Hygiene of the Skin: When Is Clean Too Clean?

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Skin hygiene, particularly of the hands, is a primary mechanism for reducing contact and fecal-oral transmission of infectious agents. Widespread use of antimicrobial products has prompted concern about emergence of resistance to antiseptics and damage to the skin barrier associated with frequent washing. This article reviews evidence for the relationship between skin hygiene and infection, the effects of washing on skin integrity, and recommendations for skin care practices.

For over a century, skin hygiene, particularly of the hands, has been accepted as a primary mechanism to control the spread of infectious agents. Although the causal link between contaminated hands and infectious disease transmission is one of the best-documented phenomena in clinical science, several factors have recently prompted a reassessment of skin hygiene and its effective practice.

In industrialized countries, exposure to potential infectious risks has increased because of changing sociologic patterns (e.g., more frequent consumption of commercially prepared food and expanded child-care services). Environmental sanitation and public health services, despite room for improvement, are generally good. In addition, choices of hygienic skin care products have never been more numerous, and the public has increasing access to health- and product-related information (1). This paper reviews evidence for the relationship between skin hygiene and infection, the effects of washing on skin integrity, and recommendations for skin care practices for the public and health-care professionals.

Does Skin Cleansing Reduce Risk for Infection?

Personal Bathing and Washing

There is a clear temporal relationship between improvement in general levels of cleanliness in society and improved health. Greene (2) used historical and cross-cultural evidence and causal inference to associate personal hygiene with better health. However, the role of personal cleanliness in the control of infectious diseases over the past century is difficult to measure, since other factors have changed at the same time (e.g., improved public services, waste disposal, water supply, commercial food handling, and nutrition) (3).

Studies of personal and domestic hygiene and its relationship to diarrhea in developing countries demonstrate the effectiveness of proper waste disposal, general sanitary conditions, and handwashing (4,5). However, aside from hand cleansing, specific evidence is lacking to link bathing or general skin cleansing with preventing infections. Part of the difficulty in demonstrating a causal association between general bathing or skin care and gastrointestinal infection is that interventions to reduce diarrheal disease have been multifaceted, often including health education, improved waste disposal, decontaminating the water supply, and general improvement in household sanitation as well as personal hygiene (6,7). Risk for diarrheal disease has also been linked to the level of parental education (8). Multiple influences complicate definition of the impact of any single intervention.

In 11 studies reviewed by Keswick et al. (9), use of antimicrobial soaps was associated with substantial reductions in rates of superficial cutaneous infections. Another 15 experimental studies demonstrated a reduction in bacteria on the skin with use of antimicrobial soaps, but none assessed rates of infection as an outcome.

Extensive studies of showering and bathing conducted since the 1960s demonstrated that these activities increase dispersal of skin bacteria into the air and ambient environment (10-12), probably through breaking up and spreading of microcolonies on the skin surface and resultant contamination of surrounding squamous cells. These studies prompted 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 persons but is remarkably consistent for each person over time. Even without bathing for many days, the flora remain qualitatively and quantitatively stable (13-15).

For surgical or other high-risk patients, showering with antiseptic agents has been tested for its effect on postoperative wound infection rates. Such agents, unlike plain soaps, reduce microbial counts on the skin (16-18). In some studies, antiseptic preoperative showers or baths have been associated with reduced postoperative infection rates, but in others, no differences were observed (19-21). Whole-body washing with chlorhexidine-containing detergent has been shown to reduce infections among neonates (22), but concerns about absorption and safety preclude this as a routine practice. Several studies have demonstrated substantial reductions in rates of acquisition of methicillin-resistant *Staphylococcus aureus* in surgical patients bathed with a triclosan-containing product (23,24). Hence, preoperative showering or bathing with an antiseptic may be justifiable in selected patient populations.

Hand Hygiene for the General Public

Much contemporary evidence for a causal link between handwashing and risk for infection in community settings comes from industrialized countries (5,7,25-27). Although

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many of these studies may be limited by confounding by other variables, evidence of an important role for handwashing in preventing infections is among the strongest available for any factor studied. Reviews of studies linking handwashing and reduced risk for infection have been recently published (28,29). The most convincing evidence of the benefits of handwashing for the general public is for prevention of infectious agents found transiently on hands or spread by the fecal-oral route or from the respiratory tract (30). Plain soaps are considered adequate for this purpose.

Several highly publicized, serious outbreaks from commercially prepared foods have raised questions about food safety and the hygienic practices of food handlers and others in the service professions. Despite public awareness, however, handwashing generally does not meet recommended standards—members of the public wash too infrequently and for short periods of time (31).

These factors have led to suggestions that antimicrobial products should be more universally used, and a myriad of antimicrobial soaps and skin care products have become commercially available. While antimicrobial drug-containing products are superior to plain soaps for reducing both transient pathogens and colonizing flora, widespread use of these agents has raised concerns about the emergence of bacterial strains resistant to antiseptic ingredients such as triclosan (32,33). Such resistance has been noted in England and Japan (34), and molecular mechanisms for the development of resistance have been proposed (32,35). Although in some settings exposure to antiseptics has occurred for years without the appearance of resistance, a recent study described mutants of *Escherichia coli* selected for resistance to one disinfectant that were also multiply-antibiotic resistant (35). Some evidence indicates that long-term use of topical antimicrobial agents may alter skin flora (36,37). The question remains whether antimicrobial soaps provide sufficient benefit in reducing transmission of infection without added risk or cost.

Hand Hygiene in Health-Care Settings

Issues regarding hand hygiene practices among health-care professionals have been widely discussed and may be even more complicated than those in the general public. Unless patient care involves invasive procedures or extensive contact with blood and body fluids, current guidelines recommend plain soap for handwashing (38,39); however, infection rates in adult or neonatal intensive care units or surgery may be further reduced when antiseptic products are used (40-42).

Skin Barrier Properties and Effect of Hand Hygiene Practices

The average adult has a skin area of about 1.75 m^2. The superficial part of the skin, the epidermis, has five layers. The stratum corneum, the outermost layer, is composed of flattened dead cells (corneocytes or squames) attached to each other to form a tough, horny layer of keratin mixed with several lipids, which help maintain the hydration, pliability, and barrier effectiveness of the skin. This horny layer has been compared to a wall of bricks (corneocytes) and mortar (lipids) and serves as the primary protective barrier (43). Approximately 15 layers make up the stratum corneum, which is completely replaced every 2 weeks; a new layer is formed approximately daily (44). From healthy skin, approximately 10^7 particles are disseminated into the air each day, and 10% of these skin squames contain viable bacteria (45). The dispersal of organisms is greater in males than in females and varies between persons using the same hygienic regimen by as much as fivefold (46).

Water content, humidity, pH, intracellular lipids, and rates of shedding help retain the protective barrier properties of the skin. When the barrier is compromised (e.g., by hand hygiene practices such as scrubbing), skin dryness, irritation, cracking, and other problems may result. Although the palmar surface of the hand has twice as many cell layers and the cells are >30 times thicker than on the rest of the skin (47), palms are quite permeable to water (48).

Long-term changes in skin pH associated with handwashing may pose a concern since some of the antibacterial characteristics of skin are associated with its normally acidic pH (49). In one report, pH increased 0.6 to 1.8 units after handwashing with plain soap for 1 to 2 min and then gradually declined to baseline levels over a period of 45 min to 2 hr (50). Some soaps can be associated with long-standing changes in skin pH, reduction in fatty acids, and subsequent changes in resident flora such as propionibacter (51).

In an investigation of the effect on skin of repeated use of two washing agents, all skin function tests (stratum corneum capacitative resistance, lipids, 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 (52). In a study of irritant skin reactions induced by three surfactants, damage lasted for several days; complete skin repair was not achieved for 17 days (53).

Soaps and detergents have been described as the most damaging of all substances routinely applied to skin (43). Anionic and cationic detergents are more harmful than nonionic detergents (54), and increased concentrations of surfactant result in more rapid, severe damage (55). Each time the skin is washed, it undergoes profound changes, most of them transient. However, among persons in occupations such as health care in which frequent handwashing is required, long-term changes in the skin can result in chronic damage, irritant contact dermatitis and eczema, and concomitant changes in flora.

Irritant contact dermatitis, which is associated with frequent handwashing, is an occupational risks for health-care professionals, with a prevalence of 10% to 45% (56-58). The prevalence of damaged skin on the hands of 410 nurses was reported to be 25.9% in one survey, with 85.6% of nurses reported to have problems at some time. Skin damage was correlated with frequency of glove use and handwashing (56). Washing with plain soap may actually increase the potential for microbial transmission because of a 17-fold increase in the dispersal of bacterial colonies from the skin of the hands (59). Skin condition clearly plays a major role in risk for transmission.

Microbiology of Hands of Health-Care Professionals

Damaged skin more often harbors increased numbers of pathogens. Moreover, washing damaged skin is less effective at reducing numbers of bacteria than washing normal skin, and numbers of organisms shed from damaged skin are often higher than from healthy skin (60,61). The microbial flora on the clean hands of nurses (samples taken immediately after handwashing) have been reported in several recent studies (Table). Methicillin resistance among coagulase-negative

Table. Microbial flora colonizing hands of health-care professionals

A. Microbial counts

Year (ref.)	Sample (No. subjects)	Mean $\log_{10}$ CFU
1986 (62)	Staff of bone marrow transplant unit (22)	4. 89
1992 (63)	Pediatric staff, Peru (62)	5.88
1997 (64)	Nurses in acute care unit (40)	5.61

B. Resistance of coagulase-negative staphylococcal flora

Year (ref.)	Sample (No. isolates)	Resistant (%) to methicillin	Resistant (%) to tetracycline
1986 (62)	Staff of bone marrow transplant unit (50)	68.0	23.0
1988 (65)	Oncology, dermatology staff (152)	50.7	30.7
1992 (63)	Pediatric staff, Peru (279)	40.9	45.4
1997 (64)	Acute care nurses (122)	59.0	10.5

staphylococcal flora on hands did not seem to increase during the 1980s to the 1990s, and tetracycline resistance decreased (Table).

When Is Clean Too Clean?

Even with use of antiseptic preparations, which substantially reduce counts of hand flora, no reductions beyond an equilibrium level are attained (66). The numbers of organisms spread from the hands of nurses who washed frequently with an antimicrobial soap actually increased after a period of time; this increase is associated with declining skin health (67). In a recent survey, nurses with damaged hands were twice as likely to be colonized with *S. hominis, S. aureus*, gram-negative bacteria, enterococci, and *Candida* spp. and had a greater number of species colonizing the hands (64).

The trend in both the general public and among health-care professionals toward more frequent washing with detergents, soaps, and antimicrobial ingredients needs careful reassessment in light of the damage done to skin and resultant increased risk for harboring and transmitting infectious agents. More washing and scrubbing are 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 for changing the ecology and health of the skin and increasing resistance in the skin flora.

Recommendations for the General Public

Bathing or showering cleans the skin by mechanical removal of bacteria shed on corneocytes. Bacterial counts are at least as high or higher after bathing or showering with a regular soap than before. Frequent bathing has aesthetic and stress-relieving benefits but serves little microbiologic purpose. Mild, nonantimicrobial soap should suffice for routine bathing. Bathing with an antimicrobial product reduces rates of cutaneous infection and could be beneficial when skin infections are likely or before certain surgical procedures. With those exceptions, available data do not support a recommendation for bathing with antimicrobial products.

No single recommendation for hand hygiene practices in the general population would be adequate. The potential advantage of sustained antimicrobial activity for certain occupations (e.g., food handlers and child-care providers) must be balanced with the theoretical possibility of emergence of resistant strains and perhaps other, as yet unrecognized, safety issues.

An alternative to detergent-based antiseptic products is the use of alcohol hand rinses, which have recently become widely available over the counter. Their advantages include rapid and broad-spectrum activity, excellent microbicidal characteristics, and lack of potential for emergence of resistance. Alcohol-based products could be recommended for use among persons who need immediate protection after touching contaminated surfaces or before and after contact with someone at high risk for infection.

Since hands are a primary mode of fecal-oral and respiratory transmission, specific indications for use of antiseptic hand products by the general public are close physical contact with persons at high risk for infection (e.g., neonates, the very old, or immunosuppressed); close physical contact with infected persons; infection with an organism likely to be transmitted by direct contact (diarrhea, upper respiratory infection, skin infections); or work in a setting in which infectious disease transmission is likely (food preparation, crowded living quarters such as chronic-care residences, prisons, child-care centers, and preschools).

Recommendations for the Health-Care Professional

Detergent-Based Antiseptics or Alcohol

Because of increasingly vulnerable patient populations, the demand for hand hygiene among health-care professionals has never been greater. However, frequent handwashing is not only potentially damaging to skin, it is also time-consuming and expensive (68). Finnish investigators demonstrated that after frequent washing the hands of patient-care providers became damaged and posed greater risk to themselves and patients than if they had washed less often. A mild emulsion cleansing rather than handwashing with liquid soap was associated with a substantial improvement in the skin of nurses' hands (69). Alcohol-based formulations are superior to antiseptic detergents for rapid microbial killing on skin (66,67,70-72) and, with the addition of appropriate moisturizers, are probably milder (67,73,74). Since alcohols are rapid acting, are broad spectrum, and require no washing or drying, damage caused by detergents and mechanical friction from toweling is avoided.

Use of Lotions and Moisturizers

Moisturizing is beneficial for skin health and reducing microbial dispersion from skin, regardless of whether the product used contains an antibacterial ingredient (75-77). Because of differences in the content and formulations of lotions and creams, products vary greatly in their effectiveness (78,79). Lotions used with products containing chlorhexidine gluconate must be carefully selected to avoid neutralization by anionic surfactants (80). The role of emollients and moisturizers in improving skin health and reducing microbial spread is an area for additional research.

To improve the skin condition of health-care professionals and reduce their chances of harboring and shedding microorganisms from the skin, the following measures are

recommended: 1) For damaged skin, mild, nonantimicrobial skin cleansing products may be used to remove dirt and debris. If antimicrobial action is needed (e.g., before invasive procedures or handling of highly susceptible patients) a waterless, alcohol-based product may be used. 2) In clinical areas such as the operating room and neonatal and transplant units, shorter, less traumatic washing regimens may be used instead of lengthy scrub protocols with brushes or other harsh mechanical action. 3) Effective skin emollients or barrier creams may be used in skin-care regimens and procedures for staff (and possibly patients as well). 4) Skin moisturizing products should be carefully assessed for compatibility with any topical antimicrobial products being used and for physiologic effects on the skin (81).

Conclusions

From the public health perspective, more frequent use of current hygiene practices may not necessarily be better (i.e., perhaps sometimes clean is "too clean"), and the same recommendations cannot be applied to all users or situations. Future investigation is likely to improve understanding of the interaction between skin physiology, microbiology, and ecology and the role of the skin in the transmission of infectious diseases.

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