

# Hand hygiene: improved standards and practice for hospital care

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## Purpose of review

To review the most recently published literature on hand hygiene practices in healthcare settings.

## Recent findings

Adherence with recommendations for hand hygiene remains low, but key factors of noncompliance have been identified and corrective actions proposed. Current guidelines recommend the use of alcohol-based handrub formulations as the new standard of care, thus requiring a system change in most hospitals. In addition, healthcare worker education and motivation are obviously important to modify hand hygiene behavior and must be part of multimodal strategies to enhance compliance in hospitals. Compliance improvement is associated with reduced infection rates and resistance spread. Handrub application according to recommended practices is an alternative to conventional surgical handscrubbing with antiseptic soap and water for surgical hand preparation.

## Summary

System change must be addressed in most hospitals where alcohol-based handrubbing has not become a standard of care. Strategies to improve hand hygiene compliance must be multimodal and include staff education and motivation, the use of performance indicators, and hospital management support. Successful campaigns will result in reduced infection rates, antimicrobial resistance spread, and enhance patient safety.

## Keywords

hand hygiene, performance, guideline, nosocomial infection, alcohol-based handrub

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## Abbreviations

HCW healthcare worker  
MRSA methicillin-resistant *Staphylococcus aureus*

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## Introduction

Hand hygiene is considered the primary measure to reduce the transmission of nosocomial pathogens. Non-compliance with hand hygiene, however, remains a major problem in hospitals. Following recent improvements in our understanding of the epidemiology of hand hygiene compliance [1,2<sup>\*</sup>], new approaches have been suggested. Guidelines for hand hygiene have been revisited [3<sup>\*\*</sup>] and should improve the standards and practice in healthcare settings.

## Agreement on terminology

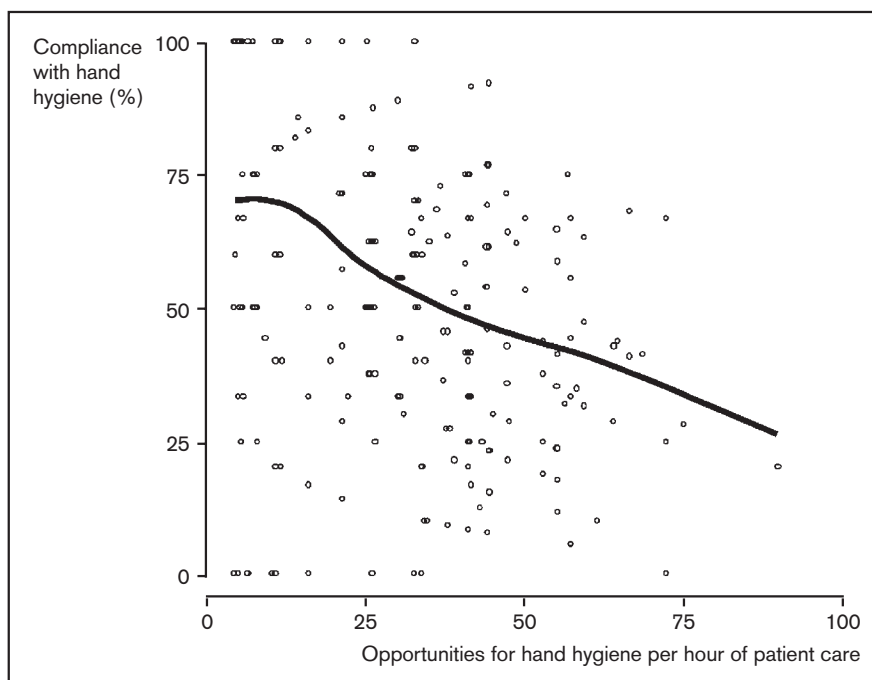
Terms used in the field have been reviewed and agreed as follows [3<sup>\*\*</sup>]. Hand hygiene is a general term that applies to either handwashing, antiseptic handwash, antiseptic handrub, or surgical hand antisepsis. Handwashing refers to the action of washing hands with plain (nonantimicrobial) soap and water. Hand antisepsis refers to either antiseptic handwash or antiseptic handrub. Antiseptic handwash refers to the action of washing hands with soap and water or other detergents containing an antiseptic agent. Antiseptic handrub refers to the application of a waterless antiseptic agent to all surfaces of the hands to reduce the number of microorganisms present. Hand decontamination is used to describe the action of reducing bacterial counts on hands by performing antiseptic handrub or antiseptic handwash. Waterless antiseptic agent is used to refer to an antiseptic agent that does not require the use of exogenous water. Visibly soiled hands are those showing visible dirt or contamination with proteinaceous body substances (e.g. blood, fecal material, urine). Indications or opportunities for hand hygiene refer to situations where a hand hygiene action is recommended, regardless of whether the action is performed or not, or the cleansing agent chosen.

## Important evidence

Studies in the literature have repeatedly documented that the importance of hand hygiene is not sufficiently recognized by healthcare workers (HCWs) [4–6] and compliance with recommended practices is unacceptably low [1,2<sup>\*</sup>,3<sup>\*\*</sup>,4–14]. Average adherence with hand hygiene recommendations is usually estimated to be below 50%, but varies between different hospital wards, among professional categories, and according to working conditions (Fig. 1). As shown, the higher the workload, that is the number of opportunities for hand hygiene per hour of patient care, the lower the compliance [1]. Similarly, Bittner and colleagues [15] observed that handwashing frequency decreased when the patient-to-

Figure 1. Relation between the number of opportunities for hand hygiene and compliance, hospital-wide. University of Geneva Hospitals, 1994

Compliance with hand hygiene is plotted against the number of opportunities per hour of patient care for 293 20-min observation periods. The line represents the nonparametric regression function. Reproduced with permission from [1].



nurse ratio increased. O'Boyle and colleagues [16] conducted a longitudinal, observational study among critical care nurses and showed that observed hand hygiene behavior was more sensitive to the intensity of activity in the nursing unit, rather than to internal motivational factors taken from the theory of planned behavior. Similarly, the results of a questionnaire survey to evaluate knowledge, attitudes, and behavior regarding hand hygiene among Italian HCWs suggested that promotional interventions should not only focus on knowledge, but also on facilitating and reinforcing factors [17].

Moreover, not only is the average level of compliance with hand hygiene recommendations low, but time spent is usually insufficient. The duration of handwashing or hygienic handwash episodes by HCWs varies between a few seconds and more than 60 s, averaging from as low as 4.7 s to 24 s in observational studies [3•]. In addition to washing their hands for very short periods of time, HCWs often fail to cover all surfaces of their hands and fingers [18] and the technique of hand hygiene is frequently deficient, even under observation [19].

Outbreak investigations have suggested an association between infections and understaffing or overcrowding that was consistently linked with reduced compliance with hand hygiene practices [20–22]. These findings

tend to show indirectly that an imbalance between workload and staffing can lead to relaxed attention to basic control measures, such as hand hygiene, and spread of microorganisms. Grundmann and colleagues [23•] reported a comprehensive analysis of risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) transmission in an ICU, including the estimation by mathematical modeling of the relative effectiveness of infection control measures. Exposure to relative staff deficit was the strongest factor associated with potential transmission. It was predicted that a 12% increase in hand hygiene compliance might have compensated for staff shortage and prevented transmission during periods of overcrowding, shared care, and high workload.

Factors that may influence hand hygiene include risk factors for noncompliance identified in epidemiologic studies, as well as reasons reported by HCWs for lack of adherence to hand hygiene recommendations (Table 1).

### Impact of compliance improvement

Larson and colleagues [26] documented that the prevalence of nosocomial infections decreased as HCWs' compliance with recommended hand hygiene measures improved. Top hospital management and medical and nursing leaders provided active support for a culture change, highlighting and enforcing the expectation for hand hygiene compliance for all HCWs. We reported the results of a successful hospital-wide hand hygiene

**Table 1. Factors influencing compliance with hand hygiene practices<sup>a</sup>**


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Observed risk factors for the lack of compliance with recommended practices
Physician and nursing assistant status (rather than a nurse)
Male gender
Working in critical care
Working during the week (versus week-end)
Wearing gowns/gloves
Automated sink
Activities with high risk of cross-transmission
High number of indications for hand hygiene per hour of patient care
Self-reported factors for poor adherence with hand hygiene
Skin irritation and dryness associated with the use of hand hygiene agents
Sinks are inconveniently located/shortage of sinks
Lack of soap, paper, towel
HCW is too busy, has insufficient time for hand hygiene
Understaffing/overcrowding
Patient needs take priority
Hand hygiene interferes with HCW–patient relation
Low risk of acquiring infection from patients
Wearing of gloves
Belief that glove use obviates the need for hand hygiene
Lack of knowledge of guidelines/protocols
Not thinking about hand hygiene/forgetfulness
No role model from colleagues or superiors
Skepticism about the value of hand hygiene
Disagreement with recommendations/indications for hand hygiene
Lack of scientific information of definitive impact of improved hand hygiene on infection rates
Additional perceived barriers to appropriate hand hygiene
Lack of active participation in hand hygiene promotion at individual or institutional level
Lack of role model for hand hygiene
Lack of institutional priority for hand hygiene
Lack of administrative sanction of noncompliers/rewarding of compliers
Lack of institutional safety climate

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HCW, healthcare worker.

<sup>a</sup>Adapted from Refs [2•,3••,24,25•].

promotion campaign [9], with a special emphasis on bedside handrubbing, that resulted in sustained improvement in compliance associated with a significant reduction in nosocomial infections and MRSA cross-transmission rates over 4 years.

In a prospective multicenter study involving more than 1100 peripheral venous catheters [27], alcohol-based hand disinfection or wearing gloves prior to device insertion resulted in a significantly lower incidence of infectious complications (relative risk 0.52, CI<sub>95</sub> 0.47–0.91) compared with washing hands with soap and water. Similarly, the implementation of a hand hygiene policy for use in a neonatal ICU by a multidisciplinary task force resulted in a significant increase in compliance and a significant decrease in false-positive coagulase-negative staphylococcal blood and cerebrospinal fluid culture rates, and a trend toward a reduced incidence of true-positive cultures [28].

Using a multimodal intervention including the placement of an alcohol-based handrub at every patient

bedside, Gopal Rao and colleagues [29•] observed a consistent reduction in the proportion of hospital-acquired MRSA infection or colonization (from 50 to 39%) over 2 years. Although not statistically significant, the average incidence of *Clostridium difficile* diarrhea decreased by 17% after intervention.

Finally, Aiello and Larson [30] recently reviewed the epidemiological evidence for a causal relation between hygiene practices in general and infections in the community setting; they concluded that there was a measurable, positive effect of personal and community hygiene on infections. Whether this observation could be translated to the hospital setting remains to be formally tested, but a similar relation might exist with nosocomial infections resulting from inappropriate behavior during patient care.

### System change is required

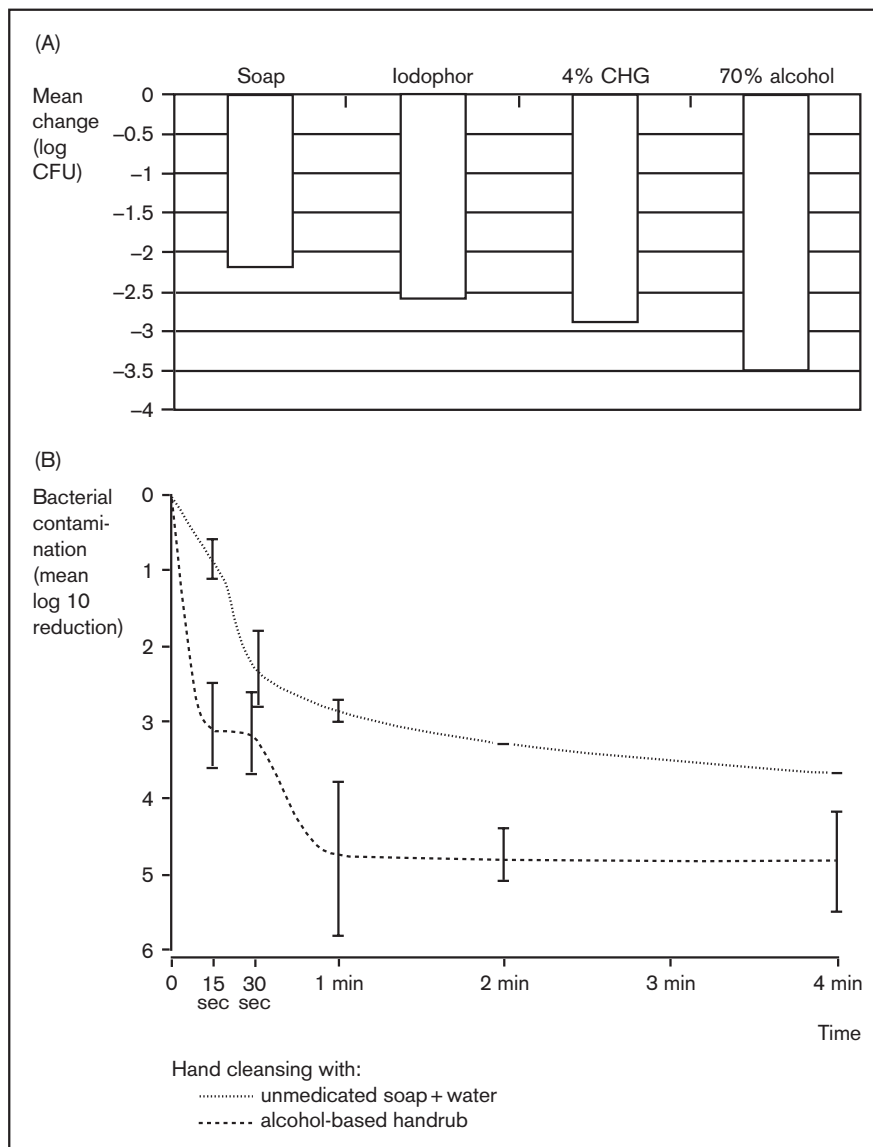
A system change that must be addressed in most hospitals concerns the leading risk factor for noncompliance with hand hygiene: time constraint. As discussed earlier, the time required for a HCW for hand hygiene is a critical component. In particular, time required for traditional handwashing may make full compliance with previous guidelines unrealistic [1,2•,3••,31]. It takes at least a minute to wash hands (i.e. go to the sink, wash, dry, return to the patient) [3••,31]. In a healthcare context ‘no time for handwashing’ (Table 1) is not an excuse but a reality: strict compliance would mean that at least a fourth of nursing time in busy wards would be spent on the practice of hand hygiene. A bedside handrub with an alcohol-based agent requires only 20 s [2•,3••]. Providing easy access to hand hygiene materials is mandatory for appropriate behavior, and should be achievable in all hospitals [2•,3••,24]. Immediate access to hand hygiene facilities and agents and rapid antimicrobial action are key elements to improve compliance. HCWs may be more likely to use an alcohol-based handrub because it not only requires less time [2•,31,32], but acts faster [3••], and irritates the hands less often [3••,32–35].

### Handrubbing efficacious

The comparative efficacy of different hand hygiene agents is shown in Fig. 2(A). As shown, hand antisepsis is significantly more efficient than standard handwashing with unmedicated soap and water or water alone [2•,3••]. Furthermore, the time spent for hand hygiene is critical, in particular when washing hands with unmedicated soap or water alone (Fig. 2(B)). These results also confirmed earlier observations: in 1847, Semmelweis observed that normal handwashing did not always prevent the spread of fatal infection and recommended hand antisepsis in a solution of chlorinated water before each vaginal examination [3••].

Figure 2. (A) Relative efficacy of solutions for hand hygiene to reduce skin flora. (B) Time-course of efficacy of unmedicated soap and water and alcohol-based handrub in reducing the release of test bacteria from artificially contaminated hands

CHG: chlorhexidine gluconate  
CFU: colony forming units



Adapted with permission from [2•]

In a prospective study in a clinical environment, alcohol-based handrubbing and handwashing with antiseptic soap were more efficacious than handwashing with nonmedicated soap in reducing bacterial counts on hands [36], confirming earlier investigations [37]. In another randomized controlled trial, handrub use was significantly more efficient in reducing hand contamination than hand disinfection with antiseptic soap [38]. The clinical effectiveness (i.e. impact on nosocomial transmission) of the use of different hand hygiene agents remains to be tested prospectively.

Because alcohols have excellent activity and the most rapid bactericidal action of all antiseptics, they are the preferred agents for hygienic handrub, so-called 'water-

less hand disinfection' [3••]. Of particular importance is the fact that alcohols dry very rapidly, allowing for fast antiseptics. In addition, there is no doubt that alcohols are much more convenient for hygienic handrub than aqueous solutions given their excellent spreading quality and rapid evaporation.

### New recommendations for hand hygiene

Guidelines for hand hygiene in healthcare settings have been recently developed by a group of international experts [3••] from the Centers for Disease Control and Prevention, the Healthcare Infection Control Practices Advisory Committee, the Society for Healthcare Epidemiology of America, the Association for Professionals in Infection Control and Epidemiology, and the Infectious

Diseases Society of America. Indications for hand hygiene during patient care are listed in Table 2; they have been classified according to their level of evidence (see footnote to Table 2) [3\*\*].

It is worth noting that unless hands are not visibly soiled, the use of an alcohol-based waterless antiseptic agent is recommended for routine hand hygiene in all clinical situations (level IA recommendation) [3\*\*]. Importantly, antiseptic handrub has no effect on soil, so visibly soiled hands should be washed with soap and water [3\*\*], as well as conditions when contamination with *Bacillus* spp. is suspected [3\*\*,39\*]. According to the guidelines, on nursing units where an alcohol-based waterless antiseptic agent is available, a nonantimicrobial soap for use when hands are visibly dirty or contaminated with proteinaceous material must be provided. It is not necessary and may be confusing to HCWs, however, to have both an alcohol-based waterless agent and an antimicrobial soap available on the same nursing unit.

**Table 2. Indications for handwashing and hand antisepsis during patient care<sup>a</sup>**

Wash hands with a non-antimicrobial soap and water or an antimicrobial soap and water when hands are visibly soiled or contaminated with proteinaceous material (IA)

If hands are not visibly soiled, use an alcohol-based handrub for routinely decontaminating hands in all other clinical situations described in items 1–8 listed below (IA)

Decontaminate hands

1. before having direct contact with patients (IB)
2. before donning sterile gloves when inserting a central intravascular catheter (IB)
3. before inserting indwelling urinary catheters, peripheral venous catheters, or other invasive devices that do not require a surgical procedure (IB)
4. after contact with a patient's intact skin (as in taking a pulse or blood pressure, or lifting a patient) (IB)
5. after contact with body fluids or excretions, mucous membranes, nonintact skin, or wound dressings, as long as hands are not visibly soiled (IA)
6. if moving from a contaminated-body site to a clean-body site during patient care (II)
7. after contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient (II)
8. after removing gloves (IB)

Wash hands with antimicrobial/nonantimicrobial soap and water if exposure to *Bacillus anthracis* is suspected or proven [39\*]. The physical action of washing and rinsing hands under such circumstances is recommended because all hand antiseptics have poor activity against spores

The Centers for Disease Control and Prevention/Healthcare Infection Control Practices Advisory Committee system for categorizing recommendations is as follows: category IA: strongly recommended for implementation and strongly supported by well designed experimental, clinical, or epidemiologic studies; category IB: strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; category IC: required for implementation, as mandated by federal and/or state regulation or standard; category II: suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale. No recommendation: unresolved issue; practices for which insufficient evidence or no consensus regarding efficacy exist.

<sup>a</sup>Adapted from Ref. [3\*\*].

## Additional recommendations

Other recommendations include providing HCWs with hand lotions or creams to minimize the occurrence of irritant contact dermatitis associated with hand hygiene action, whether it be handwashing or handrubbing [3\*\*]. In addition, the guideline recommends that HCWs having direct contact with patients should not wear artificial fingernails or extenders and they should keep natural nail tips to less than a quarter of an inch long.

## Glove use

Hand hygiene is required regardless of whether gloves are used or changed. Failure to remove gloves after patient contact or between dirty and clean body site care on the same patient has to be regarded as noncompliance with recommendations [1]. Furthermore, it may not be prudent to wash and reuse gloves between patient contact, and hand hygiene is recommended after glove removal [3\*\*]. The impact of wearing gloves on adherence to hand hygiene policies has not been definitively established, since published studies have yielded contradictory results [4,7,40–43]. A number of reports have however underlined the risk of hand-gloved HCWs moving from patient to patient without glove change, resulting in the subsequent cross-transmission of nosocomial pathogens.

The recommendations [3\*\*] are (1) to wear gloves when contact with blood, body fluids, or other potentially infectious materials, mucous membranes, and nonintact skin can be reasonably anticipated; (2) to remove gloves after caring for a patient; (3) not to wear the same gloves for the care of more than one patient; (4) not to wash gloves between patients; and (5) to change gloves during patient care if moving from a contaminated body site to a clean site.

## Education and promotion

Education is one of the cornerstones for improvement with hand hygiene practices. HCW education must be promoted at all levels of experience [3\*\*,25\*]. Educational programs need to address issues like availability and awareness of guidelines for hand hygiene, potential risks of transmission of microorganisms to patients, as well as potential risks of HCW colonization or infection acquired from the patient, knowledge about indications for hand hygiene during daily patient care, awareness of the very low average compliance with hand hygiene practices of most HCWs, and recognition of opportunities for hand hygiene associated with high risk for cross-transmission. Teaching must recall morbidity, mortality, and costs associated with nosocomial infections, and emphasize the epidemiological evidence for the definitive impact of improved hand hygiene on nosocomial infection and resistant organism(s) transmission rates. Techniques for hand hygiene should be taught, and

include the amount of hand hygiene solution to use, duration of procedure, and reasons for the institutional choice of hand hygiene agents. Coaching should also focus on the relative efficacy of the different hand hygiene agents available and on the appropriateness, efficacy, and understanding of the use of hand hygiene and skin care protection agents. Finally, education is also part of the strategies in which driving active participation for hand hygiene promotion at individual and institutional level, as well as enhancement of individual and institutional self-efficacy are enforced.

Physician compliance with hand hygiene is usually low, but can improve. Salemi and colleagues [44•] observed that personal encounters, in particular direct meetings with an infectious disease colleague, and videotaped presentations to a lesser degree, had a greater impact on physician compliance compared with e-mail reminders. Whether objective demonstration of hand contamination occurring during routine patient care activities might be a helpful component of successive educational programs remains to be further tested [45]. Good role models are also important [10,25•]: a consultant who washes or rubs his/her hands when appropriate will encourage junior staff to follow this example; unfortunately, the reverse is true too!

Based on consideration of behavioral theories and reported experiences, multimodal intervention strategies have more chance of success than single approaches or promotion programs that focus on one or two elements only [2•,3••,9,25•,29•,32]. These strategies might show similarities with principles of societal marketing methods. Studies are needed to assess the key determinants of hand hygiene behavior and promotion among the different populations of HCWs, to develop methods to obtain senior management support, and to implement and evaluate the impact of the different components of multimodal programs to promote hand hygiene.

### Hospital management support

Recently edited guidelines for hand hygiene in health-care settings include a list of specific elements that should be considered for inclusion in educational and motivational programs for its successful promotion [3••]. Some of these targets are clearly related to the institution and would require a system change in most hospitals, with the need to involve senior management support and commitment [2•,3••,9,26,46–48].

In most hospitals a system change would probably be necessary to change a hand hygiene agent (in particular when associated with increased costs), promote and facilitate skin care for HCWs' hands, and introduce monitoring and regular performance feedback of hand hygiene compliance. Some changes are sometimes

difficult to manage, or would probably be even more difficult to induce in most hospitals. These include securing the active participation for hand hygiene promotion at individual and institutional level, and administrative sanction or rewarding associated with hand hygiene behavior [3••,24,25•].

### Performance indicators

The following indicators are proposed for measuring HCWs' adherence and improvement with hand hygiene recommendations [3••]: monitoring of adherence by ward staff; monitoring of adequacy of hand hygiene practices at time of outbreaks; and monitoring of adherence to policies related to the wearing of artificial nails. In addition, performance feedback is also recommended.

Other indicators have been proposed to measure hand hygiene compliance and assess the possible impact of intervention. These include counting used paper hand towels [49], monitoring the amount of alcohol-based handrub used [9,50], or estimating the required amount using a computerized database of nursing activities [51]. These methods are less time and resource demanding, but do not allow one to assess the adequacy of hand hygiene action, and are polluted by several biases.

### Tolerance of hand hygiene agents

Skin irritation constitutes an important barrier to appropriate compliance. Because soaps and detergents can damage skin when applied on a regular basis, HCWs need to be better informed about the possible effects of hand hygiene agents. Lack of knowledge and education on this topic is a key barrier to motivation. Emollients and hand lotions help to protect skin and may reduce microbial shedding [2•,3••,34,52,53].

Using a prospective randomized trial with crossover design, Boyce *et al.* [33] showed a better tolerance to alcohol-based handrubs than to handwashing with nonmedicated soaps. Skin irritation and dryness increased significantly when nurses washed their hands with the soap tested. Importantly, alcohol-based handrubs that contain emollients, irrespective of the type of alcohol, are usually well tolerated and do not dry out or irritate the skin [54]. Larson and colleagues [55] conducted a prospective trial to compare two hand care regimens among neonatal ICU nurses; after 2 weeks, nurses using alcohol-based handrubs had significant improvements in their skin condition compared with those practising traditional antiseptic handwash with chlorhexidine-containing detergents.

### Selecting a product

Alcohol-based handrubs contain 60–95% (w/w) of alcohol. Ethanol is the commonly used alcohol but

propanol and mixtures of both are also available. Handrubs are available as rinses (with low viscosity), gels, and foams. The fluid products in the gel systems are a mixture of polyacrylic acids and neutralizer. Water is added to swell the system and the higher the alcohol content, the more difficult it is to enhance viscosity.

Important elements to be considered before selecting a hand hygiene agent are to form a multidisciplinary team; to establish criteria for product selection; to evaluate several products in clinical settings; and to project resource use and costs [56]. Importantly, fragrance, skin tolerance, user acceptance, antimicrobial properties and cost of products should be evaluated before selection [3••], as well as design and function of product dispensers that will ultimately be installed [56].

Adverse reactions possibly associated with the use of an alcohol-based handrub solution have been reported [57]. Because most nurses were later able to resume use of the product, an allergic cause could probably be excluded. Importantly, handrubs contain other components than alcohol that may actually increase the susceptibility of normal skin to an irritant, resulting in irritant contact dermatitis. The latter is unfortunately extremely common (occurring in about 25% of nurses) with detergent-based products. Thus, the replacement of medicated soaps and other hand antiseptic products used for traditional handwashing by alcohol-based handrub solutions will fortunately decrease the likelihood of skin reactions and sensitization among HCWs.

### Rinse or gel

Irritant dermatitis resulting from frequent application of soaps and detergents is commonly experienced by HCWs. Gel formulations have been proposed to reduce the drying effect of alcohols and potentially enhance compliance with hand hygiene. Using European Norms (EN1500), the antimicrobial efficacy of 10 gels and five rinses available on the market was compared to 2-propanol 60% (v/v) on artificially contaminated hands using a cross-over design [58••]. A 30 s handrub with gels containing a total amount of up to 70% (v/v) alcohol was significantly less efficacious at reducing bacterial counts on hands than a handrub with 2-propanol 60% (v/v) or any of the rinses tested. A similar observation was made using different test products and laboratory conditions [59]. Newly developed gels might have increased microbial efficacy [60].

Whether gels or rinses, alcohol-based handrubs approved for use in healthcare settings reduce bacterial counts on hands to a greater degree than antimicrobial soap or detergents. HCWs' acceptance of the agent is one of the major determinants of compliance. A legitimate concern is that rinses might be less accepted than gels, resulting

in decreased compliance. Nevertheless, there are no definitive data to suggest that compliance is higher when using gels; it may even be the opposite [61•]. The clinical significance of the observed laboratory differences remains to be further tested in controlled clinical trials [62].

### Surgical hand preparation

Effective hand antisepsis before surgery remains crucial for the prevention of surgical site infection. Recommendations on hand and forearm antisepsis for the surgical team aim at removing transient flora and reducing the resident flora by at least 2-log. Surgical hand preparation might be performed either by 5 min of handscrubbing with antiseptic soap or by a 1 min handwash with nonantimicrobial soap and water, followed by 3–5 min of handrubbing with an alcohol-based handrub solution. The latter proved to be as effective as traditional handscrubbing in preventing surgical site infection in a large, randomized equivalence trial conducted in six surgical services from teaching and nonteaching hospitals in France [63••]. Compliance with the recommended duration of hand antisepsis was better with the handrubbing protocol, as well as tolerance with less skin dryness and irritation. Similarly, an alcohol-based rinse was as efficacious in reducing microbial counts on hands as traditional handscrub in another prospective trial [64]. The recently published guideline [3••] recommends that surgical hand preparation be performed either with an antimicrobial soap or an alcohol-based handrub with persistent activity before donning sterile gloves. The latter technique implies that hands and forearms must be prewashed with a nonantimicrobial soap and dried completely before handrub application; furthermore, hands and forearms must dry completely after handrub application before donning gloves.

### Conclusion

In conclusion, adherence with the recommendations for hand hygiene practices remains extremely low in most healthcare settings. Some of the key parameters associated with noncompliance have been clearly identified and corrective actions proposed. Among those identified by careful epidemiological investigation, time constraint is the leading factor for noncompliance [1], but also the easiest to modify [9,65,66]. Importantly, the inverse relationship between increased workload and decreased compliance [1] stands for handwashing, but not for the use of handrub [67•]. System change must be addressed in most hospitals where waterless hand disinfection has not become a standard of care. In addition, HCW education and motivation are obviously important to modify hand hygiene behavior and must be part of multimodal strategies to enhance compliance in hospitals [3••]. Successful campaigns will result in reduced infection rates, antimicrobial resistance spread,

and enhance patient safety. Finally, handrub application according to recommended practices is an alternative to conventional surgical handscrubbing with antiseptic soap and water for surgical hand preparation.

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## References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

- 1 Pittet D, Mourouga P, Perneger TV, and the members of the Infection Control Program. Compliance with handwashing in a teaching hospital. *Ann Intern Med* 1999; 130:126–130.
- 2 Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. *Lancet Infect Dis* 2001; April:9–20.  
Extensive, colorful review of the topic.
- 3 Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *MMWR Morb Mortal Wkly Rep* 2002; 51:1–44.  
Newly published guideline.
- 4 Dubbert PM, Dolce J, Richter W, et al. Increasing ICU staff handwashing: effects of education and group feedback. *Infect Control Hosp Epidemiol* 1990; 11:191–193.
- 5 Simmons B, Bryant J, Neiman K, et al. The role of handwashing in prevention of endemic intensive care unit infections. *Infect Control Hosp Epidemiol* 1990; 11:589–594.
- 6 McLane C, Chenelly S, Sylwestrak M, Kirchoff KT. A nursing practice problem failure to observe aseptic technique. *Am J Infect Control* 1983; 11:178–182.
- 7 Larson E. Compliance with isolation technique. *Am J Infect Control* 1983; 11:221–225.
- 8 Watanakunakorn C, Wang C, Hazy J. An observational study of hand washing and infection control practices by healthcare workers. *Infect Control Hosp Epidemiol* 1998; 19:858–860.
- 9 Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Lancet* 2000; 356:1307–1312.
- 10 Muto CA, Siström MG, Farr BM. Hand hygiene rates unaffected by installation of dispensers of a rapidly acting hand antiseptic. *Am J Infect Control* 2000; 28:273–276.
- 11 Preston GA, Larson EL, Stamm WE. The effect of private isolation rooms on patient care practices, colonization and infection in an intensive care unit. *Am J Med* 1981; 70:641–645.
- 12 Albert RK, Condie F. Hand-washing patterns in medical intensive-care units. *N Engl J Med* 1981; 24:1465–1466.
- 13 Mayer JA, Dubbert PM, Miller M, et al. Increasing handwashing in an intensive care unit. *Infect Control* 1986; 7:259–262.
- 14 Graham M. Frequency and duration of handwashing in an intensive care unit. *Am J Infect Control* 1990; 18:77–80.
- 15 Bittner MJ, Richet EC, Turner PD, Arnold WH Jr. Limited impact of sustained simple feedback based on soap and paper towel consumption on the frequency of hand washing in an adult intensive care unit. *Infect Control Hosp Epidemiol* 2002; 23:120–126.
- 16 O'Boyle CA, Henly SJ, Larson E. Understanding adherence to hand hygiene recommendations: the theory of planned behavior. *Am J Infect Control* 2001; 29:352–360.
- 17 Nobile CGA, Montuori P, Diaco E, Villari P. Healthcare personnel and hand decontamination in intensive care units: knowledge, attitudes, and behaviour in Italy. *J Hosp Infect* 2002; 51:226–232.
- 18 Taylor LJ. An evaluation of handwashing techniques: 1. *Nursing Times* 1978; 74:54–55.
- 19 van den Broek PJ, Verbakel-Salomons EMA, Bernards AT. Quantity versus quality of hand hygiene. *J Hosp Infect* 2001; 49:297–298.
- 20 Fridkin S, Pear SM, Williamson TH, et al. The role of understaffing in central venous catheter-associated bloodstream infections. *Infect Control Hosp Epidemiol* 1996; 17:150–158.
- 21 Harbarth S, Sudre P, Dharan S, et al. Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding and poor hygiene practices. *Infect Control Hosp Epidemiol* 1999; 20:598–603.
- 22 Vicca AF. Nursing staff workload as a determinant of methicillin-resistant *Staphylococcus aureus* spread in an adult intensive therapy unit. *J Hosp Infect* 1999; 43:109–113.
- 23 Grundmann H, Hori S, Winter B, et al. Risk factors for the transmission of methicillin-resistant *Staphylococcus aureus* in an adult intensive care unit: fitting a model to the data. *J Infect Dis* 2002; 185:481–488.  
Mathematical modeling to predict the relative effectiveness of different infection control measures, including hand hygiene.
- 24 Pittet D. Improving compliance with hand hygiene in hospitals. *Infect Control Hosp Epidemiol* 2000; 21:381–386.
- 25 Pittet D. Improving adherence to hand hygiene practice: a multidisciplinary approach. *Emerging Inf Dis* 2001; 7:234–240.  
Sound review of current knowledge.
- 26 Larson EL, Early E, Cloonan P, et al. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. *Behav Med* 2000; 26:14–22.
- 27 Hirschman H, Fux L, Podusel J, et al. with assistance of EURIDIKI. The influence of hand hygiene prior to insertion of peripheral venous catheters on the frequency of complications. *J Hosp Infect* 2001; 49:199–203.
- 28 Sharek PJ, Benitz WE, Abel NJ, et al. Effect of an evidence-based hand washing policy on hand washing rates and false-positive coagulase negative staphylococcus blood and cerebrospinal fluid culture rates in a level III NICU. *J Perinatol* 2002; 22:137–143.
- 29 Gopal Rao G, Jeanes A, Osman M, et al. Marketing hand hygiene in hospitals: a case study. *J Hosp Infect* 2002; 50:42–47.  
Multimodal intervention with subsequent reductions in nosocomial MRSA transmission.
- 30 Aiello AE, Larson EL. What is the evidence for a causal link between hygiene and infections? *Lancet Infect Dis* 2002; 2:103–110.
- 31 Voss A, Widmer AF. No time for handwashing!? Handwashing versus alcoholic rub: can we afford 100% compliance? *Infect Control Hosp Epidemiol* 1997; 18:205–208.
- 32 Larson EL, Aiello AE, Bastyr J, et al. Assessment of two hand hygiene regimens for intensive care unit personnel. *Crit Care Med* 2001; 29:944–951.
- 33 Boyce JM, Kelliher S, Vallande N. Skin irritation and dryness associated with two hand-hygiene regimens: soap-and-water hand washing versus hand antiseptics with an alcoholic hand gel. *Infect Contr Hosp Epidemiol* 2000; 21:442–448.
- 34 Larson E. Skin hygiene and infection prevention: more of the same or different approaches? *Clin Infect Dis* 1999; 29:1287–1294.
- 35 Winnefeld M, Richard MA, Drancourt M, Grobb JJ. Skin tolerance and effectiveness of two hand decontamination procedures in everyday hospital use. *Br J Dermatol* 2000; 143:546–550.
- 36 Lucet J-C, Rigaud M-P, Mentre F, et al. Hand contamination before and after different hand hygiene techniques: a randomized clinical trial. *J Hosp Infect* 2002; 50:276–280.
- 37 Pittet D, Dharan S, Touveneau S, et al. Bacterial contamination of the hand of hospital staff during routine patient care. *Arch Intern Med* 1999; 159:821–826.
- 38 Girou E, Loyeau S, Legrand P, et al. Efficacy of handrubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomized clinical trial. *BMJ* 2002; 325:362–366.
- 39 Weber DJ, Sickbert-Bennett E, Gergen MF, Rutala WA. Efficacy of selected hand hygiene agents used to remove *Bacillus atrophaeus* (a surrogate of *Bacillus anthracis*) from contaminated hands. *JAMA* 2003; 289:1274–1277.  
Recently published laboratory evidence of the differential efficacy of hand hygiene agents on *Bacillus* spp.
- 40 Zimakoff J, Stormark M, Larsen SO. Use of gloves and handwashing behaviour among health care workers in intensive care units: a multicentre investigation in four hospitals in Denmark and Norway. *J Hosp Infect* 1993; 24:63–67.

- 41 Meengs MR, Giles BK, Chisholm CD, *et al.* Hand washing frequency in an emergency department. *J Emerg Nurs* 1994; 20:183–188.
- 42 Thompson BL, Dwyer DM, Ussery XT, *et al.* Handwashing and glove use in a long-term care facility. *Infect Control Hosp Epidemiol* 1997; 18:97–103.
- 43 Karabey S, Ay P, Derbentli S, *et al.* Handwashing frequencies in an intensive care unit. *J Hosp Infect* 2002; 50:36–41.
- 44 Salemi C, Canola T, Eck EK. Hand washing and physicians: how to get them together. *Infect Contr Hosp Epidemiol* 2002; 23:32–35.  
• One of the rare papers addressing the difficult issue of physicians' hand hygiene compliance improvement.
- 45 Ray AJ, Hoyen CK, Eckstein EC, Donskey CJ. Improving healthcare workers' compliance with hand hygiene: is a picture worth a thousand words? *Infect Control Hosp Epidemiol* 2002; 23:418–419.
- 46 Kretzer EK, Larson EL. Behavioral interventions to improve infection control practices. *Am J Infect Control* 1998; 26:245–253.
- 47 Teare EL, Cookson B, French GL, Jenner EA. UK handwashing initiative. *J Hosp Infect* 1999; 43:1–3.
- 48 Weeks A. Why I don't wash my hands between each patient contact. *BMJ* 1999; 319:518.
- 49 Bittner MJ, Riche EC. Surveillance of handwashing episodes in adult intensive-care units by measuring an index of soap and paper towel consumption. *Clin Perform Qual Health Care* 1998; 6:179–182.
- 50 Pittet D. Compliance with hand disinfection and its impact on nosocomial infections. *J Hosp Infect* 2001; 28 (Suppl A):S40–S46.
- 51 Colombo C, Giger H, Grote J, *et al.* Impact of teaching interventions on nurse compliance with hand disinfection. *J Hosp Infect* 2002; 51:69–72.
- 52 Berndt U, Wigger-Alberti W, Gabard B, Elsner P. Efficacy of a barrier cream and its vehicle as protective measures against occupational irritant contact dermatitis. *Contact Dermat* 2000; 42:77–80.
- 53 McCormick RD, Buchman TL, Maki D. Double-blind, randomized trial of scheduled use of a novel barrier cream and an oil-containing lotion for protecting the hands of health care workers. *Am J Infect Control* 2000; 28:302–310.
- 54 Kramer A, Bernig T, Kampf G. Clinical double-blind trial on the dermal tolerance and user acceptability of six alcohol-based hand disinfectants for hygienic hand disinfection. *J Hosp Infect* 2002; 51:114–120.
- 55 Larson E, Silberger M, Jakob K, *et al.* Assessment of alternative hand hygiene regimens to improve skin health among neonatal intensive care unit nurses. *Heart Lung* 2000; 29:136–142.
- 56 Kohan C, Ligi C, Dumigan DG, Boyce JM. The importance of evaluating product dispensers when selecting alcohol-based handrubs. *Am J Infect Control* 2002; 30:373–375.
- 57 Cimiotti JP, Marmur ES, Nesin M, *et al.* Adverse reactions associated with an alcohol-based hand antiseptic among nurses in a neonatal intensive care unit. *Am J Infect Control* 2003; 31:43–48.
- 58 Kramer A, Rudolph P, Kampf G, Pittet D. Limited efficacy of alcohol-based hand gels. *Lancet* 2002; 359:1489–1490.  
•• Cross-over trial that compares the antimicrobial efficacy of 10 alcohol-based gels and five rinses available on the market using stringent European Norms (EN 1500).
- 59 Dharan S, Hugonnet S, Sax H, Pittet D. Comparison of waterless hand antiseptics agents at short application times: raising the flag of concern. *Infect Control Hosp Epidemiol* 2003; 24:160–164.
- 60 Kamp G, Ostermeyer C. Intra-laboratory reproducibility of the hand hygiene reference procedures of EN 1499 (hygienic handwash) and EN 1500 (hygienic hand disinfection). *J Hosp Infect* 2002; 52:219–224.
- 61 Harbarth S, Pittet D, Grady L, *et al.* Interventional study to evaluate the impact of an alcohol-based hand gel in improving hand hygiene compliance. *Ped Infect Dis J* 2002; 21:489–495.  
• Multimodal intervention to promote hand hygiene in a pediatric setting.
- 62 Pittet D, Kramer A. Alcohol-based hand gels and hand hygiene in hospitals [letter]. *Lancet* 2002; 360:1511.
- 63 Parienti JJ, Thibon P, Heller R, *et al.* Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates. *JAMA* 2002; 288:722–727.  
•• Large, randomized equivalence trial conducted in six surgical services from teaching and nonteaching hospitals in France to compare two different regimens for surgical hand preparation (handscrubbing with antiseptic soap versus handrubbing). The use of an alcohol-based handrub solution proved to be as effective as traditional handscrubbing in preventing surgical site infection.
- 64 Bryce EA, Spence D, Roberts FJ. An in-use evaluation of an alcohol-based pre-surgical hand disinfectant. *Infect Control Hosp Epidemiol* 2001; 22:635–639.
- 65 Maury E, Alzieu M, Baudel JL, Haram N. Availability of an alcohol solution can improve hand disinfection compliance in an intensive care unit. *Am J Respir Crit Care Med* 2000; 162:324–327.
- 66 Bischoff W, Reynolds TM, Sessler CN, *et al.* Handwashing compliance by health care workers: the impact of introducing an accessible, alcohol-based hand antiseptic. *Arch Intern Med* 2000; 160:1017–1021.
- 67 Hugonnet S, Perneger TV, Pittet D. Alcohol-based handrub improves compliance with hand hygiene in intensive care units. *Arch Intern Med* 2002; 162:1037–1043.  
• Epidemiological evidence suggesting that the use of alcohol-based handrub at the bedside can bypass the time constraint of hand hygiene action, assessed by the association between increased workload and decreased compliance, in critical care conditions.