

REVIEW ARTICLE

Hand Hygiene for the Prevention of Nosocomial Infections

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SUMMARY

Background: The WHO regards hand hygiene as an essential tool for the prevention of nosocomial infection, but compliance in clinical practice is often low.

Methods: The relevant scientific literature and national and international evidence-based recommendations (Robert Koch Institute [Germany], WHO) were evaluated.

Results: Hygienic hand disinfection has better antimicrobial efficacy than hand-washing and is the procedure of choice to be performed before and after manual contact with patients. The hands should be washed, rather than disinfected, only when they are visibly soiled. Skin irritation is quite common among healthcare workers and is mainly caused by water, soap, and prolonged wearing of gloves. Compliance can be improved by training, by placing hand-rub dispensers at the sites where they are needed, and by physicians setting a good example for others.

Conclusions: Improved compliance in hand hygiene, with proper use of alcohol-based hand rubs, can reduce the nosocomial infection rate by as much as 40%.

Key words: hand hygiene, disinfection, compliance, nosocomial infection, protective gloves

Healthcare workers' hands represent the principal route of transmission of nosocomial pathogens. They are colonized permanently by the physiological flora ("resident flora") and temporarily, depending on the precise nature of the employee's duties, by various pathogens that do not belong to the physiological flora ("transient flora") (1). *Staphylococcus aureus*, for example, can survive for over 2 h on the hands and is found in 10% to 78% of staff (Table 1).

Clean Hands Campaign

Improvement of hand hygiene, with the aim of minimizing nosocomial infection, is a high priority of the World Health Organization (WHO). The promotion of effective measures to improve hand hygiene (e1) is therefore one of the five foremost goals of the WHO's current worldwide Patient Safety Initiative (Announce Action on Patient Safety [High 5s] Initiative, Washington, DC, 4 November 2006). By September 2008 114 countries had given written undertakings to implement these goals. In Germany, the Clean Hands Campaign ("Aktion saubere Hände") was launched on 1 January 2008 under the auspices of the Federal Ministry of Health (e2). By 14 June 2009, 550 hospitals had signed up to the campaign, including two thirds of the university hospitals. The goal is to establish hand disinfection as a decisive quality parameter anchored firmly in clinical routine.

Methods

We began by examining the scientific literature on the provisional WHO recommendation on hand hygiene from the year 2006 (e3). For studies published from 2006 onward we performed a selective review of the publications in the National Library of Medicine. Furthermore, we evaluated the recommendations of the following institutions:

- Commission for Hospital Hygiene and Prevention of Infection, Robert Koch Institute (RKI) (2)
- Association of the Scientific Medical Societies in Germany (AWMF) (e4)
- WHO (final recommendation) (3)
- Centers for Disease Control and Prevention (CDC) (e5).

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TABLE 1

Frequency and persistence of selected nosocomial pathogens on the hands of healthcare workers (1)

Pathogen	Frequent cause of nosocomial...	Frequency on hands	Persistence on hands
Staphylococcus aureus	Surgical site infection, pneumonia, sepsis	10–78%	≥150 min
Pseudomonas spp.	Lower respiratory tract infection	1–25%	30–180 min
Escherichia coli	Urinary tract infection	Unknown	6–90 min
Yeasts including Candida spp.	Lower respiratory tract infection, urinary tract infection, sepsis	23–81%	1 h
Rotavirus	Viral gastroenteritis, particularly in children	20–79%	Up to 4 h
Clostridium difficile	Antibiotic-associated diarrhea	14–59%	Unknown

Importance of protective gloves

The wearing of protective gloves is a sensible precaution in various clinical situations in order to prevent gross soiling or contamination (*Box 1*). It may even break the chain of infection more effectively than hand-washing or hand disinfection. A prospective, controlled intervention study showed that a training session and the availability of gloves directly at the bedside can significantly reduce the incidence of *Clostridium difficile*-associated diarrhea (CDAD) (4). The hands should be disinfected when protective gloves are taken off, because in contrast to surgical gloves, ordinary protective gloves are often permeable to pathogens even before use. Moreover, the hands may have come into contact with the potentially contaminated outer surface of the gloves during removal. In the case of vancomycin-resistant enterococci (VRE), a study showed that despite the use of gloves the same pathogen could be found on the hands of staff involved in treatment in 30% of cases (5).

Hand-washing

Indications

Hand-washing should be an exception in clinical routine (2, 3). The point of washing the hands is mainly to remove visible soiling and only occasionally to reduce the microbial colonization of the skin—for example in contamination by spores of *C. difficile*. Hand-washing is therefore indicated considerably less often than generally assumed. It makes sense to wash the hands before starting work, after finishing work, and following visits to the bathroom. In all other clinical situations in which hand hygiene measures are required, hand disinfection should be preferred on grounds of efficacy and skin tolerability.

Efficacy

Washing with soap and water is much less effective than hygienic hand disinfection (1–3). Even washing for several minutes reduces the skin’s resident flora

hardly at all (*Table 2*). Washing reduces the transient flora (contaminating flora) by only 2 to 3 log₁₀ levels. The same is true for bacterial spores (6). Given the frequently short duration of washing, the efficacy of antimicrobial soaps hardly exceeds that of ordinary soaps (6), so that normal soaps are generally perfectly adequate for everyday clinical use.

Benefits and risks

The limited benefits of hand-washing are accompanied by the risk of cutaneous irritation and hand eczema. Frequent washing of the hands can lead to dryness and impair the barrier function of the skin (7). The skin thus continually loses fats and water-binding factors, and noxious substances can more easily penetrate the epidermis. Clinically manifest irritant eczema of the hand may gradually develop. Given the comparatively slight benefit, it swiftly becomes clear that hand-washing should be seen as an exception. Merely in the case of contamination with spore-forming bacteria, e.g., *C. difficile*, is it useful to wash the hands after disinfection, because bacterial spores are naturally resistant to alcohol.

Hygienic hand disinfection

Indications

Hand disinfection is indicated in almost all interactions of medical staff with patients (*Box 2*) (2).

For example, the hands should be disinfected after direct patient contact (measurement of vital functions, auscultation, palpation) or after contact with potentially infectious materials, e.g., bandages. Hand disinfection is most important, however, in the case of potential nosocomial infections (2, 3). The most frequent such infections in Germany are catheter-associated urinary tract infection (ca. 42%), ventilator-associated pneumonia (ca. 21%), surgical site infection (ca. 16%), and catheter-associated bloodstream infection (ca. 8%) (8). Hygienic hand disinfection can make a substantial contribution to preventing these infections if consistently performed at the following junctures (2, 3):

BOX 1

Clinical situations in which the wearing of protective gloves is especially indicated

- Examination of incontinent patients
- Examination or treatment of MRSA patients
- Examination or treatment of patients with *C. difficile*-associated diarrhea
- Endotracheal aspiration
- Blood sampling
- Removal of drains or bandages
- Handling of secretions or excretions

- Catheter-associated urinary tract infection: before placement of the urinary catheter, before and after contact with the catheter
- Ventilator-associated pneumonia: before and after intubation, before and after aspiration
- Surgical site infection: before and after contact with wounds, after removal of a bandage
- Catheter-associated bloodstream infection: before placement of vascular catheters, before manipulation of vascular catheters, before preparation of intravenous medication.

Efficacy

The commonly available hand rubs are considerably more effective than hand-washing with soap (2, 3). Within 30 s, for example, the following bacteria are

not only greatly reduced but practically completely eliminated (e6):

- *Escherichia coli*—most frequent cause of catheter-associated urinary tract infection
- *Pseudomonas aeruginosa*—very frequent cause of ventilator-associated pneumonia
- *Staphylococcus aureus*—most frequent cause of surgical site infection
- *Staphylococcus epidermidis*—most frequent cause of catheter-associated bloodstream infection.

The same applies to yeasts such as *Candida* spp. or *Rhodotorula* spp. and to coated viruses such as HBV, HCV, HIV, and the influenza viruses. Hand disinfection thus eliminates the majority of agents known to cause nosocomial infections.

There are only a few pathogens against which the commonly available hand rubs are ineffective. These include uncoated viruses such as noroviruses and the spores of spore-forming bacteria such as *C. difficile*. In the case of the noroviruses special virucidal hand rubs are recommended (see the RKI's list of disinfectant hand rubs [9]), because epidemiological studies have shown that as part of a package of measures these preparations make a real contribution to the containment of outbreaks. For spore-forming bacteria such as *C. difficile*, the recommendation is first to disinfect the hands in order to kill off the vegetative form, then to wash them briefly but thoroughly to reduce the number of spores as much as possible (e7).

Benefits and risks

Hand disinfection is key to the prevention of nosocomial infections. At Geneva University Hospital, improvement of the compliance rate from 48% to 66% over a 5-year period lowered the frequency of nosocomial infections by more than 40% (10). Over

TABLE 2

Effect of hand-washing and hand disinfection (1, 24)

Type of treatment	Target flora	Mean reduction	Duration
Washing with soap and water	Resident flora	ca. 0.4 log ₁₀	3 min
Disinfection with n-propanol (60%)	Resident flora	ca. 2.7 log ₁₀	3 min
Washing with soap and water	<i>Escherichia coli</i>	ca. 2.6 log ₁₀	30 s
	Spores of <i>Bacillus atrophaeus</i> (as surrogate for spore-forming bacteria such as <i>Clostridium difficile</i>)	ca. 2 log ₁₀	
	<i>Staphylococcus aureus</i>	ca. 2 log ₁₀	
Hygienic hand disinfection	<i>Staphylococcus aureus</i>	ca. 6.5 log ₁₀	30 s
	<i>Enterococcus faecalis</i>	ca. 6.5 log ₁₀	
	<i>Pseudomonas aeruginosa</i>	ca. 6.7 log ₁₀	
	<i>Escherichia coli</i>	ca. 4.6 log ₁₀	

BOX 2

Hygienic hand disinfection benefits the patient in the following clinical situations (2):

- Before invasive procedures, even if gloves will be worn, e.g.
 - Insertion of a venous or bladder catheter
 - Angiography, bronchoscopy, endoscopy
 - Injections and punctures
- Before contact with patients who are at particular risk of infection, e.g.
 - Leukemia patients
 - Polytrauma patients
 - Burns patients
 - Irradiated and other severely ill patients
- Before exposure to potential contamination
 - Preparation of infusions
 - Mixing of combined infusions
 - Drawing up of syringes
- Before and after any contact with
 - Wounds
 - Insertion sites of catheters or drains
- After contact with
 - Blood, secretions, excrement, or infected regions of the body
 - Urine-collecting systems, aspirators, ventilators, ventilation masks, tracheal tubes or drains
 - Potentially infectious patients, e.g., MRSA patients
- After removal of protective gloves
- After contact with a patient during a clinical round or in the consultation or treatment room

the same period the rate of new infections by methicillin-resistant *S. aureus* (MRSA) was reduced by more than 50% (10).

In contrast to popular opinion, the irritant potential of alcohol-based hand rubs is very low. Commercially available preparations are generally tolerated much better than the detergents in hand-washing agents (7, 11). Even frequent, intensive hand disinfection detracts only minimally from the skin's barrier function and makes the skin only slightly drier. This is due partly to the skin care substances usually found in hand rubs. Allergic reactions to the ingredients of hand-rub preparations are extremely rare (1, 3).

For hand disinfection to be effective, both hands must be completely covered. To this end, an adequate amount of the hand rub must be applied efficiently. The duration of application should be 22 to 28 s. Shorter application times, e.g., 15 s, almost always fail to cover the hands completely (12). Surprisingly, the best results are achieved when users are left to their own devices, not with a strictly regulated procedure. Special attention must be paid

to the fingertips and thumbs, however; these parts of the hand are most likely to come into contact with the patient, and the greatest proportion of the bacteria are found on the fingertips (13).

Hand eczema

There can be no doubt that hygiene precautions are a risk factor for occupational hand eczema. Consequently employment in nursing and related professions involves the risk of contracting occupational dermatosis (14). Many consider rough, flaking skin on their hands as normal in their line of work and fail to realize that this may be the first sign of hand eczema (*Figure 1*). In a survey carried out by the German Contact Allergy Group (Deutsche Kontaktallergiegruppe, DKG), more than 70% of nursing staff reported irritant skin symptoms within a year, and 46% considered them detrimental in their daily lives (15).

Most nurses still believe that alcohol-based hand rubs damage their skin more than hand-washing (15). However, alcohol-based preparations are much kinder to the skin than hand-washing agents because they are less harmful to the cutaneous barrier (as measured by transepidermal water loss) and dry the skin out less (as measured by corneometry) (7, 11). Interestingly, the application of alcohols after hand-washing can even reduce the irritation caused by the washing, probably by elimination of residual detergent monomers (7). Nevertheless, many users think that hand rubs harm their skin. One reason is the burning felt when the alcohols stimulate the pain receptors in damaged areas of skin. The alcohol-based hand rub is then blamed for the symptoms (“it only burns with the alcohol”) and hand disinfection is abandoned in favor of washing. The burning stops, but the damage accelerates: a vicious circle begins, resulting in manifest hand eczema (*Figure 2*) and, in the worst case, inability to work (16).

A burning sensation on use of a disinfecting hand rub is a warning of impairment of the skin's barrier function. Those affected should avoid activities harmful to the skin—washing, occlusion (protective gloves), contact with soaps, direct contact with irritant disinfectants—and apply copious quantities of skin protection and skin care products.

Some users state that alcohol-based hand rubs have a sensitizing effect. Nevertheless, sensitization to an alcohol could be excluded in all 50 persons who were tested for allergic reactions to an alcohol-based hand rub because of suspected intolerance. Oversensitivity to an excipient (e.g., cetearyl octanoate) was demonstrated, however (15).

An intact cutaneous barrier is of more than just cosmetic and functional relevance. Eczematous hands are also colonized to a greater degree by pathogens than are healthy hands (17, 18). The principles of hand care and protection should therefore be taught to all healthcare workers and should form part of every training program (19). They are also included in the Clean Hands Campaign.



Figure 1: Early irritant skin changes between the digits



Figure 2: Manifest irritant hand eczema

Care and protection of the skin

Appropriate precautions when using potentially irritant substances can prevent harm to the skin. Moreover, adequate protection and care of the skin are of paramount importance for the maintenance of a functioning cutaneous barrier (e8). These precautions should be integrated in the working routine and can, if properly implemented, protect the hands without compromising disinfection. Skin protection plans should be drawn up with information about the available products and their use (see Technical Rule for Hazardous Substances [TRGS] 401 of June 2008: Risks resulting from skin contact—determination, evaluation, measures) (20). Staff should have access to data showing the efficacy of all preparations employed, as well as information on their uses (see the “Occupational Skin Preparations” (“Berufliche Hautmittel”) guideline of the German Working Group for Occupational and Environmental Dermatology [Arbeitsgemeinschaft für Berufs- und Umweltdermatologie, ABD]) (21). Skin protection products should be applied before starting work and after every break, in order to minimize drying out and impairment of the skin’s barrier function by wet work. After work, skin care creams help to accelerate cutaneous regeneration. Because components of some of these preparations may promote penetration of irritants, they should preferably be applied only when work is over (21).

Any member of staff exhibiting clinically manifest cutaneous irritation at work should be referred to a

BOX 3

Measures to improve compliance

- Staff training with regard to the clinical situations in which hand disinfection is indicated
- Inclusion of the goals in the training program, because behavior learned during basic training is put into practice much more effectively than that taught in later training sessions, when established routine behavior has to be changed
- Disinfecting hand rubs should be available where they are actually needed. This can be achieved by simple means both in the hospital and the doctor’s office. If wall dispensers cannot be mounted, the doctor may be able to carry a bottle of hand rub in the pocket of his/her lab coat.
- Reduction of hand-washing to a minimum in order to avoid unnecessary skin irritation
- Senior members of medical staff must recognize that they have to set an example and act accordingly.

dermatologist or occupational medicine specialist, who can then institute the appropriate procedures, including reporting of the case to the accident insurance provider (22).

Compliance

Unfortunately the overall rate of compliance in hand hygiene is poor, only 50% on average. In other words, every second time hand disinfection is required, it is not carried out. The primary goal of all initiatives to improve compliance in hand hygiene is optimization of the rate of hand disinfection. As a secondary aim, of course, it is also important to reduce hand-washing to a minimum.

Barriers

There are many different reasons why healthcare workers disinfect their hands much less often than necessary for protection of their patients. These include:

- Insufficient knowledge of the clinical situations in which the patient clearly benefits
- Lack of products or dispensers: unavailability of the disinfecting hand rub right where it is needed
- Lack of time: hand disinfection is frequently not carried out because of increasing pressure of work, or when a ward is over-occupied or understaffed (23)
- Cutaneous irritation: skin problems with use, e.g., dryness, irritation, or burning combined with inadequate knowledge of the causes

- Failure of high-ranking medical staff to set an example: junior doctors and nurses will think that hand disinfection cannot be very important if senior doctors dispense with it.

Measures to achieve improvement

Readily implementable measures can be drawn up to counter the above-mentioned factors and improve compliance (Box 3). Moreover, primary prevention by means of early education on hand hygiene (e.g., during training, with explanation of the efficacy and cutaneous tolerance of hand hygiene measures), accompanied by regular motivational campaigns, is effective. Furthermore, skin protection and care products must be available to all employees at their workplace. One can only appeal to all senior staff to set a proper example. It will then be much more difficult for junior workers not to follow suit.

Conclusion

Evidence-based hand hygiene can prevent transmission of the most important nosocomial pathogens and also keep employees' skin healthy. In most clinical situations hygienic disinfection is indicated for hand decontamination on grounds of better efficacy and cutaneous tolerance. Washing with soap and water is necessary only when the hands are visibly soiled, or following disinfection in the case of contamination by spores of bacteria such as *C. difficile*. Compliance could be improved by knowledge of the principal clinical circumstances in which hand disinfection by health-care workers genuinely benefits the patient.

Conflict of interest statement

Dr. Kampf is an employee of Bode Chemie GmbH, Hamburg. Professor Löffler has received honoraria for lectures given on behalf of Bode Chemie GmbH. Professor Gastmeier declares that no conflict of interest exists according to the guidelines of the International Committee of Medical Journal Editors. Manuscript received on 25 February 2009, revised version accepted on 6 July 2009.

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KEY MESSAGES

- Hand disinfection eliminates the transient flora and is one of the most important precautions for specific prevention of transmission of nosocomial infections.
- In practice, on average every second necessary disinfection of the hands is not actually carried out. The WHO has therefore launched a worldwide initiative to improve compliance.
- The rate of nosocomial infections can be reduced by up to 40% by improved compliance in hand disinfection.
- Hand-washing damages the skin more than hand disinfection. It should principally be restricted to visibly soiled hands and, following disinfection, hands contaminated with spore-forming bacteria such as *C. difficile*.
- A burning sensation on hand disinfection represents an important warning of damage to the cutaneous barrier. Activities harmful to the skin, e.g., frequent washing, must then be avoided and skin protection and care products applied more intensively.

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