

## REVIEW ARTICLE

# Skin Hygiene and Infection Prevention: More of the Same or Different Approaches?

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The purpose of this article is to review research indicating a link between hand hygiene and nosocomial infections and the effects of hand care practices on skin integrity and to make recommendations for potential changes in clinical practice and for further research regarding hand hygiene practices. Despite some methodological flaws and data gaps, evidence for a causal relationship between hand hygiene and reduced transmission of infections is convincing, but frequent handwashing causes skin damage, with resultant changes in microbial flora, increased skin shedding, and risk of transmission of microorganisms, suggesting that some traditional hand hygiene practices warrant reexamination. Some recommended changes in practice include use of waterless alcohol-based products rather than detergent-based antiseptics, modifications in lengthy surgical scrub protocols, and incorporation of moisturizers into skin care regimens of health care professionals.

Skin hygiene, particularly of hands, is considered to be one of the primary mechanisms to reduce risk of transmission of infectious agents by both the contact and fecal-oral routes. Over the decades, bathing, scrubbing, and washing traditions and rituals have become established within the health care setting, but several factors suggest the need for a reassessment of skin hygiene and how it is practiced effectively. First, the increasing prevalence of diseases and therapies that compromise immune function means that patients are at higher risk for infections. Therapeutic advances allow susceptible hosts (e.g., very-low-birthweight infants, persons with malignancy or HIV infection, recipients of organ transplantation) to live longer in a state of heightened vulnerability to infection. Second, the increased availability and use of gloves for patient care raise questions about the relative importance of hand hygiene in this era of ubiquitous glove wearing. Yet although gloves may offer a large measure of protection to patients and health care providers, reports of skin damage and sensitization to glove products are mounting and threaten to give rise to a new set of serious problems [1, 2]. Third, there is a limited armamentarium of antiseptic ingredients that can be safely and effectively used on skin over prolonged periods of time. In fact, the current debate surrounding the increased use of antiseptic products, not only in health care settings but also for more general bathing and

washing, has increased focus on the potential for the emergence of antiseptic-resistant strains of skin flora [3–6]. Finally, health care professionals routinely wash significantly less often and for shorter durations than recommended, and approaches to change their behavior have not been effective [7].

Unfortunately, those who do wash frequently and vigorously risk damage to their skin, which ironically results in shedding of more organisms into the environment [8–10]. Hence, we may be reaching a point of diminishing return with continued campaigns to improve the frequency and quality of skin cleansing and hand hygiene as currently practiced and recommended; the situation conjures up the image of “butting one’s head against a wall.” The purpose of this article is to facilitate a critical analysis and thoughtful approach to skin hygiene among health care professionals, an area fraught with tradition and ritual, by reviewing research on the link between hand hygiene and nosocomial infections and the effects of hand care practices on skin integrity and by making recommendations regarding the need for potential changes in hand hygiene practices and for further research.

## Does Skin Cleansing Reduce Risk of Infection?

*Transmission of nosocomial infections by contaminated hands.* Although others before Semmelweis (1861) recognized the infectious nature of puerperal sepsis and the importance of the hands of care attendants in spreading disease, he was the first to demonstrate the role of hand hygiene in the prevention of person-to-person transmission of infection [11]. There is little other published work specifically related to hand hygiene until the mid-20th century. During the 1960s, one group of investi-

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**Table 1.** Quasi-experimental, sequential hospital-based studies of the effect of hand hygiene on risk of infection.

Reference	Year	Author(s)	Hospital setting	Significant results
[36]	1977	Casewell and Phillips	Adult critical care (U.K.)	Reduced rates of nosocomial infection due to endemic <i>Klebsiella</i> species
[37]	1982	Maki	Adult critical care	Reduced rates of nosocomial infection
[38]	1984	Massanari and Hierholzer	Adult critical care	Reduced rates of nosocomial infection for some units
[23]	1990	Simmons et al.	Adult critical care	No effect
[39]	1992	Doebelling et al.	Adult critical care	Significant differences in rates of nosocomial infection between the 2 regimens
[40]	1994	Webster et al.	Neonatal intensive care	Elimination of methicillin-resistant <i>Staphylococcus aureus</i>
[41]	1995	Zafar et al.	Newborn nursery	Elimination of methicillin-resistant <i>S. aureus</i>

gators [12–14] was among the first to demonstrate that although *Staphylococcus aureus* is normal flora generally residing in the anterior nares, it is rarely airborne, it is almost always transmitted by direct touch, and handwashing reduces its transmission severalfold. They found that *S. aureus* was spread by the airborne route only 6%–10% of the time, but 54% of babies in a newborn nursery handled by a “carrier” nurse with unwashed hands subsequently became colonized with her strain of *S. aureus* [12]. When noncarrier nurses handled a baby colonized with *S. aureus* and then handled another baby without handwashing, the transmission rate from the nurses’ hands was 43%. Antiseptic handwashing subsequently reduced the transmission rate to 14%. Furthermore, 92% of babies attended by a nurse colonized with *S. aureus* who did not wash her hands before touching the baby acquired her staphylococcal strain, compared with 53% of babies handled with washed hands in the same manner. Colonization took four times longer among infants handled by nurses with washed hands [12–14]. These same researchers, however, also recognized the limitations to the effectiveness of handwashing. Careful control and monitoring of handwashing resulted in an ~50% reduction in transmission. They demonstrated that hands of personnel are probably the most important source of transmission to patients but that “at best the available means of control afford only moderate reduction in transmission. Thus, further approaches must be sought” [14].

A number of commentators have pointed out the basic misconception that simple handwashing with plain soap consistently and reliably prevents microbial transmission [15–17]. Ehrenkranz [16] discussed the necessity for use of an antiseptic agent whenever hands are heavily contaminated if a satisfactory reduction in contaminants is to be effected. Meers [10] demonstrated 2 decades ago that washing with plain soap may actually increase the potential for transmission because of a 17-fold increase in the dispersal of bacterial colonies from the skin of the hands. Even with use of antiseptic preparations, reductions in skin microbial density beyond a certain equilibrium level may not be attained [18]. In fact, Ojajarvi et al. [19] noted that the numbers of organisms spread from the hands of nurses who washed frequently with an antimicrobial soap actually increased after a period of time and that this was associated with declining skin health.

Even minimal contacts, such as touching a patient’s shoulder or hand or measuring blood pressure, result in transmission of

several logs of bacteria to the hands of the care provider [20]. Similarly, significant transmission of nurses’ antibiotic-resistant coagulase-negative staphylococcal flora to critically ill patients has been shown to occur after relatively short times [21]. Hence, it is often very difficult for providers to estimate with any degree of certainty when heavy contamination of their hands has occurred or when they are likely to transmit microorganisms from their own skin. In light of these limitations, coupled with the well-documented problems associated with inadequate handwashing practices [22], it is not surprising that some investigators have failed to detect any measurable impact of handwashing on nosocomial infection rates [23], and others have suggested that handwashing may not be necessary before gloving [24].

A search for the keyword “handwashing” in the MEDLINE database (1977–November 1998) found 676 citations, but only 39 (5.8%) were focused primarily on the role of hand hygiene in the prevention of infection. The majority of these studies were retrospective designs—case-control or outbreak investigations—that demonstrated a correlation and temporal relationship between improved handwashing and reduced rates of infection, but this causal evidence was often weak [25, 26]. From 1977–1998, there were 16 published quasi-experimental studies designed to examine the effects of a handwashing intervention on the risk of infection. Six of these were in schools or day care centers [27–32], 3 in Bangladeshi communities [33–35], and 7 in hospitals (table 1). Six of the 7 hospital-based studies had statistically significant results indicating that improved hand hygiene practices had a beneficial impact on infection rates. Although this body of evidence is impressive, only 2 studies reported an acceptable power calculation, several lacked adequate controls, and none were randomized or blinded. Unfortunately, it is not feasible in the patient care setting to blind subjects or investigators to hand hygiene regimen, since most products have distinctive characteristics. The demands of patient care and limitations of the physical setting also make randomization or separation of patients into study groups unfeasible. Therefore, it is not possible to completely rule out bias or confounding as explanations for these results. Despite these limitations, cumulative evidence for a causal link between hand hygiene and reduced risk of transmission of nosocomial pathogens is stronger than for many other accepted clinical practices.

*Bathing, showering, and body washing.* In 11 studies re-

viewed by Keswick et al. [42], antimicrobial soaps significantly reduced rates of superficial cutaneous infections. Another 15 experimental studies reviewed demonstrated a reduction in bacteria on the skin with use of antimicrobial soaps, but none of these studies assessed rates of infection as an outcome.

Studies of showering and bathing conducted during the 1960s–1980s demonstrated that these activities increase dispersal of skin bacteria into the air and ambient environment [8, 43–45]. This phenomenon seems to be due to the breaking up and spreading of microcolonies on the skin surface, with resultant contamination of more surrounding squamous cells [8]. These studies served as a basis for a change in practice among surgical personnel, who are now generally discouraged from showering immediately before entering the operating room. Other investigators have shown that the skin microflora varies between individuals but is remarkably consistent for each individual over time. Even in the absence of bathing for many days, the flora reaches an equilibrium and remains qualitatively and quantitatively stable [46–48].

In the case of surgical or other high-risk patients, showering with antiseptic agents has been tested for its effect on postoperative surgical site infection rates. In some studies, several antiseptic preoperative showers or baths have been associated with reduced postoperative infection rates, but in others, no differences were observed [49–53]. Whole-body washing with chlorhexidine-containing detergent has been shown to reduce infections among neonates [54], but risks of absorption and safety preclude this practice from routine care. Several studies have demonstrated significant reductions in rates of acquisition of methicillin-resistant *S. aureus* for surgical patients bathed with a triclosan-containing product [55–57]. Therefore, preoperative showering or bathing with an antiseptic may be justifiable for some patient populations.

### Effects of Hygienic Practices on Skin

**Skin as barrier.** The most superficial layer of the epidermis, the stratum corneum, is composed of flattened dead cells (corneocytes or squames) attached to each other to form a tough horny layer of keratin mixed with several skin lipids. This horny layer is analogous to a wall of bricks (corneocytes) and mortar (lipids) and serves as the primary protective barrier. Lipids are an important component in maintaining the hydration, pliability, and barrier effectiveness of the skin. There are ~15 layers of stratum corneum. A new layer is formed approximately daily, and it is completely replaced about every 2 weeks. From healthy skin, ~10<sup>7</sup> particles are disseminated into the air each day, and 10% of these skin squames contain viable bacteria [58, 59].

The superficial skin layers absorb or lose water and, under normal circumstances, retain sufficient moisture to keep the skin soft and pliable. Water is the plasticizer of the stratum corneum, and with increased hydration comes increased diffusibility. One important function of the intercellular lipids is

to prevent dehydration of the corneocytes. Depending on the product used, washing can raise the pH of the skin, and long-term changes in skin pH may pose a concern, since some of the antibacterial characteristics of the skin are associated with its normally acidic pH [60]. With prolonged soap contact, skin pH can reach 7.0–8.5 and remain high for 3–4 h [61]. Some soaps are associated with long-standing changes in skin pH, reduction in fatty acids, and, subsequently, changes in resident flora such as propionibacteria [62]. In a study examining the effect on the skin of repeated use of 2 different washing agents, all skin function tests (stratum corneum capacitance resistance, lipid measurements, transepidermal water loss, pH, laser Doppler flow, and skin reddening) were markedly changed after a single wash, and after 1 week, further damage was noted [63]. Wilhelm et al. [64] tested irritant skin reactions induced by 3 different surfactants and found that damage was present for days; complete skin repair was not achieved until 17 days after exposure. Soaps and detergents, particularly those that are anionic or cationic, are the most damaging of all substances routinely applied to skin [65, 66].

It is generally agreed that removal of a certain amount of contaminated surface fats and of bacteria attached to superficial epidermal cells is an essential hygienic feature. However, the lipid and cell removal through washing should be somewhat limited to avoid damage to lower layers of the epidermis [61]. Each time the skin is washed, it undergoes profound changes. Most of these changes are transient, but among persons in occupations such as health care, for whom frequent hand-washing is required, long-term changes in the skin can result in chronic damage, irritant contact dermatitis and eczema, and concomitant changes in flora.

**Impact of hand care practices on skin microbiology.** Physiological factors that control the bacterial skin flora include humidity, water content, skin lipids, temperature, and rates of desquamation [67, 68], and washing results in changes in all of these factors. Although the loss of the first few layers of stratum corneum reduces numbers of bacterial colonies shed from hands, counts remain stable with removal of subsequent layers, indicating that resident skin flora is located throughout skin layers in the deeper regions of hair follicles and sebaceous glands [69]. The loss of the outermost layers of the skin from washing is accompanied by an increase in transepidermal water loss, indicating reduced barrier function [58].

Washing defats the skin, and the rate of lipid replenishment on the dorsum of the hands is only ~20% after 1 h and 50% after 3 h [70]. Fatty acids in the horny layer also have fungicidal and bactericidal activity important in modulating the skin flora [60]. Irritant contact dermatitis associated with frequent hand-washing is one of the most prevalent occupational risks for health care professionals. The prevalence range is ~10%–45% [71–74]. Damaged skin more often harbors increased numbers of potential pathogens. Furthermore, washing damaged skin with either plain or antiseptic soap is less effective in re-

ducing numbers of bacteria on hands than is washing normal skin, and numbers of organisms shed from damaged skin are often higher than from healthy skin [75–77].

Numerous studies have shown alcohol-based formulations (isopropyl, ethyl, or *n*-propanol in concentrations of 60%–90% [vol/vol]) to be equivalent or superior to antiseptic detergents for microbial killing [78–82]. In addition, alcohols with appropriate emollients are at least as tolerable on skin as are antiseptic detergents [83–85]. Alcohols are rapid-acting and broad-spectrum and require no washing or drying, reducing damage due to mechanical friction. Alcohol formulations are commonly used in Europe but have not been readily adopted in the United States.

**Importance of emollients and moisturizers.** In the 1960s and 1970s, in response to reports of nosocomial infections traced to contaminated lotion [86–88], hand moisturizing products were generally banned from hospitals and their use by staff strongly discouraged. In the 1980s and 1990s, the increased prevalence of skin problems associated with more gloving and washing, as well as better product packaging to reduce the risk of contamination of lotions, has resulted in the realization that emollients applied to hands are desirable, perhaps even essential, in clinical practice.

As early as the 1950s and 1960s, an antiseptic hand cream was shown by British investigators to control cross-infection [89, 90] and to be more effective than alcohol alone or antiseptic detergent in reducing microbial skin counts [91]. More recent data from the United States indicate that an antiseptic ingredient in the emollient may not even be necessary for protective effects—even application of inert ointments or lotions (as long as extrinsic contamination is prevented) has been associated with reduced rates of colonization among adults [92] and notably among neonates. In 2 prospective trials, positive cultures of blood and CSF were significantly reduced after the skin of very-low-birthweight babies was treated with a preservative-free topical ointment [93, 94]. Investigators speculated that this ointment supplemented the ineffective epidermal barrier of the neonatal skin. On the other hand, this same ointment was a source of bloodstream infection in neonates after it became contaminated [95]. Skin emollient, with or without antiseptic, greatly reduces dispersal of bacteria from the skin for up to 4 h [44]; thus some of its effectiveness in reducing infections may be the result of simply preventing the bacteria present on skin from shedding.

There is biological evidence to support the hypothesis that the use of emollients on skin of health care professionals may be protective against cross-infection. Moisturizers prevent dehydration, damage to barrier properties, desquamation, and loss of skin lipids; restore the water-holding capacity of the keratin layer; and increase the width of corneocytes [96, 97]. There is growing interest in the use of barrier creams and lotions that not only shield damaged skin but also restore its structure and/or function. In a Swedish single-blind study, a moisturizing

cream was found to accelerate the rate of recovery of surfactant-damaged skin [98].

In a recent randomized, double-blind trial comparing scheduled use (four times per day) of 2 hand lotions by 54 nurses with severe hand irritation, McCormick et al. [99] reported marked, sustained improvements in skin condition in both groups. The improvement was significantly greater in the group that used an oil-based product. However, oil-containing lotions may degrade latex gloves and increase the transfer of allergenic glove proteins to skin [100]. For these reasons, the National Institute of Occupational Safety and Health recommends that oil-containing hand products not be used when latex gloves are worn.

### Skin Care Practices for the Health Care Professional

All of this suggests that more frequent washing by traditional techniques with use of detergents, soaps, and antimicrobial ingredients needs careful reassessment in light of the damage done to skin and resultant increased risks of harboring and transmitting infectious agents. With respect to washing and scrubbing, more of the same is unlikely to be better and may, in fact, be worse. The goal should be to identify skin hygiene practices that provide adequate protection from transmission of infecting agents while minimizing the risk of changing the ecology and health of the skin and increasing resistance in the skin flora.

**Degerming with detergent-based antiseptics or alcohol.** Working in areas housing patients at high risk of infection (e.g., critical care, surgery, oncology, transplantation, those at the extremes of age) requires that care providers minimize the chances that their own skin, particularly their hands, spreads infection. This often necessitates the use of topical antimicrobial products. Herein health care professionals face a dilemma. There is the high prevalence of occupational skin problems associated with frequent handwashing and gloving [101]. However, faced with increasingly vulnerable patient populations, the demand for “clean” hands has never been greater. Additionally, not only is more handwashing potentially damaging to skin, it is also costly. Voss and Widmer [102] calculated, on the basis of recommended standards for duration and frequency, that traditional soap and water handwashing would consume 16 h of time per shift for every 12 intensive care unit personnel and would probably interfere with patient care or require additional staff, compared with a requirement of 3 h per shift if alcohol hand rinses were used.

Meers and Yeo [103] reported that microbial counts on hands were reduced satisfactorily by either a surgical scrub or an alcoholic lotion but that there was no increase in skin shedding after alcohol application, compared with an 18-fold increase after scrubbing. The reduction in skin damage associated with a change from antiseptic detergent wash to alcohol lotion plus the reduced shedding led these authors to conclude that “a spirit based hand lotion should be used as a substitute for hand-

**Table 2.** Significant characteristics of hand-hygiene products.

Option	Antimicrobial activity	Sustained activity	Potential for resistance to emerge	Microbial shedding of skin squames
Non-antimicrobial soaps and detergents	Minimal	None	None	Maximal
Antimicrobial products <sup>a</sup>				
Intermittent use only	Moderate	Moderate	Moderate	Moderate
Continuous, general use	Maximal	Maximal	Maximal	Maximal
Alcohol-based products, intermittent use for degerming	Maximal	None	None	Minimal

<sup>a</sup> Products containing antiseptic ingredients such as triclosan, hexachlorophene, chlorhexidine gluconate.

washing when this is done for degerming rather than cleaning” [103]. One wonders why, if alcohol hand degerming has such advantages, it has not been readily adopted in the United States. This is probably explained in part by the fact that much of the research has come from Europe, and we seem to be more familiar with and take more seriously research done in this country. It may also be associated with the fact that a number of antiseptic detergent-based soaps available in this country are efficacious and marketed well, and there is a perception that alcohol-based products are drying or caustic.

*Use of emollients, lotions, and skin protectants.* Moisturizing the skin appears to be beneficial, not only for skin health but also perhaps for reducing the shedding and transmission of microbes. However, there is so much variability in the content and formulations of lotions and creams and in testing methodologies that it is difficult to interpret the clinical relevance of many reports [104, 105]. Hence this is one of the most promising areas of research in skin care. One caution with the use of lotion on hands is that the residual antibacterial activity of chlorhexidine gluconate is neutralized by anionic surfactants commonly found in most hand lotions [106, 107]. Unfortunately, despite the fact that some chlorhexidine-compatible lotions are available, many patient care personnel are using both a chlorhexidine-containing hand soap and a lotion that neutralizes its effect [101].

*Recommendations.* For the health care professional, important characteristics of a topical antiseptic product are antimicrobial efficacy, minimal skin shedding and damage, sustained chemical activity, and reduced potential for emergence of resistance. Unfortunately, there is no single ideal product, and use of one product or another will have various advantages and disadvantages (table 2). To improve the skin condition of health care professionals and reduce their chances of harboring and shedding microorganisms from the skin, the following recommendations warrant consideration and evaluation with well-designed clinical trials.

First, as an alternative to antimicrobial, detergent-based products when skin of staff is damaged or when frequent hand hygiene is necessary, consider use of mild, nonantimicrobial skin-cleansing products (soaps or detergents) to remove physical dirt and debris. When degerming is needed (e.g., before invasive procedures or contacting highly susceptible patients), use a waterless alcohol-based product. Second, in clinical areas such as the operating room and neonatal and transplant units,

modify lengthy scrub protocols that use brushes or other harsh mechanical action to shorter, less traumatic washing regimens. Third, incorporate use of skin emollients or barrier creams into skin care regimens and procedures for staff (and possibly patients as well). Finally, carefully assess characteristics of skin moisturizing products for compatibility with any topical antimicrobial products being used and for physiological effects on the skin.

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