Improving Adherence to Hand Hygiene Practice: A Multidisciplinary Approach

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Hand hygiene prevents cross-infection in hospitals, but health-care workers' adherence to guidelines is poor. Easy, timely access to both hand hygiene and skin protection is necessary for satisfactory hand hygiene behavior. Alcohol-based hand rubs may be better than traditional handwashing as they require less time, act faster, are less irritating, and contribute to sustained improvement in compliance associated with decreased infection rates. This article reviews barriers to appropriate hand hygiene and risk factors for noncompliance and proposes strategies for promoting hand hygiene.

Hand hygiene is the simplest, most effective measure for preventing nosocomial infections (1,2). Despite advances in infection control and hospital epidemiology, Semmelweis' message is not consistently translated into clinical practice (3,4), and health-care workers' adherence to recommended hand hygiene practices is unacceptably low (3,5-10). Average compliance with hand hygiene recommendations varies between hospital wards, among professional categories of health-care workers, and according to working conditions, as well as according to the definitions used in different studies. Compliance is usually estimated as <50% (Table 1).

Promotion of hand hygiene is a major challenge for infection control experts (3,19-21). In-service education, distribution of information leaflets, workshops and lectures, and performance feedback on compliance rates have been associated with transient improvement (3,6,13,22,23). No single intervention has consistently improved compliance with hand hygiene practices (24). This review summarizes factors influencing lack of adherence by health-care personnel to hand hygiene procedures and suggests strategies for improvement.

Table 1. Compliance with hand hygiene in different hospital settings

Year	Setting	Average compliance	Author	Ref.
1981	Open ward	16%	Preston	11
	ICU	30%		
1981	ICUs	41%	Albert	5
	ICUs	28%		
1983	All wards	45%	Larson	12
1987	PICU	30%	Donowitz	13
1990	ICU	32%	Graham	6
1990	ICU	81%	Dubbert	14
1991	SICU	51%	Pettinger	15
1992	NICU/others	29%	Larson	16
1992	ICUs	40%	Doebbeling	7
1992	ICUs	40%	Zimakoff	17
1994	Emergency room	32%	Meengs	18
1999	All wards	48%	Pittet	9
	ICUs	36%		

ICUs = intensive care units; PICU = pediatric ICU; NICU = neonatal ICU.

Definitions

Two major groups of microorganisms are found on the skin: organisms that normally reside on it (resident flora) and contaminants (transient flora) (25). Unless introduced into body tissues by trauma or medical devices such as intravenous catheters, the pathogenic potential of the resident flora is low (26). Transient flora, which are easily removed by handwashing, cause most hospital infections resulting from cross-transmission (27-29).

The term hand hygiene includes several actions intended to decrease colonization with transient flora. This objective can be achieved through handwashing or hand disinfection. Handwashing refers to washing hands with an unmedicated detergent and water or water alone. Its objective is to prevent cross-transmission by removing dirt and loose transient flora (10,30). Hygienic handwash refers to the same procedure when an antiseptic agent is added to the detergent. Hand disinfection refers to use of an antiseptic solution to clean hands, either medicated soap or alcohol. Some experts refer to the action of "degerming" as the use of detergent-based antiseptics or alcohol (21). Hygienic hand rub is rubbing hands with a small quantity (2 mL to 3 mL) of a highly effective, fast-acting antiseptic agent.

Hand Hygiene Agents

If hands are known to be or suspected of being contaminated, transient flora must be eliminated by washing or disinfecting the hands to render them safe for the next patient contact. Plain soap with water can physically remove a certain level of microbes, but antiseptic agents are necessary to kill microorganisms (10,31-33). Hand antiseptic agents are designed to rapidly eliminate most transient flora by their mechanical detergent effect and to exert an additional sustained antimicrobial activity on remaining flora. The multiplication of resident flora may be retarded as well, so that hand disinfection may be useful in situations in which microbiologically clean hands are required for extended periods.

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Rotter showed that hand hygiene with unmedicated soap and water removed some transient flora mechanically; preparations containing antiseptic or antimicrobial agents not only removed flora mechanically but also chemically killed contaminating and colonizing flora, with long-term residual activity (30,34). Alcohol-based preparations have more rapid action than products containing other antiseptics (e.g., chlorhexidine gluconate or povidone iodine) (30,31,35).

Semmelweis observed that normal handwashing did not always prevent the spread of fatal infection (1) and recommended hand disinfection in a solution of chlorinated water before each vaginal examination. Hand disinfection is substantially more efficient than standard handwashing with soap and water or water alone (2,30), particularly when contamination is heavy (14,36-40). Frequent handwashing may result in minimal reduction or even an increase in bacterial yield over baseline counts of clean hands (21,41).

Because alcohols have excellent activity and the most rapid bactericidal action of all antiseptics, they are the preferred agents for hygienic hand rubs, so-called "waterless hand disinfection." In addition, alcohols are more convenient than aqueous solutions for hygienic hand rubs because of their excellent spreading quality and rapid evaporation. At equal concentrations, n-propanol is the most effective alcohol and ethanol the least (30). Alcohol-based hand rubs are well suited for hygienic hand disinfection for the following reasons: optimal antimicrobial spectrum (active against all bacteria and most clinically important viruses, yeasts, and fungi); no wash basin necessary for use and easy availability at bedside; no microbial contamination of health-care workers' clothing; and rapidity of action. After extensive reduction following hand disinfection with an alcohol preparation, it takes the resident skin flora several hours to become completely restored (30). Since alcohol alone has no lasting effect, another compound with antiseptic activity may be added to the disinfection solution to prolong the effect. These antiseptics have recently been extensively reviewed by Rotter (30).

Prevention of bacterial contamination and subsequent infection requires timely hand cleansing. Guidelines have delineated indications for hand cleansing (10,32,42) but without reliance on evidence-based studies of microbiologic contamination acquired during routine patient care. To provide such evidence, we studied the dynamics of bacterial contamination of health-care workers' hands in daily hospital practice (43). Our findings should help identify patient-care situations associated with high contamination levels and improve hand cleansing practices.

Structured observations of patient care were conducted by trained external observers, who took an imprint of the fingertips of the health-care worker's dominant hand to quantify bacterial colony counts at the end of a defined period of patient care (43). Bacterial contamination on ungloved hands increased linearly during patient care (mean 16 CFU per minute, 95% confidence interval [CI] 11-21). Activities independently associated with higher contamination levels were direct patient contact, respiratory care, handling body fluids, and disruption in the sequence of patient care (all $p<0.05$). Contamination levels varied according to hospital location, with the medical rehabilitation ward having the highest levels (>49 CFU, $p = 0.03$). Both the duration and type of patient care influenced hand contamination. Furthermore, simple handwashing before patient care, without hand disinfection, was also associated with higher colony counts (>52 CFU, $p = 0.03$), which suggests that hand antisepsis is better than standard handwashing. These findings suggested that intervention trials should explore the role of systematic hand disinfection as a cornerstone of infection control to reduce cross-transmission in hospitals.

Factors Influencing Noncompliance with Hand Hygiene

Risk factors for noncompliance with hand hygiene have been determined objectively in several observational studies or interventions to improve compliance (3,14,20,24,44-47). Factors influencing reduced compliance, identified in observational studies of hand hygiene behavior, included being a physician or a nursing assistant rather than a nurse; being a nursing assistant rather than a nurse; being male; working in an intensive care unit (ICU); working during weekdays rather than the weekend; wearing gown and gloves; using an automated sink; performing activities with high risk for cross-transmission; and having many opportunities for hand hygiene per hour of patient care.

In the largest hospital-wide survey ever conducted (9), we also identified predictors of noncompliance with hand hygiene during routine patient care. Variables included professional category, hospital ward, time of day or week, and type and intensity of patient care, defined as the number of opportunities for hand hygiene per hour of patient care. In 2,834 observed opportunities for hand hygiene, average compliance was 48%. In multivariate analysis, compliance was highest during weekends and among nurses (odds ratio [OR] 0.6, 95% CI 0.4-0.8). Noncompliance was higher in ICUs than in internal medicine (OR 2.0, CI 1.3-3.1), during procedures with a high risk for bacterial contamination (OR 1.8, CI 1.4-2.4), and when intensity of patient care was high (21 to 40 opportunities [OR 1.3, CI 1.0-1.7], 41 to 60 opportunities [OR 2.1, CI 1.5-2.9], >60 opportunities [OR 2.1, CI9 1.3-3.5]) compared with a reference level of 0 to 20 opportunities. In other words, compliance with handwashing worsened when the demand for hand cleansing was high; on average, compliance decreased by 5% (±2%) per increment of 10 opportunities per hour when the intensity of patient care exceeded 10 opportunities per hour. Similarly, the lowest compliance rate (36%) was found in ICUs, where indications for handwashing were typically more frequent (on average, 20 opportunities per patient per hour). The highest compliance rate (59%) was observed in pediatrics, where the average activity index was low (on average, eight opportunities per patient per hour). This study confirmed modest levels of compliance with hand hygiene in a teaching institution and showed that compliance varied by hospital ward and type of health-care worker, thus suggesting that targeted educational programs may be useful. These results also suggested that full compliance with current guidelines may be unrealistic (9,20,48) and that facilitated access to hand hygiene could help improve compliance.

Perceived Barriers to Hand Hygiene

Several barriers to appropriate hand hygiene have been reported (9,14,24,44-47). Reasons reported by health-care workers for the lack of adherence with recommendations include skin irritation, inaccessible supplies, interference with worker-patient relation, patient needs perceived as priority, wearing gloves, forgetfulness, ignorance of guidelines, insufficient time, high workload and understaffing, and

lack of scientific information demonstrating impact of improved hand hygiene on hospital infection rates.

Risk Factors for Noncompliance

Some of the perceived barriers for the lack of adherence with hand hygiene guidelines have been assessed or even quantified in observational studies (3,14,20,24,44-47). The most frequently reported reasons associated with poor compliance, in addition to those mentioned above, are inconveniently located or insufficient numbers of sinks; low risk for acquiring infection from patients; belief that glove use obviates need for hand hygiene; and ignorance of or disagreement with guidelines and protocols.

Skin irritation by hand hygiene agents is an important barrier to appropriate compliance (49). The superficial skin layers contain water to keep the skin soft and pliable and lipids to prevent dehydration of the corneocytes. Hand cleansing can increase skin pH, reduce lipid content, increase transepidermal water loss, and even increase microbial shedding. Soaps and detergents are damaging when applied to skin on a regular basis, and health-care workers need to be better informed about their effects. Lack of knowledge and education on this topic is a key barrier to motivation. Alcohol-based formulations for hand disinfection (whether isopropyl, ethyl, or n-propanol, in 60% to 90% vol/vol) are less irritating than antiseptic or nonantiseptic detergents. Alcohols with added emollients are at least as well tolerated and efficacious as detergents. Emollients are recommended and may protect against cross-infection by keeping the resident skin flora intact, and hand lotions help protect skin and may reduce microbial shedding (21).

The value of easy access to hand hygiene supplies, whether sink, soap, medicated detergent, or waterless alcohol-based hand rub solution, is self explanatory. Asking busy health-care workers to walk away from the patient bed to reach a wash basin or a hand antisepsis solution invites noncompliance with hand hygiene recommendations (9,48). Engineering controls could facilitate compliance, but hand hygiene behavior should be carefully monitored to identify negative effects of newly introduced devices (50).

Wearing gloves might represent a barrier for compliance with hand hygiene (8,51,52). Failure to remove gloves after patient contact or between dirty and clean body site care for the same patient constitutes noncompliance with hand hygiene recommendations (9). Washing and reusing gloves between patient contact is ineffective, and handwashing or disinfection should be strongly encouraged after glove removal. In a study involving artificial contamination, organisms were cultured from 4% to 100% of the gloves and observed counts were up to 4.7 log on hands after glove removal (53).

Additional barriers to hand hygiene compliance include lack of active participation in promotion at the individual or institutional level, of a role model for hand hygiene, of institutional priority assigned to hand hygiene, of administrative sanctions for noncompliance; and of an institutional climate encouraging safety (14,22,41,54,55). A system change may be necessary for improvement in hand hygiene practices by health-care workers.

Impact of Improved Hand Hygiene

Lack of scientific information on the definitive impact of improved hand hygiene on hospital infection rates has been reported as a possible barrier to adherence with recommendations. Hospital infections have been recognized for more than a century as a critical problem affecting the quality of patient care provided in hospitals. Studies have shown that at least one third of all hospital infections are preventable (56). A substantial proportion of infections results from cross-contamination, and transmission of microorganisms by the hands of health-care workers is recognized as the main route of spread (57). Seven quasi-experimental hospital-based studies of the impact of hand hygiene on the risk of hospital infections were published from 1977 to 1995 (Table 2) (7,22,58,60-63). Despite limitations, most reports showed a temporal relation between improved hand hygiene practices and reduced infection rates.

We recently reported the results of a successful hospital-wide hand hygiene promotion campaign, with emphasis on hand disinfection, which resulted in sustained improvement in compliance associated with a significant reduction in hospital infections and methicilllin-resistant *Staphylococcus aureus* cross-transmission rates over a 4-year period (63). The beneficial effects of hand hygiene promotion on the risk of cross-transmission have also been reported in surveys conducted in schools, day-care centers (64-68), and a community (69-71). Although additional scientific and causal evidence is needed for the impact of improved hand hygiene on infection rates, these results indicate that improvement in behavior reduces the risk of transmission of infectious pathogens.

Improving Adherence with Practices

In 1998, Kretzer and Larson (46) revisited hand hygiene behavioral theories in an attempt to better understand how to target more successful interventions. These researchers

Table 2. Improved adherence with hand hygiene practice compared with hospital infection rates

Year	Authors	Hospital setting	Results	Ref.
1977	Casewell and Philips	Adult ICU	Reduction in HI[a] due to endemic *Klebsiella* spp	58
1982	Maki and Hecht	Adult ICU	Reduction in HI rates	59
1984	Massanari and Heirholzer	Adult ICU	Reduction in NI rates	60
1990	Simmons et al.	Adult ICU	No effect	22
1992	Doebbeling et al.	Adult ICU	Significant difference in rates of HI between two different hand hygiene agents	7
1994	Webster et al.	NICU	Elimination of MRSA	61
1995	Zafar et al.	Newborn nursery	Elimination of MRSA	62
1999	Pittet et al.	Hospital-wide	Significant reduction in HI and MRSA cross-transmission rates	63

[a]HI = hospital infection; ICU = intensive care unit; NICU = neonatal ICU; MRSA = methicillin-resistant *Staphylococcus aureus.*

proposed a hypothetical framework to enhance hand hygiene practices and stressed the importance of considering the complexity of individual and institutional factors in designing behavioral interventions. Behavioral theories and secondary interventions have primarily focused on the individual, which is insufficient to effect sustained change (46,72,73). Interventions aimed at improving compliance with hand hygiene must be based on the various levels of behavior interaction (20,46,74). Thus, the interdependence of individual factors, environmental constraints, and institutional climate should be considered in strategic planning and development of hand hygiene promotion campaigns. Factors associated with noncompliance with recommendations are related not only to the individual worker but also to the group to which he or she belongs and, by extension, to the parent institution. Factors influencing compliance at the group level include lack of education and performance feedback; working in critical care (high workload); downsizing and understaffing; and lack of encouragement or role models from key staff. Factors operating at the institutional level include lack of written guidelines; lack of appropriate hand hygiene agents; lack of skin care promotion and agents; lack of hand hygiene facilities; lack of atmosphere of compliance; and lack of administrative leadership, sanctions, rewards, and support. Interventions to promote hand hygiene in hospitals should take into account variables at all these levels.

The complex dynamic of behavioral change involves a combination of education, motivation, and system change. Various psychosocial parameters influencing hand hygiene behavior include intention, attitude toward the behavior, perceived social norms, perceived behavioral control, perceived risk of infection, habits of hand hygiene practices, perceived model roles, perceived knowledge, and motivation (46). Factors necessary for change include dissatisfaction with the current situation, perception of alternatives, and recognition, both at the individual and institutional level, of the ability and potential to change. While the last factor implies education and motivation, the former two necessitate primarily a system change.

Among reasons reported for poor adherence with hand hygiene recommendations, some that are clearly related to the institution (i.e., the system) include lack of institutional priority for hand hygiene, need for administrative sanctions for noncompliance or rewards for compliance, and lack of an institutional climate that encourages safety. Whereas all three reasons would require a system change in most institutions, the last would also involve management commitment, visible safety programs, an acceptable level of work stress, a tolerant and supportive attitude toward reported problems, and belief in the efficacy of preventive strategies (20,46,73,75).

Strategies for Improvement

Improvement in infection control practices requires questioning basic beliefs, continuous assessment of the stage of behavioral change, interventions with an appropriate process of change, and supporting individual and group creativity (46). Because of the complexity of the process of change, single interventions often fail, and a multimodal, multidisciplinary strategy is necessary.

A framework for change should include parameters to be considered for hand hygiene promotion, together with the level at which each change must be applied: education, motivation, or system (Table 3). Some parameters are based on epidemiologic evidence and others on the authors' and other investigators' experience and review of current knowledge. Some parameters may be unnecessary in certain circumstances and helpful in others. In particular, changing the hand hygiene agent could be beneficial in institutions or hospital wards with a high workload and a high demand for hand hygiene when waterless hand rub is not available (9,61,62,76). However, a change in the recommended hand hygiene agent could be deleterious if introduced during winter, when skin is more easily irritated.

Several parameters that could potentially be associated with successful promotion of hand hygiene would require a system change (Table 3). Enhancing individual and institutional self-efficacy (the judgment of one's capacity to organize and execute actions to reach the objective), obtaining active participation at both levels, and promoting an institutional safety climate represent major challenges that exceed the current perception of the infection control practitioner's role.

More research is needed to determine whether education, individual reinforcement technique, appropriate rewarding, administrative sanction, enhanced self-participation, active involvement of a larger number of organizational leaders,

Table 3. Strategies for successful promotion of hand hygiene in hospitals

Parameter	Tool for change	Selected ref.[a]
Education	E[a] (M, S)	14,23,63,74,76
Routine observation and feedback	S (E, M)	6,14,23,63,74,76
Engineering controls	S	63
Make hand hygiene easy, convenient	S	63,74,77,78
Make available alcohol-based hand rub	S	63
Alcohol-based hand rub available in high-demand situations	S	63,78
Patient education	S (M)	79
Reminders in the workplace	S	52,63
Administrative sanctions, rewards	S	3,20
Change in hand hygiene agent	S (E)	21,80
Promote, facilitate skin care for HCW hands	S (E)	17,21,47,63
Obtain active participation at individual and institutional levels	E, M, S	46,63
Ensure institutional safety climate	S (M)	46,63
Enhance individual and institutional self-efficacy	S (E, M)	46,63
Avoid overcrowding, understaffing, excessive workload	S	9,15,63,81,82
Combination of above strategies	E, M, S	14,23,46,63,74

[a]E = education; M = motivation; S = system; HCW = health-care worker

[b]Only selected references are listed; refer to more extensive reviews (10,30,46) for exhaustive reference lists.

enhanced perception of health threat, self-efficacy, and perceived social pressure (20,46,83,84), or combinations of these factors would improve health-care workers' adherence to recommendations. Ultimately, compliance with hand hygiene could become part of a culture of patient safety in which a set of interdependent elements interact to achieve a shared objective (85).

More readily achievable than major system change, easy and timely access to hand hygiene in a timely fashion and the availability, free of charge, of skin care lotion both appear to be necessary prerequisites for appropriate hand hygiene behavior. In particular, in high-demand situations, such as in critical care units, in high-stress working conditions, and at times of overcrowding or understaffing, having health-care workers use a hand rub with an alcohol-based solution appears as the best method for achieving and maintaining a higher level of compliance with hand hygiene. Alcohol-based hand rub, compared with traditional handwashing with unmedicated soap and water or medicated hand antiseptic agents, may be better because it requires less time (48), acts faster (30), and irritates hands less often (21,30). This method was used in the only program that reported a sustained improvement in hand hygiene compliance associated with decreased infection rates (63).

Finally, strategies to improve compliance with hand hygiene practices should be multimodal and multidisciplinary (Table 3). It is important to note, however, that the proposed framework for such strategies needs further research before implementation.

Future Research

Among key questions regarding the practices of hand hygiene in the health-care setting today, the following need to be addressed in controlled studies: What are the key determinants of hand hygiene behavior and promotion? Should hand disinfection replace conventional handwashing? What are the best hand hygiene agents? Should hand hygiene solution include a long-lasting compound? What are the most suitable skin emollients to include in hand hygiene solution? How can skin irritation and dryness from hand hygiene agents be reduced? How does skin care protection with hand cream affect the microbiologic efficacy of hand hygiene agents? and What are the key components of hand hygiene agent acceptability by health-care workers? Additional research questions include— How can researchers generate more definitive scientific evidence for the impact of improved compliance with hand hygiene on infection rates? What is the acceptable level of compliance with hand hygiene (i.e., What percentage increase in hand hygiene results in a predictable risk reduction in infection rates?) and To what extent should the use of gloves be encouraged or discouraged? Finally, recognizing that individual and institutional factors are interdependent in terms of behavioral changes in health-care settings, what is the best way to obtain top management support for hand hygiene promotion? These questions are addressed to infection control practitioners, laboratory research scientists, and behavioral epidemiologists.

The challenge of hand hygiene promotion could be summarized in one question: How can health-care workers' behavior be changed? Tools for change are known; some have been tested, and others need to be tested. Some may prove irrelevant in the future; others have worked in some institutions and need to be tested in others. Infection control professionals should promote and conduct outstanding research and provide solutions to improve health-care worker adherence with hand hygiene and enhance patient safety.

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