APIC Guideline for Hand Washing and Hand Antisepsis in Health-Care Settings*

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The Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) Board of Directors and Guidelines Committee are pleased to present the "APIC" Guideline for Hand Washing and Hand Antisepsis in Health Care Settings."

Elaine Larson, RN, PhD, FAAN, CIC, was selected to revise the previously published "APIC Guideline for Use of Topical Antimicrobial Agents" because of her recognized expertise in infection control and extensive research in hand washing and hand disinfection. Initial drafts received review by the APIC Guidelines Committee, key individuals, and professional organizations before publication of the Draft in the October 1994 issue of the *Journal*, soliciting further comment. All written comments were reviewed by the APIC Guidelines Committee and revisions were made. The Guideline was finalized by the Committee in February 1995 and approved by the APIC Board of Directors in March 1995.

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The success of United States efforts in infection control has been due in large part to attention paid to the individual person as a primary source of the spread and thus the prevention of nosocomial infections. It is known, for example, that hand washing causes a significant reduction in the carriage of potential pathogens on the hands.[1,2] It is also known that hand washing can result in reductions in patient morbidity and mortality from nosocomial infection.[3-6] Although a definitive, double-blind, clinical trial of the effects of hand washing with an antiseptic product on nosocomial infection rates may be infeasible, it appears that, at least in certain high-risk situations, such antimicrobial products are beneficial.[7-10] Two major dilemmas facing ICPs in health care settings today, however, are when to use antiseptic agents and which agents to use.

In addition to the Association for Professionals in Infection Control and Epidemiology, Inc. (APIC),[11] several agencies and organizations have published guidelines, regulations, and standards regarding the topical use of antimicrobials for skin hygiene.[2,12-14] This particular guideline will supplement those published by the Association of Operating Room Nurses (AORN),[12] the Centers for Disease Control and Prevention (CDC),[2] and the Food and Drug Administration (FDA)[13,14] by describing specific characteristics of antimicrobial products available for topical use, summarizing the literature regarding their efficacy, and providing recommendations for their use by surgical personnel for hand scrubbing and by health care personnel for hand washing and hand antisepsis.[9]

This guideline therefore provides information on skin flora of hands, characteristics of selected antimicrobial agents used on hands, hand washing and surgical scrub techniques, and related aspects of hand care and protection. In addition, recommendations are made regarding (1) health care personnel handwashing, (2) personnel hand preparation for operative procedures, and (3) other aspects of hand care and protection.

CHANGES SINCE 1988

This guideline focuses on hand washing, surgical personnel hand scrub, and related topics. Changes in this guideline from the 1988 publication[11] include a review of recent literature addressing handwashing and surgical hand scrub products and the addition of sections on use of gloves and lotions; wearing of artificial nails, nail polish, and hand jewelry; and the

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behavioral and technical aspects of hand hygiene. Information relative to preparation of the patient's skin has been deleted. The myriad of products and practices related to preparation of the patient's skin before surgery or other invasive procedures is beyond the scope of this guideline. This guideline supersedes the document previously published as "APIC Guideline for Use of Topical Antimicrobial Agents."[11]

For the purposes of this Guideline, the following definitions will be used:

Transient flora (also termed "contaminating or noncolonizing flora"): microorganisms isolated from the skin but not demonstrated to be consistently present in the majority of persons. Such flora generally are considered to be transient but are of concern because of ready transmission by hands unless removed by mechanical friction and soap and water washing or destroyed by the application of an antiseptic handrub. Some microorganisms, particularly some gram-negative bacteria such as *Escherichia coli,* survive very poorly on the skin and are considered noncolonizing flora.[1,2,15-17]

Resident flora (also termed "colonizing flora"): microorganisms persistently isolated from the skin of most persons. These microorganisms are considered permanent residents of the skin and are not readily removed by mechanical friction. Colonizing flora include the coagulase-negative staphylococci, members of the genus *Corynebacterium* (commonly called diphtheroids or coryneforms) and *Propionibacterium, Acinetobacter* species, and probably certain members of the Enterobacteriaceae family.[1,2,15-18]

Plain or *nonantimicrobial soap:* detergent-based cleansers in any form (bar, liquid, leaflet, or powder) used for the primary purpose of physical removal of dirt and contaminating microorganisms. Such soaps work principally by mechanical action and have no bactericidal activity. Although some soaps contain low concentrations of antimicrobial ingredients, these are used as preservatives and have minimal effect on colonizing flora.

Hand wash(ing): a process for the removal of soil and transient microorganisms from the hands.

Hand antisepsis: a process for the removal or destruction of transient microorganisms.

Surgical hand scrub: a process to remove or destroy transient microorganisms and reduce resident flora.

Antimicrobial soaps are considered drugs because they are intended to kill or inhibit microorganisms on skin when present in certain concentrations. They are included under the regulatory authority of the FDA. In 1978, the FDA published a tentative final regulation regarding the testing and classification of various topical antimicrobial ingredients.[13] Seven product categories were defined, three of which are used as handwash or hand scrub products:

Antimicrobial soap: a soap containing an ingredient with in vitro and in vivo activity against skin flora.

Health care personnel handwash: a broad-spectrum, antimicrobial preparation that is fast-acting, nonirritating, and designed for frequent use that reduces the number of transient flora on intact skin to a baseline level.

Surgical hand scrub: a broad-spectrum, fast-acting, persistent, and nonirritating preparation containing an antimicrobial ingredient designed to significantly reduce the number of microorganisms on intact skin.

The history of the role of the FDA in the regulation of topical antimicrobial products has been summarized,[19,20] as has the need for standardized methods for testing the efficacy of such products by means of clinically relevant techniques.[21] A tentative final monograph for health care antiseptic drug products was published by the FDA June 17, 1994[14] and one for surgical scrub and health care personnel hand washing products is under development. Issues regarding efficacy criteria and testing methodology continue to be debated.

BACKGROUND RATIONALE

The indications for when hand washing should occur are well delineated in the "CDC Guideline for Handwashing and Hospital Environmental Control, 1985"[2] and the *APIC Curriculum for Infection Control Practice.*[22] The decision regarding when handwashing should occur depends on (1) the intensity of contact with patients or fomites, (2) the degree of contamination that is likely to occur with that contact, (3) the susceptibility of patients to infection, and (4) the procedure to be performed. Ranking schemes to identify health care activities that are likely to cause contamination of the hands have been developed and may be helpful for defining when hand washing is indicated.[23-25]

The 1985 CDC guideline states, "Plain soap should be used for hand washing unless otherwise indicated,"[2] and points out that the absence of randomized, controlled clinical trials regarding relative benefits of antimicrobial soap over plain soap preclude any Category I (strongly supported) recommendations for use of antiseptic agents for handwashing. Until such research studies are performed (if indeed such data ever are forthcoming, because the difficulties of conducting these trials may be prohibitive), some parameters for use of antiseptic agents are necessary. If an antimicrobial product is selected, it should be

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chosen for its inherent characteristics, its type and spectrum of activity, and the application for which it will be used.

Detergent (plain soap) with water can physically remove a certain level of microbes, but antiseptic agents are necessary to kill or inhibit microorganisms and reduce the level still further.[2,9,26,27] For example, in a study by Lilly and Lowbury,[28] soap and water did not effectively reduce counts of artificially applied bacteria when the microorganisms were rubbed in. On the other hand, the application of 70% ethanol to contaminated hands resulted in a 99.7% reduction in counts.

Lilly and coworkers[29] demonstrated that even when a skin antiseptic is used, there is a maximum level of reduction in bacterial counts that can be reached, regardless of frequency or intensity of handwashing. Alcohol-based preparations required less time to effect a maximum reduction than did a product containing chlorhexidine gluconate. These researchers also reported, however, that if the counts of hand flora were brought to a low equilibrium level with antiseptic washing and hands were then washed with plain soap, there was a sharp increase in bacterial yield.

Other studies confirm that use of soap and water for frequent daily hand washing results in minimal reduction and sometimes an increase in bacterial yield over baseline counts of clean hands.[30,31] This increase is probably caused by increased shedding of viable bacteria in desquamating epithelium (resident flora) as a result of the trauma of frequent washing.[31,32] That is, plain soap simply removes transient bacteria from skin but does not kill the bacteria released by shedding of skin squames and promotes their dispersal. Studies indicate that antimicrobials increase the likelihood of killing potentially pathogenic bacteria.[30,31,33-35]

In addition to their bactericidal and bacteriostatic effects on microorganisms, a second characteristic of certain antiseptic agents that sets them apart from plain soap is the ability to bind to the stratum corneum,[36] resulting in a persistent activity on skin. Microorganisms proliferate on the hands within the moist environment of rubber or plastic gloves,[36,37] and gloves frequently become damaged during surgical procedures,[38,39] increasing the risk of operative wound contamination.[40,41] This characteristic of persistence (also called *substantivity* or *residual activity*) may be desirable to enhance continued antimicrobial activity when it is not possible to wash the hands during prolonged surgical procedures or when continued chemical activity on the skin is advantageous in other settings.

The primary action of plain soap is the mechanical removal of viable transient microorganisms, whereas the primary action of antimicrobial soap includes both mechanical removal and killing or inhibition of both transient and resident flora. The effect of antiseptic handrubs is only to inhibit flora, without any effect on soil.

The value of relative reductions (e.g., 85% vs 90% vs 99%) in total microbial counts on hands with regard to risk of subsequently transmitting infection-causing microorganisms is not known.[16,21] High-risk situations in which patients are considered compromised and a maximum reduction in bacterial counts is thought to be desirable are of two major types: (1) during the performance of invasive procedures such as surgery or the placement and care of intravascular catheters, indwelling urinary catheters, or other invasive devices and (2) before contact with patients who have immune defects resulting from alterations in humoral or cellular immunity, damage to the integumentary system (burns, pressure ulcers, or wounds), and extremes of age.[1,2,10,22] Hand washing with plain soap may fail to remove all transient microorganisms when contamination is heavy.[10,42-45] The choice of plain soap, antiseptic soap, or antiseptic handrub should therefore be based on the degree of hand contamination and whether it is important to reduce and maintain minimal counts of resident flora, as well as to mechanically remove the transient flora on the hands of health care personnel.

Characteristics of selected antiseptic ingredients

This section discusses six antimicrobial ingredients commercially available in the United States that are designed for hand washing, surgical hand scrubbing, or hand antisepsis. Each is different, and none is ideal for all uses. In addition, many antimicrobial ingredients are quite sensitive to changes in formulation (e.g., pH, type of detergent base, and presence of certain emollients). Thus the selection of an appropriate antimicrobial agent for hand washing or surgical hand scrub should be made in three stages.[46] First, one must determine what characteristics of a topical antimicrobial agent are desired (e.g., absence of absorption across skin or mucous membranes, persistence, rapid reduction in flora, spectrum of activity) and then choose an ingredient that has these characteristics. Second, one must review and evaluate the evidence of safety and efficacy in reducing microbial counts. All antiseptic products should be tested as marketed.[27,47] Compliance with use recommendations will depend on subjective reactions to features such as packaging, odor, and harshness, as well as safety and efficacy. Therefore a third step in the selection of a product is consideration of personnel acceptance of the product and the costs. In each subsequent section the following information is

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included: mode of action, spectrum of activity, safety and toxicity, rapidity of action, persistence, inactivation by organic matter, and available preparations.

Alcohols. Alcohols probably derive their antimicrobial effects by denaturation of proteins. They have excellent bactericidal activity against most vegetative gram-positive and gram-negative microorganisms and good activity against the tubercle bacillus. Although they are not sporicidal, they act against many fungi and viruses, including respiratory syncytial virus, hepatitis B virus, and HIV.[48] The data that demonstrate the virucidal activity of alcohols are derived, however, from in vitro studies. The significance of this activity in preventing transmission of viruses to health care workers is unknown. Alcohol may, rarely, be toxic; toxic reactions have been reported in children after sponging with isopropyl alcohol for fevers.[49] Nevertheless, alcohols applied to the skin are among the safest known antiseptics.[27,41,48]

In appropriate concentrations, alcohols provide the most rapid and greatest reduction in microbial counts on skin.[50-52] Alcohol applications as short as 15 seconds in duration have been effective in preventing hand transmission of gram-negative bacteria.[10] A vigorous, 1-minute rubbing with enough alcohol to wet the hands completely has been shown to be the most effective method for hand antisepsis.[27,41,53] Indeed, a 1-minute immersion or scrub with alcohol is as effective as a 4- to 7-minute skin preparation with other antiseptics in reducing the number of bacteria on skin.[41,48,54] Rubbing with alcohol for 3 minutes is as effective as 20 minutes of scrubbing.[41] Alcohols are effective as a surgical hand scrub[41,55] and also as a health care personnel hand rinse.[45,48]

It is necessary, however, to use a sufficient quantity of alcohol; that is, enough to thoroughly wet all surfaces of the hands. When used as a brief skin wipe in impregnated pads, alcohol's antimicrobial effects are less than those of liquid soaps with antiseptic ingredients.[56] The activity of alcohol does not appear to be significantly affected by small amounts of blood.[57] Alcohols are not good cleaning agents, however, and are therefore not recommended in the presence of physical dirt. Further study is needed to determine the activity of alcohol in the presence of other types and larger amounts of organic material.

Although the alcohols do not leave a persistent chemical effect on the skin, the bacterial count on alcohol-scrubbed hands continues to drop for several hours after gloving, probably as a result of the continued deaths of damaged organisms.[58]

Three alcohols are most appropriate for use on the skin: ethyl (ethanol), normal-propyl (*n*-propyl), and isopropyl, although there are slight differences in their antimicrobial effects. For example, isopropyl alcohol may be less active against enteroviruses, more active against lipid-enveloped viruses, and slightly more bactericidal than ethanol.[48] Rotter[53] reported that the antibacterial effect of *n*-propanol was slightly superior to that of ethanol or isopropyl alcohol. The concentration of alcohol is of much more importance than the type, however, in determining its effectiveness. Alcohols must be diluted with water to denature protein. Alcohol concentrations between 60% to 90% by weight are most effective. Generally, a concentration of no more than 70% by weight is used because it causes less skin drying and chemical dermatitis and is less costly than higher concentrations.[41,48]

The major disadvantage of alcohol for skin antisepsis is its drying effect. Isopropyl alcohol, a more efficient fat solvent, may cause slightly more skin roughness than the other alcohols. However, some recently marketed preparations contain 60% to 70% ethanol or isopropyl alcohol with the addition of emollients to minimize skin drying.[59] These have been shown to be quite acceptable to users as well as having excellent antibacterial activity. The added emollient also may enhance antibacterial activity by slowing the drying time and thus increasing contact time of the alcohol with the skin.[34] Alcohol should be allowed to thoroughly evaporate from the skin to be fully effective and decrease irritation. A second disadvantage of the alcohols is that they are volatile and flammable and consequently must be stored carefully.

Chlorhexidine gluconate. Chlorhexidine gluconate (CHG) was used as a degerming agent in Europe and Canada for several decades before its approval for use in the United States in the 1970s. Chlorhexidine is a cationic bisbiguanide that derives its antimicrobial action by causing disruption of microbial cell membranes and precipitation of cell contents. Although it has a broad spectrum of activity, CHG is more effective against gram-positive than gram-negative bacteria. Action against the tubercle bacillus is minimal. CHG is only a fair inhibitor of fungi but in vitro is active against enveloped viruses including HIV, herpes simplex virus, cytomegalovirus, and influenza.[60-63] The significance of this activity in preventing transmission of these viruses to health care workers is unknown.

Numerous animal studies, as well as data from several decades of studies with human beings, indicate that CHG is nontoxic,[64,65] even when used on the skin of newborn infants.[66,67] Skin absorption is minimal.[36,41,66,67] Ototoxicity can result, however, if chlorhexidine is instilled directly into the middle ear,[68,69] and corneal damage can result from

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instillation of CHG into the eye.[70,71] Contact urticaria syndrome leading to anaphylaxis and other allergic manifestations including respiratory symptoms and contact dermatitis have also been reported.[72-74] It has a relatively low skin-irritation potential.[61,65]

Although the antibacterial activity of CHG is not as rapid as that of the alcohols, several clinical studies report good reductions in flora after a 15-second hand wash.[30,75] Its speed of antibacterial effect is classified as intermediate. In a recent study, CHG and a povidone-iodine product were compared in a surgical scrub protocol. The duration of scrub (3-minute initial and 30-second consecutive, as compared with 5-minute initial and 3-minute consecutive scrub) was not a significant variable when the iodophor was used, but the longer scrub was better when a CHG product was used. Additionally, CHG at both times resulted in a lower reduction of bacterial counts than did the povidone-iodine product.[76] One of the most important attributes of CHG is its persistence. It has strong affinity for the skin, remaining chemically active for at least 6 hours. Indeed, it probably has the best persistent effect of any agent currently available for handwashing.[36,52,77] After a few days of daily use of products that contain CHG, bacterial yield from hands is as low as that after use of alcohol-based products.[34,52] The sequential use of CHG followed by a product containing 70% isopropyl alcohol and 0.5% CHG has been shown to be highly effective as a surgical scrub.[8]

The activity of CHG is not significantly affected by blood or other organic material.[57,78,79] Its activity is pH-dependent (5.5 to 7.0), however, and is reduced or neutralized in the presence of nonionic surfactants, inorganic anions (e.g., phosphate, nitrate, chloride), and other substances present in hard tap water and in many pharmaceutical preparations and hand creams and organic anions such as natural soaps.[60,61,65] For this reason, the activity of CHG is particularly formula dependent[80] and may be influenced by individual differences in skin pH, secretions, and moisture level.[81] Although efficacy data are difficult to interpret in terms of clinical impact, users may wish to compare data on reduction of flora when deciding which formulation to use. The potential for the development of bacterial resistance to CHG seems low[82] but has been reported.[83,84]

CHG currently is offered in several formulations, the most common being 4% in a detergent base. Newer 2% aqueous formulations and foams appear to have antimicrobial activity slightly but not significantly less effective than that of the 4% liquid preparations.[85-87] CHG is also available in some countries as an alcohol-based hand rinse (0.5% CHG). A combination of the rapid effect of alcohol and the persistence of CHG would seem to offer a desirable antiseptic combination.[88-90]

Hexachlorophene. Hexachlorophene (HCP) is a chlorinated bisphenol that acts in high concentrations by disruption of microbial cell walls and precipitation of cell proteins. In low concentrations, it probably acts by inactivating essential enzyme systems within microorganisms.[91] At typical use concentrations (3%), it is bacteriostatic for gram-positive cocci but has little activity against gram-negative bacteria, the tubercle bacillus, fungi, or viruses.[60,92-95]

As early as the 1940s, tests demonstrated potential toxicity of HCP, but for many years such evidence went unnoted. In the late 1960s and early 1970s, neurologic effects were reported in patients with burns who were bathed with HCP.[96] These neurotoxic effects were verified in animal studies and in premature infants.[97-99] As a result of these findings regarding the lack of safety of a product that was then in widespread use, the FDA instituted stringent regulations for testing and approval of antiseptic agents for over-the-counter (OTC) sale.[19,36]

HCP is not fast acting, and one wash with HCP does not reduce cutaneous flora. Its rate of killing is classified as slow to intermediate. The major advantage of HCP is its persistence.[92] Unfortunately, long-term use of HCP followed by nonuse results in a temporary rebound increase in growth of skin flora.[41] Soaps and other organic materials have little effect on the activity of HCP.[41] HCP is available as an antiseptic, by prescription only, in a 3% formulation. Use on broken skin or mucous membranes or for routine total-body bathing is contraindicated.[98]

Iodine and iodophors. Tincture of iodine has been used as a preoperative skin preparation for years. It is relatively safe and fast acting[50] but is not commonly used for hand washing. It must be removed from the skin after drying because of its potential to cause skin irritation.[13,50]

The iodine-containing products that are used for handwashing and surgical hand scrub are the iodophors. Iodophors are complexes that consist of iodine and a carrier such as polyvinylpyrrolidone (PVP or povidone). The combination increases the solubility of iodine and provides a reservoir of iodine. The term "available iodine" indicates the extent of the reservoir, whereas "free iodine" is the amount of iodine in solution. The concentration of free iodine is the major chemical and microbicidal factor in the activity of iodophors and changes with the degree of dilution. A 10% povidone-iodine solution containing 1% available iodine will release free iodine to provide an equilibrium level of approximately 1 ppm.[100-102] Solutions with lower concentrations of iodophor may have higher

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relative activity because conditions favoring dissociation of iodine into solution are present.[103] Recommended levels of free iodine for antiseptics are 1 to 2 mg/L. Levels of free iodine below 1 ppm have been associated with contamination during manufacture.[101,104] The antimicrobial effects of iodophors are similar to those of iodine and are the result of cell wall penetration, oxidation, and substitution of microbial contents with free iodine. Iodine and iodophors have a wide range of activity against gram-positive and gram-negative bacteria, the tubercle bacillus, fungi, and viruses. They also have some activity against bacterial spores.[41,101,105,106] Iodophors are rapidly neutralized in the presence of organic materials such as blood or sputum.[79,101,107]

Iodine and, to a lesser extent, the iodophors are characterized by a propensity toward skin irritation and damage, as well as allergic or toxic effects in sensitive persons. Percutaneous and mucous membrane absorption occur, with the possible induction of hypothyroidism in newborn infants.[106,108,109]

The iodophor most commonly used is povidone-iodine. A formulation containing 7.5% is used as a surgical hand scrub. Lower concentration iodophors (0.05%) have been shown to have good antimicrobial activity[103,110] because the amount of free iodine increases to some extent as the solution is diluted.[103] Other forms available for antiseptic use include 10% solution in applicators and various 2% solutions.

***Para*-chloro-*meta*-xylenol.** *Para*-chloro-*meta*-xylenol (PCMX or chloroxylenol) is a halogen-substituted xylenol that acts by microbial cell wall disruption and enzyme inactivation. It is less active than CHG and has good activity against gram-positive organisms, but it is less active against gram-negative bacteria. Its activity, especially against *Pseudomonas* species, is potentiated by the addition of ethylenediamine tetraacetic acid (EDTA) because of the binding of EDTA to metal ions in the cell wall of *Pseudomonas* species.[111,112] It has fair activity against the tubercle bacillus, some fungi, and viruses.[47] In several in-use studies, various concentrations of PCMX have been shown to be less effective than either CHG or iodophors in reducing skin flora.[33,113-115]

Even though PCMX penetrates the skin, the reported incidence of skin sensitization from PCMX is low.[116] Rapidity of activity of PCMX is intermediate, and it has a persistent effect over a few hours. It is active in alkaline pH but is neutralized by nonionic surfactants. For this reason, the efficacy of PCMX, like that of CHG, is highly formula dependent. Its activity is only minimally affected by organic matter.[117] PCMX is currently available in a number of hand washing products, usually in concentrations of 0.5% to 3.75%.

Triclosan. Triclosan (5 - chloro - 2 - [2,4 - dichlorophenoxyl] phenol is a diphenyl ether. Its antimicrobial activity is thought to derive from disruption of the microbial cell wall. It is broad spectrum, with good activity against gram-positive and most gram-negative bacteria; little information is available regarding its activity against viruses, and it appears to be a poor fungicide.[114,118] Triclosan can be absorbed through intact skin but appears to be nonallergenic and nonmutagenic with short-term use. Its speed of antibacterial effect is intermediate, it has excellent persistent activity on skin, and its activity is only minimally affected by organic matter.[36,117-120] It has been tested in concentrations from 0.3% to 2.0%. In one study, 0.3% triclosan was less effective than 2% CHG in reducing skin flora.[33] Another study however, found 1% triclosan superior to 4% CHG in reducing methicillin-resistant *Staphylococcus aureus* colonization in neonates.[121] One study in 20 healthy volunteers reported less prolonged effects and greater skin irritation with a 2% triclosan detergent than with a 4% CHG product.[122] Although it is commonly used in commercial soaps in concentrations of up to 1% to reduce body odor by inhibiting the growth of skin bacteria over time, additional safety and efficacy data are needed to determine the usefulness of higher concentrations in health care.

Technique

Hand washing. The purpose of hand washing is to remove dirt, organic material, and transient microorganisms (Table 1).[9,25,123] Efficacy of handwashing is influenced by a number of factors. Although the amount of plain soap used does not appear to influence the result, antimicrobial products have a dose response, and 3 to 5 ml is recommended.[35] Wet hands with running water. Apply handwashing agent and thoroughly distribute over hands. Vigorously rub hands together for 10 to 15 seconds, generating friction on all surfaces of the hands and fingers.[1,2,22-24] A technique to ensure coverage of all surfaces has been described[25] because parts of the thumbs, backs of the fingers, backs of the hands, and beneath the fingernails are often missed.[124,125] Debris may be removed from under the fingernails because the subungual area has higher microbial counts and contamination of the hands can increase when gloves provide a warm, moist environment.[126] Duration of washing is important, not only for mechanical action but also to allow antimicrobial products sufficient contact time to achieve the desired effect when they are used.[127] Hands should be thoroughly rinsed to remove residual soap and then dried. When the sink does not have

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Table 1 Types of hand care

	Purpose	Method
Handwash	To remove soil and transient microorganisms	Soap or detergent for at least 10-15 seconds
Hand antisepsis	To remove or destroy transient microorganisms	Antimicrobial soap or detergent or alcohol-based handrub for at least 10-15 seconds
Surgical hand scrub	To remove or destroy transient microorganisms and reduce resident flora	Antimicrobial soap or detergent preparation with brush to achieve friction for at least 120 seconds, or alcohol-based preparation for at least 20 seconds

foot controls or an automatic shutoff, a paper towel may be used to shut off the faucet to avoid recontaminating the hands.

A variety of methods are available for drying hands.[128] Cloth towels are rarely used in health care settings because of concerns regarding contamination.[27,129,130] Although warm-air dryers are used in many public rest rooms, they are rarely found in patient care areas of health care facilities. Research is scant, but one study comparing cloth towels, paper towels, and warm-air drying found that all three methods resulted in a further reduction of flora, with warm-air drying producing the greatest reduction and cloth drying the least.[131] Another study found no difference in the numbers of bacteria remaining after paper towel and air drying.[132] However, it usually takes longer to dry hands with an air dryer, and many have standard 30-second cycles that may be inadequate.[27,132] In addition, hand dryers can serve only one person at a time, and paper towels will not be available to use when shutting off faucets without foot or automatic controls. The noise associated with air dryers may also pose problems in patient care areas. Paper towels should be dispensed from holders that require the user to remove them one at a time. The hand-drying materials should be placed near the sink in an area that will not become contaminated by splash.

Hand antisepsis. The purpose of hand antisepsis is to destroy or remove transient microorganisms from hands (Table 1).[9,25,123] Hand antisepsis can occur simultaneously with hand washing when soaps or detergents that contain antiseptics are used. Hand antisepsis can also be accomplished by use of alcohol-containing antiseptic handrubs when hands are already clean; that is, not soiled with dirt or organic material.

A number of studies indicate that plain handwashing does not always remove transient microorganisms.[10,42-45,133] However, the concerns regarding adequacy of hand washing technique also apply to the use of alcohol handrubs. Failure to cover all surfaces of the hands because of poor technique or use of insufficient amounts of alcohol handrub solution can leave contaminated surfaces.[134] Although alcohol is often recommended for use in areas where hand washing facilities are not readily available, it is important to reiterate that they are not good cleaning agents and are not recommended in the presence of physical dirt. In addition, although small amounts of blood do not appear to adversely affect the activity of alcohol,[57] it is unclear that the same is true for larger amounts of organic material. Health care personnel working in settings where hand washing facilities are not readily available and heavy hand contamination with organic material occurs may wish to use detergent-containing towelettes for physical cleansing of the hands before use of alcohol-containing handrubs for antisepsis.

Surgical scrub. Surgical hand scrub is performed to remove transient flora and reduce resident flora for the duration of surgery in case of glove tears (Table 1).[12] The process must begin with washing the hands and forearms thoroughly to remove dirt and transient bacteria. A nail cleaner should be used to clean under the nails.

The traditional surgical scrub in the United States has been 5 minutes in duration for both the initial and subsequent scrubs, with chlorhexidine or iodophor products,[12,40,135-137] agents that demonstrate persistence and help maintain lower microbial counts under gloves.[138] In Europe, alcohol-based preparations are often considered the agent of choice. These preparations are applied by rubbing on 3 to 5 ml until dry and repeating applications for approximately 5 minutes.[50] With alcohol preparations, persistence may be less important because bacterial counts are so low that it takes several hours for regrowth to occur to

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prescrub levels.[55] AORN has recommended that persons sensitive to antimicrobial agents with residual activity should scrub with a nonmedicated soap, followed by application of an alcohol-based preparation.[12]

The optimum duration of surgical scrub is unclear,[12] although research indicates that it may be agent dependent.* Also unclear is whether scrubs for subsequent consecutive cases may be shorter than for the first case.[40] O'Shaughnessy and associates suggest that scrub time can be reduced for subsequent cases when CHG is used because of its persistent and cumulative effect,[138] whereas Rehork and Ruden suggest that the time between initial and subsequent scrubs must also be considered.[139] The American College of Surgeons suggests that a surgical scrub of 120 seconds, which includes brushing of the nail and fingertip areas, is adequate.[141]

As with personnel hand washing, the clinical impact of relative reductions in microbial counts after surgical scrubs is unknown. Although Cruse and Foord[142] initially reported that glove punctures were associated with an increased clean surgery infection rate, their later work[143] and another study[144] showed no relationship between the incidence of surgical infections and glove tears during surgery.

Other aspects of hand care and protection

Glove use. The wearing of gloves to provide a protective barrier to microbial transmission has increased dramatically since the inception of universal precautions[145-147] and has been recommended to prevent heavy contamination of hands.[148,149] Extreme variability in the quality of gloves has been reported, however, with leakage in 4% to 63% of vinyl gloves and 3% to 52% of latex gloves.[150-154] A recent study found little benefit in double gloving when latex gloves were worn.[155] Additionally, microbial contamination of hands and possible transmission of infection have been reported even when gloves were worn.[156-159] Soap and water hand wash or an antiseptic handrub should therefore be used after glove removal.

Disposable single-use gloves should not be reused. Studies have indicated that microorganisms are not always removed from gloves despite friction, a cleansing agent, and drying,[156] and washing may decrease the integrity of the glove.[160] The Occupational Safety and Health Administration Bloodborne Pathogens Standard prohibits washing or decontaminating disposable (single-use) gloves for reuse.[161]

Inappropriate glove use has been recognized as a problem.[162-164] Failure to change gloves between patients and contaminated body sites was identified as the cause of an *Acinetobacter* outbreak.[164]

Nails, nail polish, and artificial nails. One report suggests that artificial nails may increase the microbial load on hands, particularly of gram-negative bacteria.[165] Another report showed no significant difference in colony counts between operating room nurses wearing artificial nails and those with natural nails. In two instances when the prosthetic nails were broken or had separated from the natural nails, however, high colony counts were found despite a 30-second wash with povidone-iodine.[166] Dermatologists report secondary infections with *Pseudomonas* and *Candida* when reactions to nail lacquers and hardeners cause onycholysis.[167,168]

Nail polish applied to natural nails seems to have no detrimental influence on microbial load, as long as nails are short.[169] Short nails are probably important because the majority of flora on the hand is found under and around the fingernails.[126] Clear polish is preferable because dark colors may obscure the subungual space, reducing the likelihood of careful cleaning. In addition, long nails can make donning gloves more difficult and may cause gloves to tear more readily.

AORN recommends[12] that artificial nails not be worn by operating room personnel, citing reports of fungal and bacterial infections. Concerns have also been raised by others that use of artificial fingernails and nail polish may discourage vigorous handwashing.[124]

Jewelry. Total bacterial counts are higher when rings are worn,[170,171] although Jacobson and coworkers did not find that rings interfered with removal of bacteria by handwashing.[170] Rings and nail jewelry can make donning gloves more difficult and may cause gloves to tear more readily.[124]

Lotion. Lotions are often recommended to ease the dryness resulting from frequent hand washing,[1,124,172] and more recently to prevent dermatitis resulting from glove use.[173] A study has demonstrated that the application of a lotion can reduce the dispersal of bacteria.[174] Hand lotion can become contaminated,[175-177] however, and should be considered as a possible reservoir in the event of an outbreak.

Petroleum jelly under gloves has been shown to be acceptable from a microbiologic point of view,[178] but concerns have been raised about the potential for petroleum-based lotion formulations to weaken latex gloves and cause increased permeability.[179] For that reason, lotions that contain petroleum or other oil emollients may affect the integrity of gloves. Lotions designed to protect against latex sensitivity are now on the market. Because latex allergy and anaphylactic reactions to latex products are being reported with

*References 41, 76, 80, 113, 136, and 138-140.

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increased frequency,[180-186] such products would be highly desirable if indicated. One study of such a lotion found no interference with effectiveness of the surgical scrub nor any increase in leakage in gloves worn for 2 hours after application of the lotion.[187] Anionic moisturizing products and surfactants, however, have been shown to interfere with the residual activity of CHG.[188,189] Interaction between lotions and CHG antimicrobial products used must therefore be considered at the time of product selection.

Storage and dispensing of hand care products. Hand wash products, including both plain soap and antiseptic products, can become contaminated or support the growth of microorganisms.[100,104,190-198] Bar soap should be provided in small bars that can be changed frequently, with soap racks that promote drainage.[2,199-202] Liquid products should be stored in closed containers and dispensed from either disposable containers or containers that are washed and dried thoroughly before refilling.[1,2] Some have suggested that dispensers should be foot- or elbow-operated to decrease the potential for contamination.[27,203] Lotions can also become contaminated and support bacterial growth and should be dispensed in small, individual-use containers or from pump dispensers that are not opened or refilled.[175,176]

Behavior and compliance. The primary problem with hand hygiene is not a paucity of good products, but rather the laxity of practice. Variations in handwashing practice have been reported by type of unit (pediatric personnel have been shown to have higher frequency of hand washing) and profession (in general, nurses wash more often than physicians, although physicians have been shown to wash more thoroughly).[129,204-208] Overall, however, hand washing associated with general patient care occurs in approximately half of the instances in which it is indicated and usually is of shorter duration than recommended. Additionally, staff overestimate the frequency and quality of their hand washing behavior.[17,125,209-211]

A number of studies have examined the influence of various factors on hand washing behavior. Staffing,[212,213] placement of sinks,[214] and the effect of hand washing on skin condition[215-218] have been identified as obstacles, whereas the main motivating factor has been awareness of the importance of hand washing in preventing infection.[215,216] One study found senior British nurses were better hand washers than more junior nurses.[219]

Several studies, summarized in Table 2, have evaluated the influence of behavioral and educational interventions on hand washing practices in critical care units.[7,210,220-224] These interventions met with varying success, but even when hand washing increased the change in behavior was not sustained beyond the period of the study intervention. Clearly, simple educational efforts to influence hand washing practices are of minimal benefit. Studies indicate that health care personnel are aware of the reasons hand washing should be done.[215,225] A number of studies also suggest, however, that sustained feedback on hand washing behavior or feedback about patient infections influences performance.[210,220,221,224,226] The use of role models or mentors to influence behavior has also been suggested.[215,225-227]

A committed and thoughtful overall approach that includes staff involvement is important. In developing such approaches, the issue of which product to use must *not* take precedence over improving the quantity and quality of handwashing.[228]

Complications of hand washing and gloving

Handwashing can cause detrimental effects on the skin.[16,59,172] Some of these effects occur regardless of the products used; others involve reactions to the ingredients in various hand washing agents.[72,73,116,229,230] Contrary to popular opinion, antiseptics do not necessarily cause greater damage to skin than plain soap; often it is the detergent base that is harsh.[30,31] Recently, as glove use has increased, reports of reactions to latex gloves have also increased.[183-186,230-233] Dermatitis in health care personnel may place patients at risk because hand washing will not decrease bacterial counts on dermatitic skin,[1,234] and dermatitic skin contains high numbers of microorganisms. Health care personnel with dermatitis may be at increased risk of exposure to bloodborne pathogens during skin contact with blood or body fluids because the integrity of the skin is not present.

A variety of solutions have been proposed to remedy these problems. Use of moisturizers to alleviate skin dryness has long been recommended.[1,124,172] Emollients have been added to soaps. Emulsions and antiseptic "no-wash" products have been suggested as substitutes for soap and water washes.[59,235-237] Nonlatex, powder- or chemical-free gloves are available.[184,230,232,233] Use of vinyl or cotton gloves under latex gloves or barrier lotions for latex-sensitive persons has also been suggested.[173,230,233] Unfortunately, none of these solutions has been studied under long-term, in-use conditions to determine either efficacy in alleviating the identified problem or the impact on the microbiologic condition of the skin.

New technologies

A variety of new devices have been proposed to improve hand washing compliance and technique. In one trial, automated sinks with water flow and soap

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Table 2 Intervention studies to improve hand washing practices in critical care areas

Reference	Setting	Type of intervention	Results
Doebbeling et al.[7]	3 ICUs, 46 beds	A. Chlorhexidine gluconate vs soap-alcohol crossover trial B. Videotaped and written instruction with refresher at midpoint C. Visual observations; monthly summary of compliance posted	Handwashing compliance was significantly better during chlorhexidine use; infection rate was reduced with chlorhexidine but not significantly
Simmons et al.[210]	Two ICUs, 24 beds, community teaching hospital	Threefold: A. Handwashing questionnaire; physician-provided compulsory in-service; supportive literature distributed B. Button campaign C. Observation of hand washing with critique of method and staff feedback	No significant changes in hand washing rates
Dubbert et al.[221]	12-bed ICU	A. Three series of classes by ICNs	A. Immediate increase in hand washing, followed by decline to baseline over 4 weeks
		B. Observation of handwashing with next-day feedback to staff	B. Improvement to 95% compliance, with feedback sustained to end of study
Graham[223]	18-bed ICU, Australia	Introduction of handrub solution after instruction	Significant increase (13%) in frequency in hand decontamination
Conly et al.[220]	16-bed ICU, Canada	A. Feedback on hand washing practices; memoranda regarding hand washing to attending staff and departments; posters B. Infection control staff "emphasized the importance of hand washing"; results of two previous surveys reviewed; ICU directors actively encouraged hand washing	Significant increase in hand washing compliance; decrease in nosocomial infection rates

ICU, Intensive care unit; *ICN,* infection control nurse; *VA,* Veterans Affairs.

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Table 2 Intervention studies to improve hand washing practices in critical care areas—cont'd

Reference	Setting	Type of intervention	Results
Mayer et al.[224]	ICU, VA medical center	Two phases: A. Introduction of new emollient soap	A. No increase in hand washing after introduction of new soap
		B. Feedback on hand washing compliance by daily memo	B. Immediate increase in hand washing frequency when feedback phase began
Larson et al.[222]	Six-bed postanesthesia recovery room and 15-bed neonatal ICU	Automated sink	Hand washing quality significantly improved but frequency declined significantly

dispensing controlled by electronic sensor improved the quality of hand washing when used but were avoided by staff during busy times.[222] Hand washing machines are also available[238] but are largely untested in clinical use. Recently, gloves containing a chlorhexidine coating on the inner surface were tested.[239] Undoubtedly, other items will be developed and promoted as solutions to the poor compliance with hand washing recommendations. All will require evaluation in clinical settings to determine their effectiveness.

Areas for future investigation

Definitive studies are needed to determine whether antimicrobial soaps or antiseptic handrubs are better than plain soap in preventing infection transmission. Circumstances under which use of an antiseptic agent will consistently reduce the occurrence of nosocomial infection need to be identified. Increased glove use in recent years may require a redefinition of the resident and transient flora of gloved and ungloved hands and the effect of hand washing, with or without antiseptic agents, on this flora. The use of nail polish, artificial nails, and hand jewelry by health care providers will remain controversial until further information is available. The optimum durations for surgical personnel hand scrub for both initial and subsequent cases need to be clearly delineated for each antimicrobial agent used. As new products and new technologies emerge to combat skin irritation and sensitivity to glove material, as well as to improve hand washing technique, they will need to be carefully evaluated for efficacy, compatibility, and adverse effects. Standardization of test methods is needed to allow consumers to evaluate studies conducted in different settings with different agents. Studies should be conducted under long-term, in-use clinical conditions.

Many hand washing studies focus on products and technology. Much less attention is given to investigating methods for improving compliance of health care personnel with recommended hand washing practices. Such studies are sorely needed. ICPs need to collaborate with other disciplines to determine how to maintain lasting improvement in hand washing, a behavior considered essential for infection prevention and control.

RECOMMENDATIONS

A. Health care personnel hand washing and hand antisepsis

1. Hands must be washed thoroughly with soap and water when visibly soiled.
2. Hands must be cared for by hand washing with soap and water or by hand antisepsis with alcohol-based handrubs (if hands are not visibly soiled):
   a) Before and after patient contact.
   b) After contact with a source of microorganisms (body fluids and substances, mucous membranes, nonintact skin, inanimate objects that are likely to be contaminated).
   c) After removing gloves.
3. Wet hands with running water. Apply hand washing agent and thoroughly distribute over hands. Vigorously rub hands together for 10 to 15 seconds, covering all surfaces of the hands and fingers.
4. For general patient care, a plain, nonantimicrobial soap is recommended in any convenient form (bar, leaflets, liquid, powder). Such detergent-based products may contain very low concentrations of antimicrobial agents that are used as preservatives to prevent microbial contamination. If bar soap is used, small bars that can be changed frequently and soap racks that promote drainage should be used.

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5. Hand antisepsis, achieved by handwashing or surgical scrub with antimicrobial-containing soaps or detergents or by use of alcohol-based antiseptic handrubs, is recommended in the following instances:
   a) Before the performance of invasive procedures such as surgery or the placement of intravascular catheters, indwelling urinary catheters, or other invasive devices.
   b) When persistent antimicrobial activity on the hands is desired.
   c) When it is important to reduce numbers of resident skin flora in addition to transient microorganisms.
6. In settings where hand washing facilities are inadequate or inaccessible and hands are not soiled with dirt or heavily contaminated with blood or other organic material, alcohol-based handrubs are recommended for use. In situations where soilage occurs, detergent-containing towelettes should be used to cleanse the hands; alcohol-based handrubs can then be used to achieve hand antisepsis.
7. In the event of interruption of water supply, alternative agents such as detergent-containing towelettes and alcohol-based handrubs should be available.
8. Products used for hand washing, surgical scrubs, and hand care should be chosen by persons knowledgeable about the purpose of use, the advantages and disadvantages, cost, and acceptance of the product by users.
9. Routine use of hexachlorophene is not recommended.

B. Personnel hand preparation for operative procedures

1. The procedure for surgical hand scrub should include the following steps:
   a) Wash hands and forearms thoroughly.
   b) Clean under nails with a nail cleaner.
   c) Rinse thoroughly.
   d) Apply antimicrobial agent to wet hands and forearm with friction for at least 120 seconds.
2. If an alcohol-based preparation is selected for use, wash hands and arms, clean fingernails thoroughly, dry completely, and follow manufacturer's recommendations for application. Generally, application should last for at least 20 seconds.
3. Personnel with allergic reactions to antiseptic agents other than alcohol may apply ethanol or isopropanol.

C. Other aspects of hand care and protection

1. Glove use
   a) Gloves should be used as an adjunct to, not a substitute for, hand washing.
   b) Gloves should be used for hand-contaminating activities. Gloves should be removed and hands washed when such activity is completed, when the integrity of the gloves is in doubt, and between patients. Gloves may need to be changed during the care of a single patient, for example when moving from one procedure to another.
   c) Disposable gloves should be used only once and should not be washed for reuse.
   d) Gloves made of other materials should be available for personnel with sensitivity to usual glove material (such as latex).
2. Condition of nails and hands
   a) Nails should be short enough to allow the individual to thoroughly clean underneath them and not cause glove tears.
   b) The hands, including the nails and surrounding tissue, should be inflammation free.
3. Lotion
   a) Lotions may be used to prevent skin dryness associated with hand washing.
   b) If used, lotion should be supplied in small, individual-use or pump dispenser containers that are not refilled.
   c) Compatibility between lotion and antiseptic products and the effect of petroleum or other oil emollients on the integrity of gloves should be considered at the time of product selection.
4. Storage and dispensing of hand care products
   a) Liquid products should be stored in closed containers.
   b) Disposable containers should be used. If disposable containers cannot be used, routine maintenance schedules for cleaning and refilling should be followed. Reusable containers should be thoroughly washed and dried before refilling.
   c) There should be a routine mechanism to ensure that soap and towel dispensers function properly and are adequately supplied.
   d) Containers of alcohol should be stored in cabinets or areas approved for flammables.
5. Drying of hands
   a) Cloth towels, hanging or roll type, are not recommended for use in health care facilities.
   b) Paper towels or hand blowers should be within easy reach of the sink but beyond splash contamination.
   c) Lever-operated towel dispensers should be activated before beginning hand washing. Hand blowers should be activated with the elbow.
6. Behavior and compliance. Efforts to improve handwashing practice should be multifaceted and should include continuing education and feedback to staff on behavior or infection surveillance data. Unit clinical and administrative staff should be involved in the planning and implementation of strategies to improve compliance and hand washing.

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