs' hands.[17,18] Surprisingly, 1 study reported that even 3 mL of ABHR is not enough to cover all surfaces of medium- or large-sized hands.[19] These studies suggested that the volume of ABHR applied should be based on the size of HCPs' hands.[18] However, HCP with large hands often do not apply a larger amount of ABHR to their hands than those with small or medium-sized hands.[10,19] It has been suggested that applying 1.5-2.0 mL should be sufficient to provide adequate coverage of the hands, and that a volume of 2 mL may be acceptable to most HCP.[12,14] To evaluate the issues of handrub duration (dry time), volume of ABHR/application, and hand size, a laboratory study that used a modified EN 1500 methodology asked volunteers to apply 1 mL, 2 mL, and 3 mL of 60% n-propanol (EN reference standard) and rub their hands until they felt dry.[20] Investigators found that mean $\log_{10}$ reductions and dry times were clearly associated with the volume of alcohol applied (Table 1). Importantly, the investigators found a statistically significant correlation between dry time and the $\log_{10}$ reduction achieved that was independent of application volume.[20] They also found a significant correlation between hand size and dry times. However, there was no correlation between hand size and microbiological efficacy, a finding reported earlier by Goroncy-Bermes et al.[17] The study suggested that product dry time appears to be the major driver of ABHR efficacy, and that ABHR doses should be customized to individual HCP to achieve dry times that yield appropriate efficacy.[20,21]

The optimum technique for how to rub hands together when applying an ABHR is also a matter of some controversy. The 2002 CDC guideline recommends applying ABHR to the palm of 1 hand, then rubbing hands together to cover all surfaces of the hands and fingers, until hands are dry.[1] The WHO guideline recommends that HCP apply a palmful of ABHR and rub hands together to cover all surfaces of the hands. Rubbing should continue until hands are dry, which the guideline states should take 20-30 seconds.[2] The guideline recommends using a 6-step procedure, which is described in detail in the guideline. However, HCP often do not complete all 6 steps of this somewhat complicated technique.[22-24] Two randomized controlled trials compared the 6-step WHO method with the more simplified CDC approach.[3,25] One study found no significant difference in the effectiveness of the 2 methods,[25] whereas the other reported that the WHO method was more effective.[3] Two prospective studies used a video camera-based device with immediate feedback to provide "HCP with a self-directed check on compliance with the 6-step technique."[23,24] Both studies found that HCP missed 1 or more of the 6 steps despite individuals in 1 study having a favorable opinion of the device. Of note, Kampf et al[26] found that instructing HCP to cover both hands completely (so-called "responsible application"), without providing any specific steps, was as effective as the 6-step method. Tschudin-Sutter et al[27] proposed a modified method that includes only 3 steps: 1) cover all surfaces of the hands with ABHR, 2) rotational rubbing of fingertips in the palm of the alternate hand, and 3) rotational rubbing of both thumbs. The investigators found that the 3-step method was more effective microbiologically than the 6-step WHO method. Additional research is needed to identify the optimal technique for applying ABHR.[28]

MULTIMODAL STRATEGIES FOR IMPROVING HAND HYGIENE

A number of strategies for improving hand hygiene compliance have been outlined in hand hygiene guidelines and more recent studies of hand hygiene promotion. The WHO multimodal strategy for improving hand hygiene, which includes 5 major elements ("WHO-5"), is available for download from WHO (https://apps.who.int/iris/bitstream/handle/10665/70030/WHO_IER_PSP_2009.02_eng.pdf?sequence=1) (Table 2). The system change element of the strategy recommends making ABHR available at the point of care. Evidence favors locating dispensers both in patient rooms and in corridors.[29,30] In areas of a facility where there are a few locations for placing wall-mounted dispensers, consideration should be given to making pump bottles available or providing HCP with pocket-sized bottles.[31,32]

Training HCP regarding the indications for hand hygiene and how to perform hand hygiene is an essential part of hand hygiene promotion programs. The WHO guideline outlines the "My 5 Moments for Hand Hygiene" that are designed to facilitate educating HCP about when they should perform hand hygiene, and to provide a framework for monitoring hand hygiene compliance (Fig 1).[2] A sign depicting "My 5 Moments for Hand Hygiene" can be downloaded for free at the WHO website (https://www.who.int/gpsc/5may/Your_5_Moments_For_Hand_Hygiene_Poster.pdf). Periodic re-education of personnel is important and has been addressed in some hospitals by making annual online learning sessions mandatory for hospital personnel.

Observation of HCP hand hygiene practices and providing them with feedback regarding their performance are essential parts of hand hygiene promotion programs. However, the ideal methods for providing feedback are not clear. Although providing personnel with monthly or quarterly feedback regarding hand hygiene is relatively common, more research is needed to identify the most effective frequency for providing feedback. Having dedicated individuals or peers on nursing units provide HCP with feedback immediately after observing their behavior, so-called "just in time coaching" is considered to be an effective strategy.[33,34] There is some controversy regarding who should serve as "just in time coaches"; auditors performing hand hygiene observations, or other designated individuals. There is a concern that having auditors provide immediate feedback may increase the likelihood that a Hawthorne effect will affect compliance rates. Other approaches to feedback include sending weekly e-mails to nurse or department managers, sending text messages to front-line HCP, or real-time computer displays located on nursing units, or novel feedback posters.[35-38]

Examples of reminders in the workplace include the use of screensaver messages on nursing unit computer displays, placing signs promoting hand hygiene throughout the facility, providing patients and family members with brochures, and promotional messages on items such as coffee cups or pens. Additional research is needed regarding

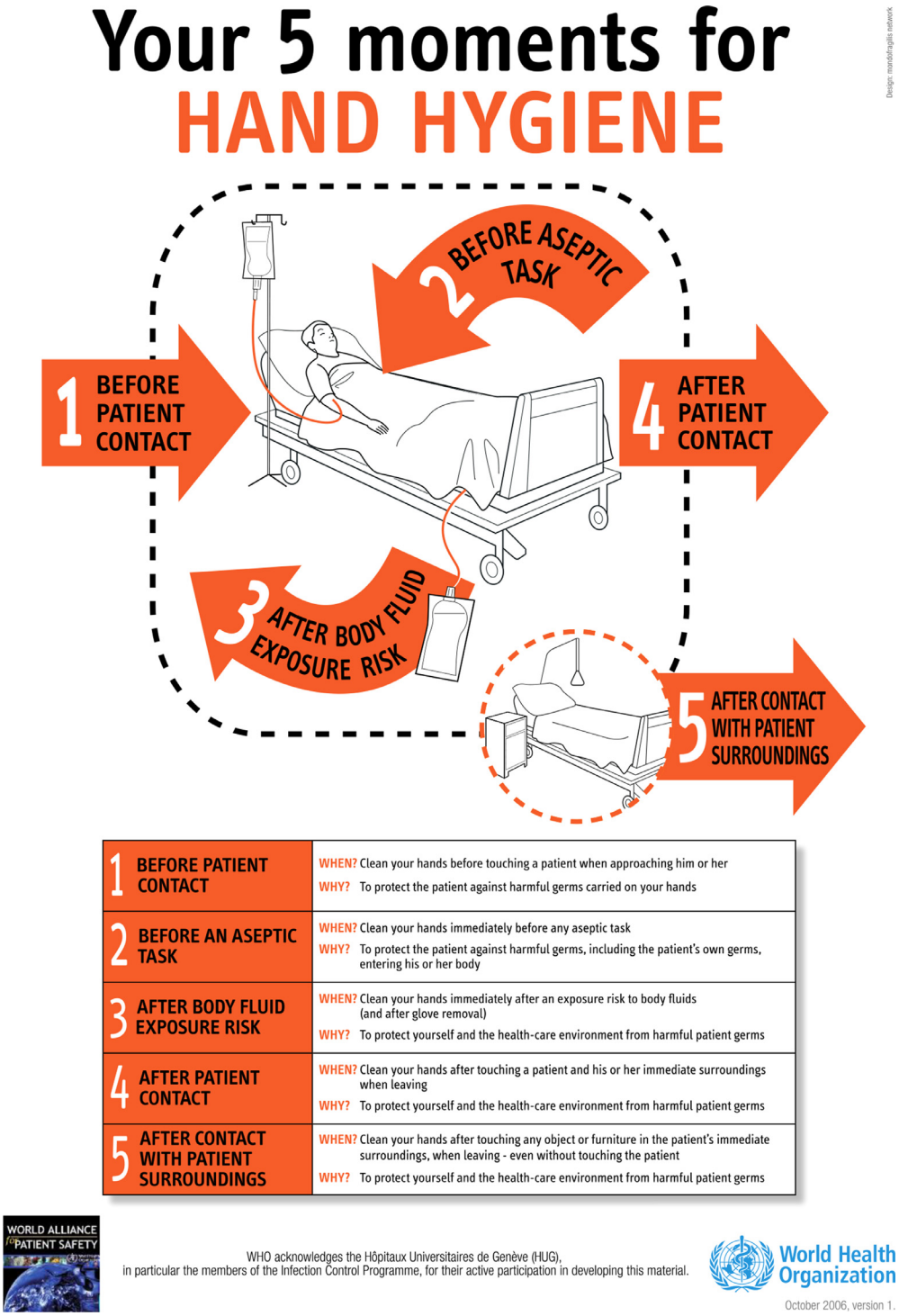

Fig 1. Your 5 moments for hand hygiene.

the most effective design of signs promoting hand hygiene and the efficacy of posting signs in patient care areas.[39] Some studies suggest that signs based on cognitive biases may be more effective.[40]

Efforts to improve institutional safety climate should include visible and vocal support for hand hygiene promotion by hospital administrators. Hand hygiene performance rates should be discussed at high-level board and committee meetings, and administrators should provide adequate personnel and financial resources for hand hygiene promotion. Some hospitals have developed "Do No Harm" programs,[41] whereas others have included hand hygiene as part of "high reliability organization" initiatives.

A systematic review and meta-analysis of hand hygiene improvement strategies included 41 studies, including 6 randomized controlled trials and 32 interrupted time series studies.[42] Meta-analysis of the 2 randomized controlled trials revealed that adding goal setting to the WHO-5 yielded additional improvement. Of 22 pairwise comparisons

of interrupted time series, 18 showed stepwise improvement in hand hygiene compliance.

Additional strategies include providing HCP with various types of incentives or rewards and promoting personal accountability.[42,43]

MONITORING HAND HYGIENE PERFORMANCE

Direct Observation

Monitoring hand hygiene compliance continues to be a challenge in many health care facilities. Direct observation of personnel by trained observers is currently considered the "gold-standard" method for determining hand hygiene compliance rates, and is the most widely adopted strategy for monitoring compliance.[44] Advantages of direct observation include the ability to determine compliance with all 5 Moments for Hand Hygiene, the feasibility of evaluating hand hygiene technique, its applicability in health care settings of all types and sizes, and the option of providing immediate feedback to HCP.[45] However, direct observation has a number of limitations, which include a lack of standardized methods for training and validating observers and for performing observations, and the fact that making direct observations is very time-consuming. As a result, most institutions observe from <1%-2% of all hand hygiene opportunities that occur in the facility.[45] Furthermore, compliance rates generated by direct observations are often 2- to 3-fold higher than those determined by automated systems because of the Hawthorne effect.[46-49] The impact of the Hawthorne effect can be reduced by limiting observation periods on a given unit to <10-15 minutes, and by having observations performed by "secret shoppers."[38,48,50]

Conducting and analyzing the results of direct observations can be facilitated by using digital apps designed specifically to make the process more efficient. At least 1 such app (iScrub Lite) is available for free on the Internet,[51] whereas others have been developed "in house."[48,52,53]

Automated hand hygiene monitoring systems

In addition to direct observation, several automated methods for monitoring hand hygiene practices are available.[45,54,55] Automated monitoring of product usage is 1 approach to monitoring hand hygiene frequency. Electronic devices placed inside hand hygiene product dispensers can record each time a dispenser is accessed (hand hygiene event). Each event can be time- and date-stamped and be forwarded to a centralized computer for analysis. Electronic counting devices have been useful in studying trends in the frequency of hand hygiene over time or between nursing units, and detecting changes in hand hygiene frequency after promotional interventions.[40,45,47,56] However, electronic counting devices cannot tell who has accessed the dispensers (HCP, patients, or visitors), and cannot provide information about hand hygiene compliance rates because hand hygiene opportunities are not recorded.

One system combines the use of electronic counting devices in dispensers that record hand hygiene events along with an algorithm for estimating the number of hand hygiene opportunities that occur on each nursing unit.[57,58] Hand hygiene opportunities are estimated based on patient census, patient-to-nurse ratio, and several adjustment factors. Estimated compliance rates are generated by dividing the number of hand hygiene events by the estimated number of opportunities. Several publications have described trials in which this system was implemented over varying periods of time in several different institutions.[59-62] Because the algorithm for estimating the number of hand hygiene opportunities has been validated on only 2 medical units in 2 large hospitals,[58,60] additional studies are warranted to determine if the algorithm provides accurate estimates of hand hygiene opportunities in additional types of nursing units and in different sized hospitals.

There are 3 more complex types of automated hand hygiene monitoring systems, including group monitoring, badge-based systems that can monitor individual performance, and video camera-based systems. Group monitoring (also called activity monitoring) systems use automated dispensers to record the time and location of hand hygiene events, and sensors near the doorway of each patient room record each time someone enters or exits the room (each considered a hand hygiene opportunity). Room entry is considered a proxy for Moment 1, and room exit is a proxy for Moments 4 and 5. Hand hygiene performance (an estimate of compliance) is determined by dividing the number of hand hygiene events by the number of hand hygiene opportunities. Validation of 1 such system revealed good sensitivity (92.7%) and reasonable positive predictive value (84.4%).[63] When implementation of the system was combined with other promotional activities, frequent feedback and efforts to emphasize accountability, sustained improvements in hand hygiene compliance rates have been documented.[41,43] Implementation of group monitoring systems alone, without supplementary promotional and motivational activities, is unlikely to yield sustained improvements in hand hygiene performance.[64] The highest compliance rates achieved with group monitoring have generally been in the range of 50%-70%.[41,43]

Advantages of group monitoring systems include the fact that they are less complex and less expensive than badge-based systems, and are considered less intrusive than systems that record individual performance by some HCP who are concerned about how hand hygiene performance data will be used by hospital administrators.[65] Limitations include the costs of implementing an automated monitoring system and the fact that these systems cannot determine who entered or exited patient rooms (HCP, patients, visitors), which may lead to some exaggeration of the number of hand hygiene opportunities among HCP. HCP often attribute the fact that hand hygiene performance rates generated by such systems are lower than compliance rates derived from direct observation to poor hand hygiene practices by visitors or patients rather than by HCP, which can affect acceptance of feedback rates provided by the system. A recent study that included observation of 14,876 opportunities on 29 units in 16 hospitals found that, on average, the percentage of opportunities that were due to HCP was 85.2% on adults wards and 76.9% on pediatric wards.[66] These findings can assist users of group monitoring systems in setting realist goals for hand hygiene performance rates.

Multiple trials of badge-based systems have been reported.[37,45,54,55,67-72] These systems use a combination of automated hand hygiene product dispensers, sensors that detect room entry and exit or proximity to a patient's bed, and specialized electronic badges that record hand hygiene events and opportunities by individual HCP. Advantages of badge-based systems include the ability of some systems to provide badged HCP with immediate feedback by virtue of audible or visual reminders incorporated into the badge or patient rooms.[37,67,69-71] Trials of varying duration have yielded relatively high hand hygiene performance rates, often (but not always) >80%.[37,67-73] The relatively high performance rates reported with these systems may be due in part to immediate individualized feedback and/or an increased sense of personal accountability among HCP. Systems without real-time reminders may not yield significant improvements in performance rates.[73] Some systems allow individuals overseeing the system to send weekly e-mails to department or unit managers or send text messages to badged HCP.[36,37]

Limitations of badge-based systems include their greater complexity and cost compared with direct observations or group monitoring systems. Several systems have suffered from poor accuracy in detecting hand hygiene opportunities,[74,75] whereas others have reasonably good accuracy.[68,76,77] Poor acceptance of system-generated

performance rates by HCP has been noted with some badge-based systems,[73] but not others.[56,67,78]

Advantages associated with both group monitoring and badge-based systems include the ability to record several orders of magnitude of more hand hygiene events and opportunities than can be achieved by direction observation.[41,43,68,69] For example, with direct observation, auditors often record from 20-100 opportunities per month per nursing unit,[41,44,69,70] whereas automated systems may record 10,000 to >150,000 opportunities per nursing unit per month.[41,43,46,68-70,79] Automated systems are not affected by observer bias or the type of Hawthorne effect that often influences the results of direct observations, and require less time commitment by HCP than direct observation. They have also been useful in assessing direct observation methods, HCP-patient visit frequency and transmission dynamics.[46,79-83] Some automated systems also monitor dispenser function, and can notify the appropriate department when dispensers require refills or battery changes, and allow for unit-specific software rules regarding when individuals entering or exiting a room are credited with performing hand hygiene at an appropriate time.

Unlike direct observation, both group and badge-based monitoring systems are currently unable to monitor compliance with Moments 2 and 3 for hand hygiene, as described by the WHO.[54,84] The extent to which this limitation affects overall assessment of hand hygiene compliance and the ability to improve hand hygiene practices remains a matter of some controversy.[45,84,85] However, monitoring Moments 2 and 3 is also a challenge even for those performing direct observations.[86] One system in France that integrates electronic badges with an automated system for recording patient care activities has the capability to estimate data on compliance with all 5 Moments for hand hygiene.

Experience with video camera-based systems is more limited. One such system used video cameras installed at the entrances of nursing units, and real-time monitoring of compliance by off-sight auditors.[35] In 1 hospital, implementing this system initially in a medical intensive care unit, and later in a surgical intensive care unit, yielded significant improvement in hand hygiene compliance in both units, with sustained rates of 80% or greater.[35,87] Others have also used video cameras to monitor hand hygiene performance and the frequency with which HCP touch surfaces with their hands, and to record care activities and discuss deficiencies with HCP who agreed to be observed during patient care.[7,88,89] Further experience with such systems, which can also be used to monitor other health care activities such as cleaning and disinfection practices and donning and doffing of personal protective equipment, appear warranted. Limitations of such systems include the cost of equipment and auditor personnel time, and concerns about possible liability if the confidentiality of video records were not maintained.

Limitations experienced with implementing various types of automated monitoring systems include technical problems, HCP behavioral issues, challenges in providing feedback of data in an effective manner, and the need to supplement automated monitoring with additional promotional and motivational activities and improve institutional safety climate.[37,43,73,74,90] Current and future systems should undergo validation in real-life settings using observations by trained observers.[54,55,91] Additional research of automated systems is needed to establish their ability to yield sustained improvements in hand hygiene performance and reduce health care–associated infections and their cost-effectiveness.[54]

The ideal approach to monitoring hand hygiene performance has not yet been identified. Given the advantages and limitations of both direct observation and automated monitoring systems, hospitals in developed countries may want to consider using a combination of both strategies. Direct observation might be used primarily as a qualitative measure of hand hygiene practices, whereas automated systems can provide a more quantitative approach to monitoring hand hygiene performance.[45]

In summary, despite considerable progress in improving hand hygiene practices that has occurred after publication of the CDC and WHO guidelines, many aspects of hand hygiene require further research. Only limited studies have addressed the question of the degree of reduction of pathogens on hands that must occur to prevent transmission.[92] Further research is needed to establish optimum hand hygiene technique, including the duration of handrubbing, the most effective and practical steps to assure adequate coverage of skin surfaces, and doses of ABHR that provide appropriate dry times and microbiological efficacy. Additional studies are needed to establish the most effective means of providing feedback, motivating HCP, and monitoring hand hygiene practices.

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