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AORN eGuidelines+

Guidelines for Perioperative Practice: Hand Hygiene

The Guideline for Hand Hygiene was approved by the AORN Guidelines Advisory Board and became effective as of June 15, 2022. The recommendations in the guideline are intended to be achievable and represent what is believed to be an optimal level of practice. Policies and procedures will reflect variations in practice settings and/or clinical situations that determine the degree to which the guideline can be implemented. AORN recognizes the many diverse settings in which perioperative nurses practice; therefore, this guideline is adaptable to all areas where operative or other invasive procedures may be performed.

Purpose

This document provides perioperative team members with evidence-based practice guidance for performing **hand hygiene** and **surgical hand antisepsis** to promote patient and personnel safety and reduce the risk for health care–associated infections, especially surgical site infections (SSIs). Hand hygiene is widely recognized as a primary method to prevent health care–associated infections and the transmission of pathogens in the health care setting.[1] Health care–associated infections can result in untoward patient outcomes, such as morbidity and mortality, pain and suffering, longer lengths of hospital stay, delayed wound healing, increased use of antibiotics, and higher costs of care.[2] Thus, the prevention of health care–associated infections is a priority for all health care personnel. Hand hygiene and surgical hand antisepsis are effective and cost-efficient ways to prevent and control infections in the perioperative setting.[3]

Normal skin flora on the hands includes transient and resident microorganisms. Transient microorganisms colonize the superficial layers of the skin. These microorganisms are transmitted to perioperative team members while they are caring for patients and when they come in contact with contaminated environmental surfaces. Moderate-quality evidence has confirmed intraoperative transmission of *Staphylococcus aureus* from the hands of anesthesia providers,[4] surgical attendings, surgical assistants, and circulating nurses[5] to patients and environmental surfaces. Transient microorganisms are easier to remove by performing hand hygiene than are resident microorganisms, which are seated in the deeper layers of the skin. Skin and nail condition and the presence of jewelry contribute to the number of transient microorganisms on the hands. In a review of 10 hospital outbreaks caused by gram-negative bacteria in which health care workers were thought to be the source of the outbreak, Ulrich et al[6] found that the main reservoir of transmission in seven of the outbreaks was the hands of health care personnel with nail fungus, **artificial nails**, or jewelry.

Surgical hand antisepsis aims to remove soil and transient microorganisms from the hands of perioperative team members and suppress the growth of resident microorganisms for the duration of the surgical procedure to reduce the risk that the patient will develop an SSI.[7] Safe and effective **surgical hand antiseptics** rapidly and persistently remove transient microorganisms and suppress the growth of resident microorganisms with minimal skin and tissue irritation.[1]

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The perioperative registered nurse (RN) plays a crucial role in developing and implementing protocols for hand hygiene and surgical hand antisepsis in the perioperative setting. This includes involvement in the selection of surgical hand antiseptics and hand hygiene products and the development of procedures inclusive of health care workers' religious and cultural beliefs (eg, some individuals have restrictions about showing bare skin below the elbows in the presence of others).[8,9]

Topics outside the scope of this document include hand hygiene in health care settings other than the perioperative setting and glove use (See the Guideline for Transmission-Based Precautions).[10]

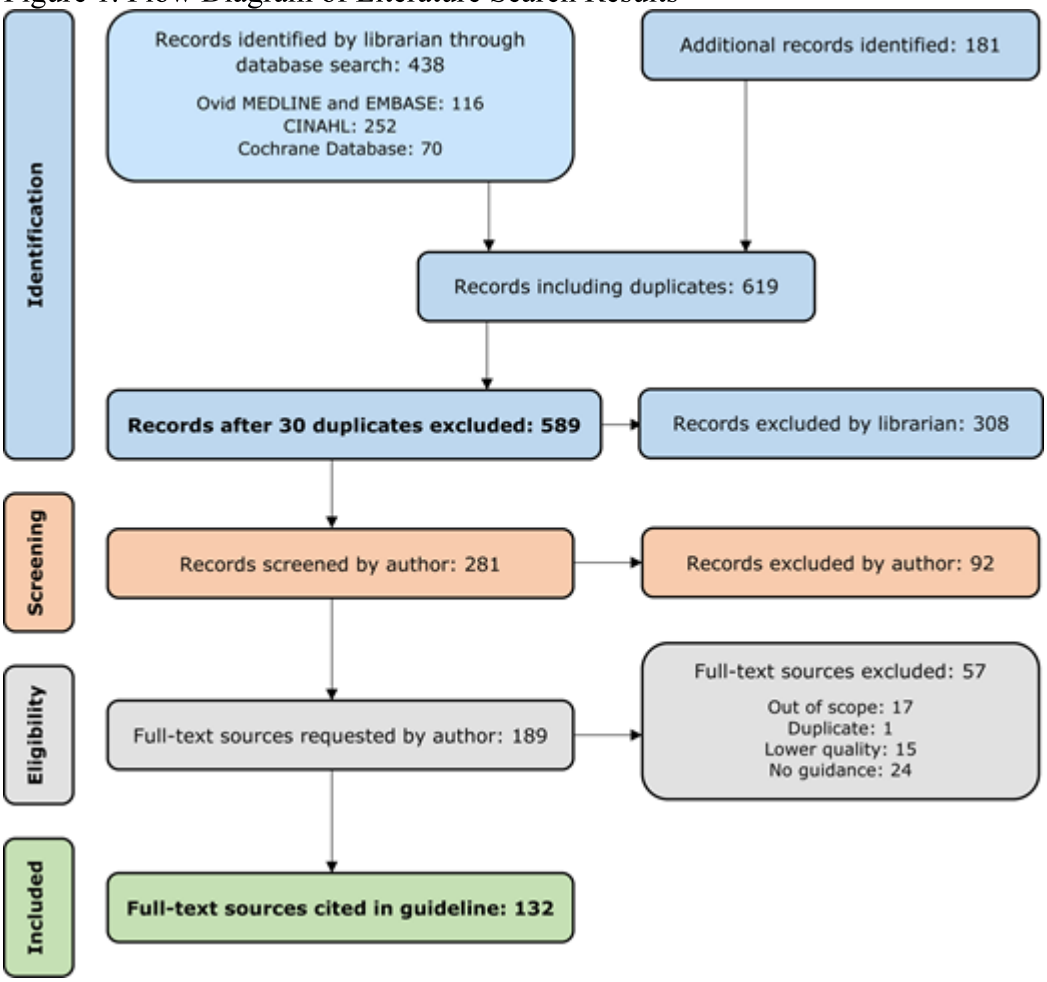
Evidence Review

A medical librarian with a perioperative background conducted a systematic search of Ovid MEDLINE, Ovid Embase, EBSCO CINAHL, and the Cochrane Database of Systematic Reviews. The search was limited to literature published in English from March 2016 through February 2021. At the time of the initial search, weekly alerts were created on the topics included in that search. Results from these alerts were provided to the lead author until September 2021. The lead author requested additional articles that either did not fit the original search criteria or were discovered during the evidence appraisal process. The lead author and the medical librarian also identified relevant guidelines from government agencies, professional organizations, and standards-setting bodies.

Search terms included *2-propanol, acrylic nails, alcohol, alcohol based hand sanitizer, alcohol based hand scrub, alcohol prohibition, allergic contact dermatitis, allergy, Alphadine, ambulatory surgery center, anesthesiologists, artificial nails, Asepsol, Avaguard, audits, bare below the elbows, betadine, Betaisodona, benzalkonium chloride, Birnbach, *contamination, cardiac catheterization laboratory, chaplains, chloroxylenol, clergy, clerics, compatible products, compliance, contact dermatitis, contact eczema, contact irritant dermatitis, contact sensitivity, cross contaminat*, cross infect*, deacons, dermatitis, dermatitis (allergic contact), dermatitis (contact), dermatitis (irritant), Disadine, Drapolene, eczema flare, electric eye faucets, endoscopy suite, exanthema, exudates and transudates, fingernails, gel nail overlay, gel nail polish, Germex, gloves, guideline adherence, hand antisep*, hand disinfect*, hand hygiene, hand sanitiz*, hand wash*, handwashing, henna, hexachlorophane, hypersensitivity, imams, infection, infection control, inflamed skin, interventional radiology, intraoperative period, iodine, irritant dermatitis, Islam, Isodine, isopropanol, isopropyl alcohol, pastors, perioperative care, perioperative nursing, perioperative period, perioperative setting, petrolatum, petroleum, petroleum jelly, policy compliance, povidone iodine, pre-operative hand antisepsis, pre-operative hand preparation, pre-operative rub, pre-operative scrub, pre-operative wash, pre-surgical hand antisepsis, pre-surgical hand preparation, pre-surgical rub, pre-surgical scrub, pre-surgical wash, preoperative hand antisepsis, preoperative hand preparation, preoperative rub, preoperative scrub, preoperative wash, preoperative period, presurgical, presurgical hand antisepsis, presurgical hand preparation, presurgical rub, presurgical scrub, presurgical wash, priests, procedural areas, protocol compliance, PVP-I, PVP-iodine, rabbis, radiology (interventional), rash, religious compliance, religious practices, rings, rubbing alcohol, scrub brush, scrub sink, self tanning products, skin cream, skin inflammation, skin irritation, skin lotion, skin rash, skin sloughing, squames, super shedder, surgical hand antisepsis, surgical hand preparation, surgical nursing, surgical rub, surgical scrub, surgical scrubbing, surgical suite, surgical wash, surgicenters, UV-cured nail polish, waterless hand sanitizer, wearable dispensers, wedding band, wedding ring, wood alcohol,* and *Zephiran*.

Included were research and non-research literature in English, complete publications, and publications with dates within the time restriction when available. Excluded were non-peer-reviewed publications and older evidence within the time restriction when more recent evidence was available. Editorials, news items, and other brief items were excluded. Low-quality evidence was excluded when higher-quality evidence was available, and literature outside the time restriction was excluded when literature within the time restriction was available (Figure 1).

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Figure 1. Flow Diagram of Literature Search Results



Adapted from Moher D, Liberati A, Tetzlaff J, Atman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. PLoS Med. *2009;6(6):e1000097.*

Articles identified in the search were provided to the project team for evaluation. The team consisted of the lead author and two evidence appraisers. The lead author divided the search results into topics and assigned members of the team to review and critically appraise each article using the AORN Research or Non-Research Evidence Appraisal Tools as appropriate. The literature was independently evaluated and appraised according to the strength and quality of the evidence. Each article was then assigned an appraisal score. The appraisal score is noted in brackets after each reference as applicable.

Each recommendation rating is based on a synthesis of the collective evidence, a benefit-harm assessment, and consideration of resource use. The strength of the recommendation was determined using the AORN Evidence Rating Model and the quality and consistency of the evidence supporting a recommendation. The recommendation strength rating is noted in brackets after each recommendation.

Note: The evidence summary table is available at http://www.aorn.org/evidencetables/.

Recommendations

1.

Fingernail and Hand Condition

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1.1.

Maintain healthy, short, natural fingernails.[1,7,11-14] ***[Recommendation]***

Moderate-quality evidence and guidance from health agencies and professional societies support that health care personnel should maintain healthy, natural fingernails at a short length.[1,7,11-14] Unhealthy or long fingernails may impede the removal of microorganisms from the nails during hand hygiene. Transmission to the patient of microorganisms harbored in unhealthy or long fingernails may result in the patient developing a health care–associated infection.

In a case report, McNeil et al[15] described an outbreak of 16 postoperative *Pseudomonas aeruginosa* wound infections in a thoracic surgical setting. The outbreak source was traced to a scrub person with severe chronic (ie, > 2 years) onycholysis of her right thumbnail. The person kept the lesion covered by continuously concealing it with flesh-colored **nail lacquer**, which prevented her colleagues from noticing it. *P aeruginosa* was cultured from the nail's **subungual** region and the nurse's home manicure products. After the individual abstained from participating in surgical procedures until after the previously infected thumbnail was totally removed, no additional postoperative *P aeruginosa* wound infections were reported.

In a prospective observational study with an educational intervention, Hautemaniere et al[14] evaluated factors associated with hand hygiene effectiveness for 3,067 hospital personnel in France. The researchers evaluated hand hygiene before and after an educational intervention, which consisted of a 30-minute session to teach best practices for using an **alcohol-based hand rub**. Hand hygiene effectiveness was determined using a validated observation technique for rubbing time (limit 30 seconds), adherence to the application method protocol, and evaluation by visual criteria. The researchers visually assessed hand hygiene effectiveness by having personnel apply a fluorescent alcohol-based hand rub and using ultraviolet light to evaluate the percentage of hand coverage. In this study, the evaluation criteria showed an association between long nails and ineffective hand rub use. However, the researchers did not describe the nail length used to classify nails as long in this study.

In a literature review conducted to assess the efficacy of rectal screening of health care workers to determine the source of gram-negative pathogen outbreaks, Ulrich et al[6] found that examining health care workers' hands and fingernails was more beneficial, lower in cost, and more efficient than rectal screening for intestinal colonization. In six of the 10 case reports reviewed, the hands of health care workers were identified as reservoirs because of onychomycosis, nail length, and artificial nails.

The benefits of maintaining healthy, short nails include a reduced risk of harboring potential pathogens under fingernails. The harms of having long nails may include puncturing gloves,[1,7,12] limiting the effectiveness of hand hygiene,[7,14] or injuring patients during patient care.

1.1.1.

Keep fingernail tips no longer than 2 mm (0.08 inch).[16-18] ***[Recommendation]***

The most recent research found in the evidence review supports maintaining fingernail length no longer than 2 mm (Figure 2).[16-18]

Figure 2. Measuring Fingernail Tip Length

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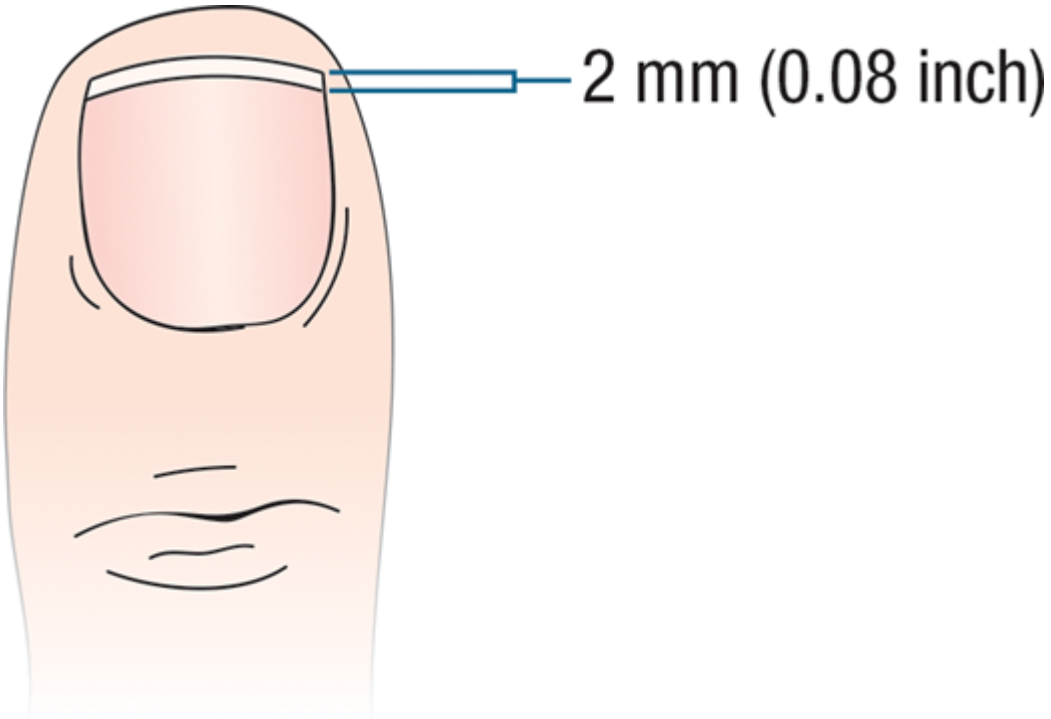
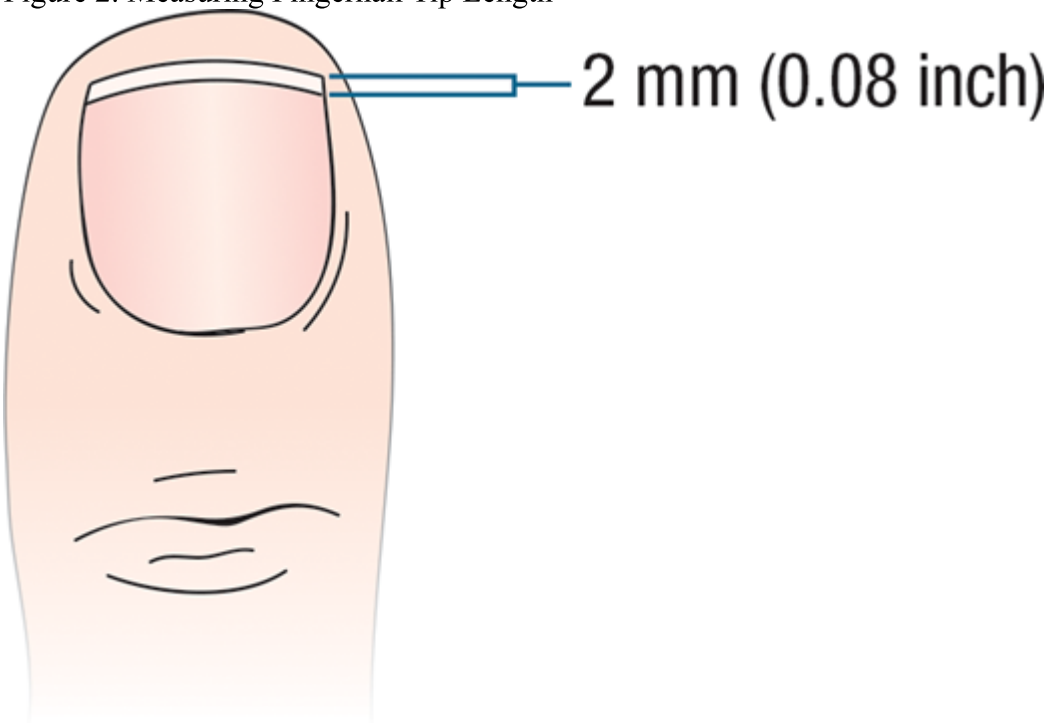


Figure 2. Measuring Fingernail Tip Length



The Centers for Disease Control and Prevention (CDC)[11] and the World Health Organization (WHO)[7] concluded that the areas under the fingernails can harbor high concentrations of transient flora including bacteria (eg, coagulase-negative staphylococci, gram-negative rods *[Pseudomonas]*, *Corynebacteria*) and yeasts, which can remain present even after careful hand hygiene or surgical hand antisepsis. In 2002, the CDC recommended keeping natural nail length shorter than 6 mm (0.25 inches).[11] In 2009, the WHO also recommended that health care personnel who have direct contact with patients keep natural nails short, with tips shorter than 0.25 inches or 6 mm.[7] Rather than providing a specific recommendation on fingernail length, the Association of Surgical Technologists (AST) recommended in 2008 that fingernail length not extend beyond the fingertips because of the risk for glove puncture.[12]

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More recent moderate-quality research has indicated that the 6-mm (0.25-inch) recommendation for fingernail length is too long.[16-18] Hardy et al[18] conducted a randomized crossover study to determine the influence of nail characteristics on the total bacterial count (TBC) of the hands of 21 veterinary surgery personnel (ie, fourth-year veterinary students, interns, residents, technicians) who participated in a minimum of two surgical procedures per week. For 1 week, one group of participants wore a single coat of designated nail lacquer, and the other group wore no nail lacquer. The next week, the groups switched so that the first group wore no nail lacquer, and the second group wore a single coat of lacquer. Each participant performed a standardized surgical hand antisepsis protocol using 2% chlorhexidine gluconate (CHG). Fingernail length was measured daily, and samples from fingernail surfaces and subungual areas were obtained before and after surgical hand antisepsis. Data were collected on participants' dominant hand, nail-biting practices, and time since the initial application of nail lacquer.

The researchers found that TBC was not influenced by the presence of nail polish or any other factors (eg, chipping of nail lacquer, duration of nail lacquer wear, nail biting, hand dominance), but nail length exceeding 2 mm was a significant risk factor for increased bacterial counts. This led the researchers to recommend that surgical personnel keep their nails shorter than 2 mm to minimize bacterial counts. A limitation of this study was that it was conducted in a veterinary surgical hospital; however, the study outcomes were based on hand cultures of human participants after surgical antisepsis with CHG using the same method performed for surgical patient care of humans.[18]

In one prospective controlled crossover trial[17] and one observational study,[16] researchers evaluated hand contamination using a modified **glove juice method**. They found that fingernail length was a significant contributing factor in the amount and type of microorganisms (eg, bacteria, fungi, viruses) recovered from hands and nails.

Rupp et al[17] introduced an alcohol-based hand rub during a 2-year period in two medical-surgical intensive care units of a tertiary care teaching hospital to investigate whether alcohol-based hand rub improved hand hygiene compliance, affected patient outcomes (ie, health care–associated infections), or altered the number of microorganisms on the hands of health care personnel. The researchers introduced the hand rub in Unit B the first year, then removed it and introduced it in Unit A the second year. The dominant hands of personnel (N = 174) in both units were cultured every 60 days. The researchers found that fingernail length longer than 2 mm (0.08 inches) was significantly associated with a higher number of microorganisms than was fingernail length shorter than 2 mm.

Fagernes and Lingaas[16] evaluated the number of bacteria on the hands of 465 Norwegian health care personnel from three acute care hospitals after they had worked at least 2 hours. The researchers found that fingernails longer than 2 mm were significantly associated with the prevalence of *Staphylococcus aureus*. Thus, the researchers recommended that the fingernails of health care personnel be no longer than 2 mm.
1.2.

Do not wear artificial fingernails or extenders in the perioperative setting.[1,7,11,12,19] ***[Recommendation]***

Artificial nails have been associated with hand contamination and epidemiologically implicated in outbreaks caused by gram-negative bacteria and yeasts.[1,6,7,11] Health agency and professional societies recommend that personnel who have direct contact with patients not wear artificial nails or extenders.[1,7,11,12,19]

Clinical trials involving artificial nails might expose patients to harm and thus may not be ethical. Additional research is needed to determine whether it is the length of the fingernail or the artificial nail itself that poses a risk for the transmission of microorganisms.[7,11]

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1.3.

Do not wear nail lacquer or enhanced nail lacquer while performing the scrub role. ***[Recommendation]***

Lacquered nails may harbor more bacteria than natural nails. Bacteria can accumulate in the crevices of the lacquer, thereby increasing the potential for pathogen transmission. Nail lacquer also has the potential to be dislodged from nail surfaces and transported into the wound. The WHO,[7] the National Institute for Health and Care Excellence (NICE),[19] and the AST[12] recommend removing nail lacquer before performing surgical hand antisepsis.

1.4.

Convene an interdisciplinary team (ie, one or more infection preventionists, perioperative RNs, surgeons, anesthesia professionals, risk management personnel, and other stakeholders identified by the health care organization) to determine whether non-scrubbed personnel will be permitted to wear nail lacquer or enhanced nail lacquer in the perioperative setting.[1,7,20] ***[Recommendation]***

Moderate-quality evidence is inconclusive regarding the effect of nail lacquer on the effective performance of hand hygiene or the number of residual microorganisms after hand hygiene.[16,18,21,22] The benefits of allowing nail lacquer in the perioperative setting (eg, health care worker satisfaction; prevention of flaking, breaking, or chipping of the nail) do not appear to outweigh the potential harms (eg, obscuring a nail infection,[15] hindering the effectiveness of hand hygiene, transmitting pathogens harbored in chipped or old nail polish to a patient, chipped polish becoming deposited in the sterile field or wound).

Health agencies and professional societies provide differing opinions on wearing of nail lacquer based on the inconclusive evidence. For example, the WHO recommends that health care facilities develop policies on the wearing of nail lacquer by health care personnel.[7] The CDC does not make any recommendation on the wearing of nail lacquer, although the CDC guideline for hand hygiene discusses the evidence on nail lacquer.[11] The NICE guidelines in the United Kingdom recommend that the operating team remove nail lacquer before surgeries because of the lack of evidence on the effect of nail lacquer on hand contamination.[19] The AST recommends that nail lacquer be freshly applied and free of chips if the health care facility permits nail polish to be worn.[12] Additional research is needed to determine whether wearing nail lacquer affects hand contamination or patient outcomes, including the rate of SSIs.[20]

In their randomized controlled crossover study, Hardy et al[18] cultured the fingernail surfaces and subungual regions of lacquered (N = 21) and natural nails (N = 21) before and after surgical hand antisepsis for two surgical procedures. Among the first sampling of lacquered nails, which was collected fewer than 48 hours after lacquer application, 23% of the participants had chipped nail lacquer, and at the second sampling, collected after more than 48 hours of wear, 100% of the participants had chipped nail lacquer. However, regardless of the application time frame or chipping of lacquer, the researchers found no difference in TBC between lacquered and natural nails.

Arrowsmith and Taylor[21] conducted a systematic review with meta-analysis of one small randomized controlled trial (RCT) published in 1994. The RCT compared the bacterial counts measured in colony-forming units (CFU) on the hands of perioperative nurses (N = 102) with and without nail lacquer before and after surgical hand antisepsis. In the study, the participants had either natural nails (n = 34), freshly applied nail lacquer that was fewer than 2 days old (n = 34), or old nail lacquer that was either obviously chipped or more than 4 days old (n = 34). The researchers found a significantly higher median number of CFU after surgical hand antisepsis in the group wearing old or chipped nail lacquer compared to the groups with natural nails or freshly applied nail

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lacquer. However, in the meta-analysis of this RCT, Arrowsmith and Taylor[21] did not find significant differences in the mean CFU among any of the study groups. A methodological flaw of the RCT is that the data were skewed because of a contaminated sample in the freshly applied nail lacquer group before surgical hand antisepsis. Thus, the researchers used the median CFU values rather than the mean CFU values to test for statistical significance. Although the median values showed a significant difference in CFU in the old or chipped nail lacquer group after surgical hand antisepsis, the mean values did not show any difference.

In a high-quality quasi-experimental study conducted by Blackburn et al,[22] the three middle fingers of the dominant hand of 89 oncology nurses who provided direct patient care had nail lacquer applied to two nails and no lacquer on the third nail. The nurses were asked to follow the standardized hand hygiene practices outlined in an educational brochure provided to them at the time of study enrollment. Cultures were taken from the nails on day 1 and day 4 of nail lacquer wear after the nurses completed a work shift. The researchers found that the nails with lacquer had the same bacterial counts (eg, gram-negative and gram-positive organisms) as the natural nails for the first 24 hours, but the bacterial burden increased when nail lacquer chipping was present (after 24 hours).

In their observational study, Fagernes and Lingaas[16] cultured the hands of 465 Norwegian health care personnel after they had completed a minimum of 2 hours of direct patient care. They recorded the presence of nail lacquer for each study participant as no lacquer present (n = 377), intact lacquer (n = 35), or chipped lacquer (n = 51); in two cases, nail lacquer status was not recorded. In previous nail lacquer studies, only the fingernails were cultured, whereas in this study, the whole hand was cultured using the modified glove juice method. The researchers found no effect of nail lacquer status on the bacterial count for the whole hand.

The evidence review found minimal research to support or refute wearing of enhanced nail lacquer products in the health care setting. The Society for Healthcare Epidemiology of America (SHEA)/Infectious Diseases Society of America (IDSA) hand hygiene practice recommendations also cite a lack of evidence-based guidance on wearing **ultraviolet (UV)-cured nail lacquer** and other enhanced nail lacquer products in the patient care setting.[1] A conservative approach recommended by SHEA/IDSA is for the health care organization to deem UV-cured nails to be artificial and to not allow health care personnel to wear this type of enhanced nail lacquer in high-risk areas, such as the operating room (OR).[1] The challenge with any nail lacquer policy is monitoring and enforcement, particularly if nail lacquer is allowed but enhanced nail lacquer is not, because it is difficult to tell them apart.

In a quasi-experimental study, Hewlett et al[20] evaluated the bacterial burden of UV-cured nail lacquer (ie, gel polish), standard nail lacquer, and natural nails on the hands of 88 health care workers from three health care facilities. Ultraviolet-cured nail lacquer and standard nail lacquer were applied by a licensed nail technician to two different nails on the health care worker's dominant hand; all other nails on the hand remained natural. On days 1, 7, and 14 of wear, the researchers obtained bacterial cultures from each nail type's fingernail surface, cuticle bed, and subungual area. On day 7, additional cultures were obtained before and after hand hygiene with an alcohol-based hand rub. The researchers obtained 741 cultures and found that the bacterial burden of nails became greater for all three nail types as timed passed. However, after hand hygiene on day 7, the bacterial burden decreased significantly for standard lacquer and natural nails but not for UV-cured nail lacquer. The researchers purported that alcohol-based hand rub may not be as effective on thicker gel polish because of the nail outgrowth that occurs, creating deep crevices that are more difficult to clean. They recommended that larger, high-quality studies be conducted to verify this deduction.

Whether enhanced nail lacquer products carry the same risk of harboring microorganisms or transmission of infection to patients as artificial nails is unknown. The harms of wearing enhanced nail lacquer products may include damage to the natural fingernail, formation of microfractures that may serve as a reservoir for microorganisms, harboring of microorganisms in the gaps created as the nail and cuticle grow, and difficulty of product removal in the perioperative setting (ie, soaking in acetone).

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More research is needed to determine whether enhanced nail lacquer products affect hand hygiene effectiveness and the number of microorganisms on the hands of health care personnel.

1.4.1.

If wearing nail lacquer or enhanced nail lacquer is approved by the health care organization, the lacquer should be free of chips and cracks. ***[Recommendation]***

Nail lacquer and enhanced nail lacquer that is cracked introduces the risk for transmission of harbored pathogens to a patient.
1.5.

Take measures to prevent hand dermatitis, to include

- using moisturizing skin care products compatible with hand hygiene products,
- implementing practices that decrease skin irritation (eg, controlling water temperature, completely drying hands),
- selecting less irritating hand hygiene products, and
- participating in education on hand dermatitis prevention.[1,7,11,23]

[Recommendation]

Hand dermatitis is one of the most prevalent occupational diseases in health care and may have a negative effect on hand hygiene.[7,23,24] According to the WHO, damage to the skin may change skin flora and has been associated with more frequent colonization by staphylococci and gram-negative bacilli.[7] Because health care workers have an increased risk for dermatitis as a result of frequent hand hygiene and glove use, the WHO,[7] the CDC,[11] and the SHEA/IDSA[1] recommend taking preventive measures to decrease the likelihood of developing dermatitis.

In an RCT conducted by van der Meer et al,[23] personnel in 48 departments from three university hospitals in the Netherlands were randomly assigned by the department to either a control group or a group that participated in an educational intervention to prevent hand dermatitis. The preventive measures included the use of alcohol-based hand rub when hands were not visibly contaminated, wearing gloves for wet work (ie, activities where hands become wet or moist), wearing cotton glove liners if gloves were worn for more than 10 minutes, daily use of moisturizer, and absence of jewelry at work. All participants (N = 1,649) self-reported hand dermatitis and preventive behavior at 3, 6, 9 and 12 months. The researchers found that 12 months after the baseline report, the intervention group was significantly more likely to report hand dermatitis, less soap and water use and more alcohol-based hand rub use, more frequent moisturizer use, and more use of cotton undergloves. The researchers concluded that the intervention had a positive effect on recognition and reporting of hand dermatitis and participant engagement in preventive behavior.

Having hand dermatitis may result in hand colonization with microorganisms, less hand washing, and increased risk for infection of both patients and perioperative team members. Benefits of using preventive measures for hand dermatitis may include preventing skin damage and promoting optimal hand hygiene.

1.5.1.

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Use moisturizing skin care products that are compatible with hand hygiene and surgical hand antisepsis products and are approved for use by the health care organization.[1,7,11,24] *[Recommendation]*

High-quality evidence and guidance from health agencies and professional organizations support the use of moisturizing skin care products to maintain healthy skin condition.[1,7,11,24] Additional research is needed to determine the effect of hand lotion use on bacterial colonization (See Recommendation 7.5 for guidance on the selection of skin care products).

The WHO recommends that health care personnel use moisturizing skin care products after hand cleansing to minimize irritant contact dermatitis caused by hand hygiene.[7] The CDC[11] and the SHEA/IDSA[1] also encourage the use of hand lotion by health care personnel as a strategy to prevent and manage hand hygiene–related irritant contact dermatitis.

Harnoss et al[24] conducted a survey of 16,000 German surgeons and received 1,433 responses (response rate 11%). Although 50% of the respondents reported having experienced skin irritation or discomfort, only 5% reported that they used skin protection or skin care products at the beginning of their shifts. Ten percent of the surgeons refused to use skin care products because of concern that the product would reduce the antimicrobial efficacy of the surgical hand rub.

After the survey, Harnoss et al[24] conducted an experimental crossover study (N = 26) using European Norm standards for testing to determine the effect of skin protection and skin care products on surgical hand antisepsis efficacy and glove microperforations. Healthy volunteers applied an alcohol-based surgical hand rub, allowed it to dry, and donned surgical gloves for a 3-hour period while performing their normal daily activities (eg, office and laboratory work). After using the skin care products three times daily for 8 days, the participants in the intervention group (n = 13) had significantly higher skin moisture with no significant changes in surgical hand rub effectiveness or glove microperforations than the group that did not use any skin care products (n = 13). Although the study did not find a significant rate of glove microperforations, the group with no skin care product use had a higher perforation rate (23.1%) than the group that used skin care products (7.7%), which may indicate that having dry hands increases the microperforation rate. However, this study was not designed to examine the correlation of dry skin to glove microperforation, so additional research is needed to evaluate this relationship. In the interpretation of this study, the researchers emphasized the importance of assessing the compatibility of skin care products with hand hygiene products during the product selection process.

In an observational study, Fagernes and Lingaas[16] cultured the hands of 465 Norwegian health care personnel using the glove juice method. For each study participant, the minutes between the application of hand lotion and hand culturing were recorded. The researchers found that 10 health care personnel used hand lotion within 5 minutes before sampling, which was significantly associated with *Staphylococcus aureus*. The researchers postulated that the use of hand lotion may increase the efficiency of the skin to acquire staphylococci or may cause better recovery during sampling culturing methods because of the surface-active ingredients or that the findings might be a result of statistical chance. The researchers cited a historical report of increased hand bacterial counts after hand lotion use, which supported their findings, but they acknowledged further studies are needed.

1.5.2.

Control water temperature for hand hygiene between 70° F and 80° F (21.1° C and 26.7° C).[25] *[Recommendation]*

The Facility Guidelines Institute (FGI) recommends controlling water temperature at **hand washing stations** between 70° F and 80° F (21.1° C and 26.7° C).[25] Water temperatures higher than 80° F (26.7° C) are conducive to the growth of *Legionella* bacteria.[25]

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The WHO,[7] the CDC,[11] and the SHEA/IDSA[1] recommend avoiding hand washing in hot water because repeated exposure to hot water can irritate the skin and may lead to dermatitis or bacterial colonization. As an alternative, the SHEA/IDSA recommends using either warm or cold water for hand washing because of a lack of evidence that either water temperature is superior.[1] Notably, these professional organizations do not define temperature ranges for hot, warm, and cold water. Additional research is needed to determine the effect of water temperature on hand dermatitis and bacterial colonization.

1.5.3.

After performing hand hygiene, completely dry hands before donning gloves.[7] *[Recommendation]*

The WHO recommends that health care personnel allow their hands to dry completely before donning gloves after either hand washing or use of an alcohol-based hand rub because of an increased risk for skin irritation from wearing gloves on wet hands.[7]

1.5.4.

Cotton glove liners may be worn under non-sterile gloves. Sterile cotton glove liners may be worn under sterile gloves.[1,26] *[Conditional Recommendation]*

The SHEA/IDSA recommends that individuals with irritant contact dermatitis use cotton glove liners to maintain healthy skin condition when extended use of gloves is anticipated but does not define the time for extended use.[1]

The Netherlands Society of Occupational Medicine guideline for prevention of contact dermatitis recommends wearing cotton undergloves if gloves are worn for longer than 10 minutes.[26] The authors stated that the use of undergloves helps to prevent perspiration that can lead to skin softening. However, they recommended changing the undergloves if they become too moist (ie, “clammy”).[26]

1.5.5.

Discard single-use cotton glove liners after each use. Reprocess reusable cotton glove liners in accordance with the manufacturer’s instructions for use. *[Recommendation]*

1.5.6.

Unless hand washing with soap and water is indicated (See Recommendation 3.4), disinfect hands with an alcohol-based hand rub (ie, ethanol, isopropyl).[1,7] *[Recommendation]*

The WHO[7] and the SHEA/IDSA[1] recommend promoting the use of alcohol-based hand rub for hand hygiene as preferred to hand washing with soap and water because alcohol-based hand rubs are well tolerated and associated with lower irritant contact dermatitis (See Recommendation 7.6 for guidance on the selection of hand hygiene products, including alcohol concentration in alcohol-based hand rubs. See Sections 3 and 4 for performing hand hygiene and surgical hand antisepsis).

1.5.7.

Provide education to perioperative team members on recognizing and preventing hand dermatitis.[1,7,23] *[Recommendation]*

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The WHO[7] and the SHEA/IDSA[1] recommend educating health care personnel on hand care practices to prevent irritant contact dermatitis and other skin damage from hand hygiene practices.

van der Meer et al[23] studied use of a multifaceted strategy that included an educational intervention to prevent hand eczema in the Netherlands. The researchers provided education to the intervention group and no education to the control group. The researchers found that the educational intervention was effective in influencing personnel to implement evidence-based measures to prevent hand eczema, including more frequent moisturizer use and more use of cotton undergloves compared to the control group.
1.6.

Restrict the activities of health care personnel with dermatitis; infections; exudative lesions; and non-intact skin of the nails, hands, or arms when these activities pose a risk for transmission of infection to patients and other health care providers.[10,27] ***[Recommendation]***

Perioperative team members with breaks in skin integrity or infections of the nails, hands, or arms may be at risk for acquiring infections or transmitting pathogens to patients (See the AORN Guideline for Transmission-Based Precautions[10] for additional guidance).
2.

Jewelry

2.1.

The organization should implement policies about the wearing of jewelry in the perioperative setting for both scrubbed and non-scrubbed team members. ***[Recommendation]***

Wearing jewelry can impede the removal of microorganism from the hands during hand hygiene. Moderate-quality evidence indicates that wearing jewelry on the hands and wrists is associated with increased bacterial counts on the hands[16,17] and ineffective use of alcohol-based hand rubs.[14] Transmission to the patient of microorganisms on jewelry worn by perioperative team members may result in the patient developing a health care–associated infection.[28]

Four health agencies and professional organizations have provided guidance on wearing jewelry in the health care setting. However, the evidence could not be synthesized or generalized as two recommendations only apply to perioperative team members who perform surgical antisepsis[12,19]; one recommendation is for all perioperative team members entering the OR[7]; and one makes no recommendation, citing a lack of evidence.[11]

The WHO strongly discourages wearing of rings or other jewelry in the health care setting and recommends that all rings or jewelry be removed in the OR. The WHO recognizes that religious and cultural beliefs may strongly condition health care workers' attitudes toward removing their wedding rings. Thus, the WHO advises that for these individuals, wearing a simple wedding band may be suitable except in a high-risk setting such as the OR.[7]

The NICE guidelines recommend that the operating team remove hand jewelry before surgeries as a measure to decrease the risk for SSI.[19] The AST recommends that all jewelry, including rings, bracelets, and watches, be removed before surgical hand antisepsis is performed.[12] The CDC makes no recommendation for the wearing of rings in health care settings, designating the issue as unresolved because of the lack of evidence to determine whether wearing rings results in increased transmission of pathogens.[11]

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Fagernes and Lingaas[16] used the modified glove juice method to evaluate the microflora on the hands of 465 Norwegian health care personnel and found that wearing a wristwatch (n = 79) was significantly associated with a higher total bacteria count on hands than not wearing a watch (n = 121). Wristwatch status was not recorded for 265 study participants. The researchers also found that wearing rings was associated with a higher number of bacteria on hands. However, they found that study participants wearing rings were more likely also to wear watches. Because of this confounding factor, the researchers did not use these data in statistical analysis.

Fagernes and Lingaas[16] also found that wearing one ring (n = 192) increased the rate of colonization with *Enterobacteriaceae.* However, there was insufficient statistical power to detect a significant difference between wearing a single decorative ring (n = 50) or wearing multiple rings (n = 10). Based on their findings, the researchers recommended that health care personnel not wear finger rings or wristwatches in the patient care setting.

In the study conducted by Rupp et al,[17] as described in Recommendation 1.1.1, the effect of wearing rings on microbial hand flora was also evaluated. Every 60 days during the study period, unannounced cultures were obtained from the dominant hand of 174 nurses, regardless of whether hand hygiene had recently been performed. The number of rings that the nurse wore was also recorded; 122 nurses wore one or more rings and 52 wore no rings. The researchers found a significant association between wearing at least one ring on the dominant hand and the number of recovered microbe species and gram-negative bacilli carriage.

In a case study, Jepson et al[28] described six *Serratia marcescens* postoperative wound infections that developed in cardiothoracic patients during a 5-month period. A scrub person and an assistant surgeon were present for all six surgeries, but screening did not indicate any colonization with *S marcescens*. However, it was noted that the assistant surgeon had two tightly fitting rings on his right hand that he could not remove. When cultures were taken from under the rings, the genomic analysis showed an exact match with the outbreak species. After the assistant was asked to abstain from participating in surgeries until the rings were removed and three negative cultures were obtained, no additional infections occurred.

Although strong evidence has not confirmed the risk of direct transmission of microorganisms to the patient from health care personnel wearing jewelry or watches on the hands or wrists, the benefits of removing jewelry may include more effective and frequent hand hygiene[7,14] and preventing harm to patients, damage to gloves,[1,7,12] or loss of jewelry.

2.1.1.

Scrubbed team members should not wear jewelry (eg, rings, watches, bracelets) on the hands or wrists.[7,12,14,16,17,19] ***[Recommendation]***

2.1.2.

The organization may determine whether non-scrubbed team members who are not performing a task requiring sterile technique can wear a

- ring that is constructed of smooth materials without any stones or adornments or
- a wristwatch or personal fitness tracker that is constructed of smooth materials without stones or adornments.

[Conditional Recommendation]

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Evidence is inconclusive regarding the effect for non-scrubbed personnel of wearing a simple ring in the perioperative setting. Some individuals hold beliefs about the symbolic value of wearing a ring (eg, a wedding band) and being required to remove it can cause distress for these individuals. However, harms may include the potential for the ring to interfere with effective hand hygiene and the inability to clean the ring, which could pose an infection risk to the wearer.

The study conducted by Hautemaniere et al,[14] as described in Recommendation 1.1, evaluated the wearing of jewelry on hand hygiene effectiveness. The researchers found that wearing a watch, bracelet, or rings (other than a wedding ring) was significantly associated with ineffective hand rub use. In this study, wearing a wedding ring was not independently associated with hand hygiene ineffectiveness. Notably, the researchers did not describe characteristics of a wedding ring, such as the band type or stone setting. However, they discussed that even though wedding rings had a strong symbolic and sentimental value to the health care personnel, some personnel became aware of the importance of removing their rings because the alcohol solution did not penetrate under the ring, and thus the ring could harbor microorganisms.

The WHO advises that wearing a simple wedding band may be suitable except in a high-risk setting such as the OR.[7]

The benefits to the wearer of wearing a simple wristwatch or fitness tracker may include improved personnel health and fitness, continual ability to assess time, and the ability to measure the patient's pulse and respirations. Harms may include infection risk to the patient and wearer due to frequent contact of the device with the wearer's hands and the inability to clean the device. Harms may also include the risk for injury to the patient or wearer because of potential entrapment of the device within patient's gown, linens, or drapes.
3.

Performing Hand Hygiene

3.1.

All individuals who participate in patient care in the perioperative setting should perform hand hygiene.[1,7,11,29] ***[Recommendation]***

The benefits of performing hand hygiene clearly outweigh any potential harms. Benefits include removal of soil and transient microorganisms from the hands of perioperative team members, possibly reducing occupational exposure to hazards commonly found in the OR and the risk for the patient to develop a health care–associated infection as a result of microbial transmission from the hands of perioperative personnel. Potential harms can include dermatitis related to product use and brief delays in task performance.

Guidance from health agencies concurs that the performance of hand hygiene is essential in reducing the incidence of health care–associated infections[1,7,11,29] Surgical patient care involves frequent contact with patients, equipment, and environmental surfaces, providing multiple indications for hand hygiene. However, observations of hand hygiene in the perioperative environment indicate that compliance with health agencies' recommendations are suboptimal.[30-34]

Moderate-quality evidence from observations of contaminants on environmental surfaces in the perioperative environment, which were attributable to health care workers' hands, also supports the importance of hand hygiene.[35,36] Loftus et al[35] followed patients undergoing general anesthesia (N = 548) to identify which bacterial reservoir was associated with transmission events from IV stopcocks. The researchers sampled three bacterial reservoirs: providers' hands, the patient's axillae and nasopharynx, and two high-touch sites on the anesthesia machine. All three reservoirs contributed to transmission, although 64% of stopcock contamination

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was traced to the anesthesia machine, which was associated with contact from the provider's hands. The researchers also found that IV stopcock contamination was significantly associated with patient mortality and 30-day postoperative infections.

Heid et al[36] evaluated bacterial contamination on syringes (N = 319) used to administer multiple injections that were handled under different conditions by anesthesia professionals during urological surgeries. After the medication was delivered, the syringes were recapped with a new cap (n = 102), remained uncapped and uncovered (n = 116), or were placed back in the original wrapping (n = 101). The overall contamination rate of syringes was 21%, with no significant differences between the groups (ie, 26%, 23%, and 14%, respectively), whereas the contamination rate of syringes prepared without patient contact (N = 90) was 4%. Coagulase-negative staphylococci, a common skin flora, was the main source of contamination, thereby leading the researchers to reiterate the importance of hand hygiene.
3.2.

Perioperative team members should perform hand hygiene

- before and after patient contact (eg, marking the site, transferring or positioning the patient[37]),[1,7,10,11,13]
- before performing a clean or sterile task (eg, handling instruments for sterilization packaging,[38] preparing medication for delivery to the sterile field[37]),[7,10,39]
- after potential blood or body fluid exposure (eg, removing personal protective equipment,[13] handling used sponges[37,40]),[1,7,11,39]
- after contact with patient surroundings (eg, patient bed and linens,[33] the floor or items that have come in contact with the floor[41]),[1,7,11,42]
- when hands are visibly soiled (eg, dirt, blood, body fluids[11]),[1,7,11,39]
- before and after eating,[11] and
- after using the restroom.[7,11]

[Recommendation]

The WHO[7] and the CDC[11] recommend performing hand hygiene before and after patient contact, before performing a clean or sterile task, after risk for blood or body fluid exposure, after contact with patient surroundings, and any time hands are visibly dirty or soiled. In a literature review of factors that potentially influence hand hygiene performance, Allegranzi et al[43] hypothesized that individuals with dark skin may have greater difficulty visualizing when their skin is soiled, and additional explanation and examples may be needed.

When determining indications for hand hygiene, it is important to identify any contact that occurs with the patient, the patient's equipment, and those items touched by the patient.[7] However, in the perioperative environment, the patient's contact with surrounding surfaces may be minimal because of the short time spent in each perioperative phase and the patient's limited mobility while in these phases. It is also important to recognize that contact of health care personnel with equipment and surfaces not in the immediate vicinity of the patient (ie, other areas of the procedure room) may be potential sources of microorganism transmission to the patient.

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To promote better visualization of indications for hand hygiene during care of a single patient in a health care setting, the WHO conceptualized two regions as the patient zone and the health care zone.[7] Performing hand hygiene after contact with the patient surroundings interrupts the transmission of microorganisms from equipment in the patient zone to the health care zone. The cleaning of patient zone equipment after the patient has left the area additionally contributes to the disruption of microbial transmission.[7,41,42]

3.2.1.

The health care organization may establish and communicate the delineation of the perioperative patient zone when determining the indications for hand hygiene after contact with patient surroundings.[7,44] ***[Conditional Recommendation]***

The Association for Professionals in Infection Control and Epidemiology (APIC) identifies the patient zone as the area where the patient, health care worker, and environment intersect.[44] The location, provision of patient care, and equipment can be unique from one unit to another (eg, OR versus postanesthesia care unit). Therefore, establishing local specificity of the patient zone and making it known to health care personnel working in that area can assist with recognition of hand hygiene indications.[7,42]

In a quality project to improve the identification of hand hygiene indications in the OR according to the WHO patient zone and health care zone concept,[7] an infection preventionist observed a variety of adult and pediatric surgical specialty procedures (N = 11) and identified equipment in direct contact with the patient and equipment touched by non-scrubbed personnel after patient contact.[42] Next, the infection preventionist tallied any subsequent hand contact with the same piece of equipment. If the patient was brought into the OR on a stretcher and did not touch any equipment outside of the stretcher or OR bed, the hand hygiene indication for contact with equipment touched by patients was not included. Additionally, the anesthesia professionals' hand contact with the anesthesia work area was not quantified because that area is already known to be a source of health care–associated infection and part of the patient zone.[4,35]

After observations were completed, the data were shared with OR personnel, who, together with the infection preventionist, designated to which area the equipment would be assigned based on intraoperative workflow, practical application of hand hygiene, time allotment for cleaning, and ease of cleaning the equipment. This exercise resulted in 37 pieces of equipment being identified as part of the patient zone (eg, patient warming device, OR bed control) and 20 pieces of equipment being identified as part of the health care zone (eg, door plate, trash receptacle). Patient zone equipment was photographed and placed on a poster used for education and a visual reminder in the OR. The delineation of the patient zone gave perioperative personnel clarity on the hand hygiene indication of "after contact with patient surroundings," thereby increasing hand hygiene compliance. The authors noted that they had also used this method in other procedural areas in their health care facility (ie, radiology, endoscopy) with favorable results.[42]

3.2.2.

When hand hygiene is indicated, remove gloves and perform hand hygiene.[7,11] ***[Recommendation]***

The use of gloves does not replace the performance of hand hygiene.[7,11]

3.2.3.

Performing a single act of hand hygiene may fulfill multiple indications.[7] ***[Conditional Recommendation]***

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Multiple indications for hand hygiene may arise simultaneously (eg, opening multiple sterile items sequentially) and create a single opportunity to perform hand hygiene.[7]
3.3.

If performing hand hygiene would put the patient at risk, weigh the risks and benefits of delaying hand hygiene. *[Recommendation]*

The benefits of performing hand hygiene may not outweigh the harms, depending on the clinical situation (eg, trauma that is a threat to life). Benefits include reducing the risk of the patient developing a health care–associated infection. Potential harms can include delaying necessary, possibly life-saving activities, such as intervening to prevent patient falls or providing ventilation.

In a small organizational experience study conducted to examine the context of anesthesia care delivery and determine the feasibility and accuracy of measuring anesthesia providers' hand hygiene, an infection preventionist observed one anesthesiologist in the OR for 3.5 hours.[45] The authors found that both the frequency and speed of anesthesia activities contributed to the difficulty of hand hygiene performance, and in some instances, the patient would be placed at significant risk if the provider stopped care to perform hand hygiene.

3.3.1.

When inserting an airway device, the health care professional may

- wear two pairs of gloves (ie, double glove),
- remove the contaminated outer gloves after airway manipulation,
- continue care until the patient's status permits inner glove removal,
- remove inner gloves, and
- perform hand hygiene when the clinical situation permits.[13,39,46,47]

[Conditional Recommendation]

The hands of health care professionals can become contaminated with upper-airway secretions during airway management and intubation, which can result in cross contamination of the work area.[39] High-quality evidence[46,47] and recommendations from two professional societies[13,39] support double gloving during airway manipulation.

The SHEA has published expert guidance to address infection control in the OR anesthesia work area, recommending that the health care professional consider wearing two pairs of gloves during airway management, with immediate removal of outer gloves upon completion of airway manipulation, and removal of inner gloves and hand hygiene performance as soon as feasible.[39]

The American Association of Nurse Anesthetists (AANA) recommends that anesthesia professionals double glove during airway manipulation.[13] The AANA recommends maintaining patient oxygenation by ventilating the patient immediately after airway manipulation, auscultating breath sounds, and confirming end-tidal carbon dioxide.[13] Removing gloves to perform hand hygiene immediately after airway management may jeopardize the patient's safety. As an alternative, the AANA recommends that anesthesia professionals don two pairs of gloves

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before airway manipulation, remove the outer gloves after the airway device is inserted, and perform hand hygiene when the patient is stable.[13]

Birnbach et al[46] conducted an RCT to assess contamination of the OR surfaces during simulated laryngoscopy and intubation by anesthesiology residents (N = 22). The intervention group members (n = 11) wore two pairs of gloves and removed the outer pair of gloves after intubation, whereas the control group members (n = 11) each wore a single pair of gloves. The group wearing two pairs of gloves during intubation and removing the outer gloves immediately after intubation contaminated significantly fewer surfaces, as measured by fluorescent marking gel.

In a similar RCT conducted with anesthesiology residents in simulations (N = 45), Birnbach et al[47] compared the level of OR surface contamination after single gloving (n = 15), double gloving with the outer gloves removed after intubation (n = 15), and double gloving with the outer gloves used to cover the laryngoscope (n = 15). The researchers found that both double gloving techniques were associated with significantly lower contamination than single gloving. Use of the outer pair as a sheath for the laryngoscope immediately after intubation was associated with the least contamination of the IV hub, patient, and intraoperative environment. Although double gloving significantly reduced surface contamination in both RCTs,[46,47] complete elimination of contamination did not occur. Thus, the removal of inner gloves and performance of hand hygiene as soon as possible is essential to prevent additional contamination and possible cross transmission. A limitation of these studies is that they were not conducted in the clinical setting but were simulations. Additional research is needed. 3.4.

Perform hand washing with soap (antimicrobial or plain) and water

- after being exposed to blood or body fluids[7,11];
- after using the restroom[7,11];
- when hands are visibly soiled[1,7,11];
- when caring for a patient with *Bacillus anthracis*[1,7,11] or norovirus[1]; and
- when caring for a patient with a *Clostridioides difficile* infection if
    - a facility is experiencing a *C difficile* outbreak or high infection rate, or
    - direct contact is made with patient feces or body areas where fecal contamination is likely (ie, the perineum).[48]

[Recommendation]

Performing hand hygiene with an alcohol-based hand rub may not be effective when hands are visibly or potentially soiled with organic matter, such as blood and body fluids. Also, *B anthracis* and norovirus may be removed from the hands more effectively with soap and water than with an alcohol-based hand rub.[1,7,11]

In a review of the literature, McDonald et al[48] found minimal evidence to support the use of soap and water as the preferred method of hand hygiene after care of a patient with *C difficile* infection unless there was an outbreak, sustained high rates of *C difficile* infection, reoccurrence of *C difficile* infection in the same patient room, or direct contact with patient feces. Additionally, sinks may not be readily available in the perioperative setting, and repeated use of soap and water can lead to dermatitis.

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3.4.1.

Hand hygiene may be performed with an alcohol-based hand rub in a setting that is not experiencing a *C difficile* outbreak.[48]
[Conditional Recommendation]

Refer to the AORN Guideline for Transmission-Based Precautions for additional information.[10]

3.4.2.

Use a standardized protocol to perform hand washing in the following order:

1. Remove any jewelry from hands and wrists (eg, rings, watches, fitness trackers).[7,11]
2. Adjust water temperature (See Recommendation 1.5.2).[7]
3. Wet hands thoroughly with water.[7,11]
4. Apply the amount of soap needed to cover all surfaces of the hands.[7,11]
5. Rub hands together vigorously, covering all surfaces of the hands and fingers for at least 15 seconds.[11]
6. Rinse with water to remove all soap.[7,11]
7. Dry hands thoroughly with a disposable paper towel.[7,11]
8. When hands-free controls are not available on the sink, use a clean paper towel to turn off the water.[11]

[Recommendation]
3.5.

Unless hand washing with soap and water is indicated (See Recommendation 3.4), perform hand hygiene using an alcohol-based hand rub according to the manufacturer's instructions for use.[7,11]
[Recommendation]

The WHO[7] and the CDC[11] recommend performing hand hygiene with an alcohol-based hand rub when hands are not visibly soiled or dirty.

3.5.1.

Use a standardized protocol to perform hand hygiene with an alcohol-based hand rub in the following order:

1. Remove any jewelry from hands and wrists (eg, rings, watches, fitness trackers).[7,11]
2. Apply the amount of alcohol-based hand rub recommended by the manufacturer to cover all surfaces of the hands.[7,11]
3. Rub hands together, covering all surfaces of the hands and fingers until dry.[7,11]

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[Recommendation]
4.

Surgical Hand Antisepsis

4.1.

Perform surgical hand antisepsis before donning a sterile gown and gloves for operative and other invasive procedures.[1,7,11,12] ***[Recommendation]***

Surgical hand antisepsis is the primary line of defense to protect the patient from pathogens on the hands of perioperative team members. The risk for glove failure[49] makes the performance of surgical hand antisepsis critical for the prevention of SSIs.[7,11] Surgical hand antisepsis reduces transient and resident microorganisms on the hands of perioperative team members, which may lower the risk of the patient developing an SSI.[2]

Although research has demonstrated that surgical hand antisepsis reduces the number of bacteria on the hands of health care personnel, in a systematic review, Tanner et al[2] found that the evidence is unclear about how the number of bacteria correlates to the likelihood a patient will develop an SSI. However, it is not ethical to conduct clinical trials to determine this correlation because they could expose patients to harm.[7]

Bacteria on the hands of surgeons can cause wound infections if introduced to the sterile field during surgery.[11] Bacteria multiply rapidly under surgical gloves when hands are washed with non-antimicrobial soap[11] and the use of a nonantimicrobial surgical scrub was implicated in an outbreak of SSIs.[7]

4.1.1.

Complete surgical hand antisepsis by performing a surgical hand rub or surgical hand scrub.[1,2,7,11,12,50-53] ***[Recommendation]***

Several health agencies and professional societies recommend performing either a surgical hand scrub or a surgical hand rub for surgical hand antisepsis.[1,7,11,12,52,53]

The 2014 SHEA compendium on preventing SSIs does not recommend a specific method but instead recommends using an efficacious antiseptic agent to complete surgical hand antisepsis.[29] The WHO *Global Guidelines for the Prevention of Surgical Site Infection* recommend performing a surgical hand scrub for the first procedure of the day and for subsequent cases if hands are soiled. However, if hands are not soiled, an alcohol-based surgical hand rub is sufficient for subsequent cases.[54]

High-quality evidence comparing the performance of a surgical hand scrub to a surgical hand rub showed both methods to be equally effective in reducing bacterial counts on the hands of health care personnel and reducing the likelihood of the patient developing an SSI.[2,50,51]

In their systematic review, Tanner et al[2] analyzed four RCTs that compared the use of a surgical hand rub to a traditional hand scrub, with SSI rates as an outcome measure. Among the four studies, no significant difference in SSI rates was found between the methods evaluated.

Similarly, in a non-experimental study, Kashkoush et al[55] surveyed 42 neurosurgeons regarding their preferred method for surgical hand antisepsis (ie, surgical hand scrub designated as wet scrub; surgical hand rub designated as dry scrub). Next, using a prospectively maintained database, 90-day SSIs for four procedures (ie,

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craniotomy, shunt placement, fusion, laminectomy) performed by each of the neurosurgeons during the previous 5 years (N = 14,200) were used to calculate procedure SSI rates. The researchers found that the surgeon's preference for wet or dry scrub was not significantly associated with the SSI rate for any of the four procedures.

In a quasi-experimental study conducted at a university hospital in Brazil to implement a surgical hand rub for cardiac and orthopedic scrub personnel (N = 56), Gaspar et al[50] compared the probability that patients undergoing cardiac and orthopedic surgery would develop an SSI before and after the intervention. For 3 months before the intervention, when only surgical hand scrubs were performed, 132 patients were evaluated for SSI risk factors (ie, comorbidities, immunosuppressants, body mass index, length of surgery) and followed for 1 month for SSI incidence. The same data were collected on 99 patients for the 3 months after the intervention. The researchers found that the individual risk of developing an SSI did not significantly change between the two time periods. Therefore, they concluded that the surgical hand rub was equally effective for the prevention of SSI as the surgical hand scrub.

In another quasi-experimental study, López Martin and Calvo-Sotelo[51] cultured the hands of 34 surgeons and scrubbed persons before and after surgical hand antisepsis and at the end of surgery after glove removal. Cultures were performed on day 1 after surgical hand scrub completion and on day 2 after surgical hand rub completion. Bacterial counts measured in CFU were detected on the hands of five participants after they used a surgical hand rub and on the hands of 14 participants after the surgical hand scrub. The number of CFU after glove removal was similar for both methods. The researchers concluded that surgical hand rub significantly reduced CFU on hands and had a similar latency duration as a surgical hand scrub.

4.2.

Perform a surgical hand rub according to the manufacturer's instructions for use.[52,53] ***[Recommendation]***

The evidence review found no literature related to the application technique. Antiseptic manufacturers' instructions convey important safety and efficacy information to the user. Failure to adhere to the manufacturer's instructions for use may result in harm or ineffectiveness of the surgical hand antiseptic. (See Recommendation 7.3 for guidance on the selection of surgical hand antisepsis products, including surgical hand rubs).

The WHO guideline recommendation for surgical hand rub technique states that the hand and forearm size determine the volume required to keep the skin wet for the duration of the surgical hand rub.[7]

In a small non-experimental study conducted in Germany, Kampf and Ostermeyer[56] evaluated whether the efficacy of surgical hand disinfection with an alcohol-only surgical hand rub (ie, n-propanol 60%, which is not used in the United States) was influenced by volume applied and the size of the user's hands. They found that participants with larger hands required more antiseptic product to keep their hands and forearms wet for the recommended 3 minutes.

4.2.1.

Perform a standardized surgical hand rub protocol in the following order:

1. Remove jewelry from hands and wrists (eg, rings, watches, fitness trackers).[7,11]
2. Don a surgical mask.[7,49]
3. If hands are visibly soiled, wash hands with soap and water.[7,11]
4. Remove debris from underneath fingernails using a disposable nail cleaner under running water.[7,11]

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5. Dry hands and arms thoroughly[7,11] with a disposable paper towel.
6. Apply the surgical hand rub product to the hands and arms according to the manufacturer's instructions for use (eg, amount, method, time).[7,11]
7. Allow hands and arms to dry completely[7,11] before using sterile technique to don a surgical gown and gloves.[49]

[Recommendation]
4.3.

Perform a surgical hand scrub according to the manufacturer's instructions for use.[52,53]
[Recommendation]

The evidence review found no literature related to application technique, including sequence of scrubbing, alternating between arms, and scrubbing above the elbow. Antiseptic manufacturers' instructions for use convey important safety and efficacy instructions to the user. Failure to adhere to the manufacturer's instructions for use may result in harm or ineffectiveness of the surgical hand antiseptic.

4.3.1.

Perform a standardized surgical hand scrub protocol in the following order:

1. Remove jewelry from hands and wrists (eg, rings, watches, fitness trackers).[7,11,28]
2. Don a surgical mask.[7,49]
3. If hands are visibly soiled, wash hands with soap and water.[7,11]
4. Dry hands and arms thoroughly[7,11] with a disposable paper towel.
5. Remove debris from underneath fingernails using a disposable nail cleaner under running water.[7,11]
6. Apply the amount of surgical hand scrub product recommended by the manufacturer to the hands and forearms using a soft, nonabrasive sponge.
7. Visualize each finger, hand, and arm as having four sides. Wash all four sides effectively, keeping the hands elevated.[7]
8. Scrub for the length of time recommended by the manufacturer.[11] The scrub should be timed to allow sufficient product contact with the skin.[7]
9. For water conservation, turn off water when it is not in use, if possible.
10. Avoid splashing on surgical attire.[7]
11. Discard sponges, if used.
12. Rinse hands and arms under running water in one direction, from fingertips to elbows.[7]

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13. Hold hands higher than elbows and away from surgical attire.

14. In the OR or procedure room, dry hands and arms with a sterile towel using sterile technique before donning a surgical gown and gloves.[7,49,57]

[Recommendation]
4.3.2.

Do not perform the surgical hand scrub using a brush.[7,11,58-61] *[Recommendation]*

Scrubbing with a brush may damage skin and increase the number of bacteria shedding from the hands.[11] Several moderate-quality studies have shown that the use of a brush is not necessary to reduce the number of bacteria on the hands.[7,11,58-60]

Additionally, in an RCT, Parlak et al[61] found that a brush was not necessary for nail cleaning. The researchers assigned 180 nurses and surgeons to one of four groups to perform a standardized surgical hand scrub with 4% CHG. The four groups were: I) 1-minute scrub using a brush for nails, II) 1-minute scrub with no nail brush, III) 2-minute scrub using a brush for nails, and IV) 2-minute scrub with no nail brush. Using the glove juice method, the researchers obtained bacterial counts from each participant's dominant hand before the hand scrub, immediately after the hand scrub, and at the conclusion of the surgical procedure. The researchers found increased bacterial counts with the use of a nail brush compared to no nail brush use. However, there was no difference in bacterial counts between Group II and Group IV, indicating that a 1-minute scrub without a nail brush was just as effective as a 2-minute scrub without a nail brush.
5.

Sinks, Faucets, and Drains

5.1.

Place hand washing stations in convenient locations as determined by an infection prevention risk assessment and in accordance with federal, state, and local regulatory requirements and applicable construction guidelines.[25,62] *[Recommendation]*

The proximity of sinks to patient care areas may increase the hand hygiene performance of health care personnel. The FGI has established the minimum number and locations for hand washing stations. The FGI recommends conducting an infection control risk assessment to evaluate the convenience of hand washing station locations for clinical use and to identify locations that improve accessibility to hand hygiene products.[25,62] The AORN Guideline for Sterilization Packaging Systems[38] and the Guideline for Processing Flexible Endoscopes[63] provide more information for the location of hand washing stations.

5.1.1.

When designing areas with multiple patient care stations, place at least one hand washing station for every four patient care stations. Position the hand washing station to be approximately an equal distance between the furthest stations.[25,62] *[Recommendation]*

Refer to the AORN Guideline for Design and Maintenance of the Surgical Suite[64] for more information.

5.1.2.

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Sinks designated for hand hygiene should only be used for hand hygiene; plumbed eyewash stations can be located with designated hand hygiene sinks if permitted by state and local regulations.[65] *[Recommendation]*

Performing activities other than hand washing or surgical hand antisepsis could contaminate the sink, faucet, or hands of personnel subsequently using the sink. Some states might require dedicated eye wash stations.
5.2.

Install a hand scrub sink in the semi-restricted area near the entrance to the OR or procedure room.[25,62] *[Recommendation]*

The FGI recommends that hand scrub facilities be located near the entrance of each cesarean delivery, trauma, operating, interventional imaging procedure, and procedure room in hospitals, outpatient facilities, and office-based surgery settings.[25,62]

5.2.1.

One hand scrub sink with two scrub positions may serve two operating or procedure rooms if located next to the entrance to each room.[25,62] *[Conditional Recommendation]*

5.3.

Select and use sinks for hand hygiene and surgical hand scrub that minimize the risk for hand contamination (eg, hands-free).[25,62,65] *[Recommendation]*

Hands-free sinks reduce the risk of cross contamination after hand hygiene is performed. Operating the scrub sink with hands-free controls enables perioperative team members to maintain sterile technique during surgical hand antisepsis. The FGI recommends that hand washing sinks have hands-free controls and scrub sinks have foot, knee, or electronic sensor controls.[25,62] State and local guidelines and building codes provide additional guidance.

Moderate-quality evidence elucidates the risk for water contamination relative to sink and hardware configuration. Sink utilization, water flow rate, and complexity and composition of internal plumbing, as well as the location and size of mixing chambers in plumbing, are all factors that have been associated with biofilm formation and bacterial growth.[66-69] Hands-free sinks can be operated manually or activated by an electronic sensor. Evidence of risk for water contamination exists for sinks that are operated by an electronic sensor (See Recommendation 5.4).

5.4.

As part of a facility's water pathogen plan, an interdisciplinary water management team (See Recommendation 9.2) should conduct a risk assessment to determine whether faucets with electronic sensors will be used in the perioperative environment and under what circumstances.[7,65,68] *[Recommendation]*

According to the WHO, performance of one surgical hand scrub takes approximately 20 L of warm water, or 60 L for all members of a surgical team.[7] A benefit of electronic sensor controls is the ability to conserve water, which is both cost effective and environmentally responsible.[65] Another benefit may be more compliant hand hygiene performance by health care personnel as the absence of potentially contaminated handles lessens the risk of hand recontamination on completion of hand hygiene.[65] However, the design and function of electronic

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faucets can contribute to biofilm formation and bacterial growth.[65] Moderate-quality evidence indicates that electronic faucets can be a source of *Pseudomonas aeruginosa* [66,67,69,70] and other bacterial growth,[67,69] including *Legionella* species.[68] A direct link between electronic faucets and health care–associated infections in vulnerable patient populations (ie, neonates) has also been found.[67,69]

Although water conservation may be a benefit of using electronic faucets, the reduced water flow, which can sometimes be as low as 2 L/minute, creates a lower flushing effect than would occur with manual handle faucets.[65,66] The reduction in flow can increase the number of potential waterborne pathogens released, particularly with initial activation.

In a non-experimental study to compare *P aeruginosa* prevalence in electronic and manual faucets, Charron et al[66] took water samples from 105 electronic, 90 manual, and 14 foot-operated faucets in four Canadian hospitals. Concentrations of *P aeruginosa* were measured using standard culture and enzyme detection methods in four consecutive volumes of cold water from each of the faucets. The researchers found higher concentrations of *P aeruginosa* in the first 250 mL of faucet water from all three types, implying an increased risk of *P aeruginosa* exposure with the first flush. However, the researchers noted that all faucet types in the study had a similar flow rate (5.8 L/minute) and concluded that health care workers using the first 25 mL to 50 mL from an electronic faucet had more exposure to bacteria than those who used a manual faucet, which flushes 25 mL to 50 mL away while a person turns the controls to adjust the water temperature.

Standard procedures for biofilm and water disinfection in electronic faucets have been minimally successful, which is believed to be a result of the complex design of these faucets.[65,68,70] In some situations, removal and replacement of faucet components was believed to be the best disinfection course.[67-70] In a non-experimental study to compare the bacterial contamination of water from different faucet types, Sydnor et al[68] cultured tap water from newly installed electronic faucets and existing manual faucets in three units in a large university hospital during a 6-week period. However, at the start of sampling, two disruptions in the city water supply occurred. Because disruptions decrease incoming water pressure and chlorine concentration and can increase the number of bacteria in the water, chlorine dioxide remediation (5.0 ppm for 6 hours) was performed.

After remediation, water samples from electronic faucets continued to have significant bacterial growth (eight of 28) compared to manual faucet water samples (two of 30). Although not significant, *Legionella* species were also present more often after remediation in electronic faucet water samples (four of 28) than in manual faucet samples (one of 30).[68] The researchers concluded that unsuccessful remediation with chlorine dioxide in the electronic faucets was a result of the rubber and polyvinyl chloride internal surfaces and low water flow, which contributed to biofilm formation. As a result of this study, the facility decided to remove all electronic faucets from clinical areas and not install any additional electronic faucets.[68]

Electronic faucets tend to have a lower water temperature than manual faucets because of the cold water that permanently flows through the mixing valve. The lower temperature can contribute to the growth of waterborne pathogens, such as *P aeruginosa*. Additionally, a temperature of 55° C (131° F) is recommended for control of any suspended or fixed *P aeruginosa* that may be present.[66] In the study by Charron et al[66] to compare *P aeruginosa* prevalence in electronic and manual faucets, the researchers also measured the mean hot water temperature from both faucet types after a 1-minute flush. They found that the temperature of water in 105 electronic faucets was significantly lower than the temperature of water in 105 manual faucets (ie, 45.3° C [113.5° F] compared to 55.0° C [131° F]).

5.4.1.

The interdisciplinary water management team should evaluate the following factors if contemplating installing electronic faucets in hand hygiene sinks or surgical hand scrub sinks:

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- sink utilization,[66,70]
- water flow rate,[65,66,68,70]
- holding water temperature,[65,66]
- complexity of the internal components,[66,68-70]
- composition of the internal components,[65,67-70]
- location of the mixing chamber,[66,70] and
- volume of the mixing chamber.[66,70]

[Recommendation]

The design of electronic faucets varies and can affect their susceptibility to bacterial contamination with waterborne pathogens.[70] Therefore, a review of electronic faucet design features may be a proactive approach to mitigating waterborne pathogens.

When electronic faucets are not used for long periods, water remains in the tap assembly. If low levels of bacteria are already present in the water, as time passes, this water stagnation can increase the bacterial count.[65] The increased use of alcohol-based hand rubs for both hand hygiene and surgical hand antisepsis may result in hand hygiene sinks and scrub stations with electronic faucets being used fewer times, thereby increasing the chance for water stagnation. After water stagnation occurs, if the electronic faucet has a low water flow rate (ie, 2 L/minute), when it is used again, it may not have enough force to flush out the increased amount of bacteria.[66,68]

Most electronic faucets hold water at a temperature of 35° C (95° F) where it stays until released from the tap.[67,68] The optimal growth temperature of *P aeruginosa* is 37° C (98.6° F), but it can grow in temperatures between 10° C and 42° C (50° F and 107.6° F).[70] In the study by Charron et al,[66] water temperature was a significant contributor to *P aeruginosa* presence, emphasizing that electronic faucets designed to sustain high temperature flushing and minimize chamber stagnant volume are fundamental to decreasing growth.

The water in plumbing systems is not sterile, making biofilm formation on plumbing materials a concern. Biofilms are an inherent way for bacteria, such as *P aeruginosa*, to survive in water systems.[65,69,70] Plastic and elastomeric material (ie, polypropylene, polyethylene, polyvinyl chloride, rubber, silicone, latex) support biofilm development and hence *P aeruginosa* growth.[66,69,70] Smooth surfaces have a lower tendency to support biofilm formation than surfaces with irregularities and indentations.[65] The number of internal components in electronic faucets (eg, magnetic valves, solenoid units, sensor cables) may be greater than in manual faucets, increasing the likelihood of biofilm formation. Moderate-quality studies have shown that the design and composition of electronic faucet internal components are important factors in biofilm development.[66,68,69]

When comparing bacteria presence in water from existing manual and newly installed electronic faucets, Sydnor et al[68] found bacterial counts were higher in electronic faucets. To investigate the cause, extent, and location of bacterial contamination, the researchers disassembled and cultured 25 internal components (eg, inline filter, check valve, solenoid valve) from four electronic faucets. All internal components cultured showed growth of *Legionella pneumophila* and significant aerobic and facultative anerobic bacterial counts. The researchers

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concluded that the rubber and polyvinyl chloride make-up of these internal components, along with low flow rates, contributed to the bacterial contamination.

Walker et al[69] dismantled and cultured a sampling of electronic and manual faucet components, as well as **flow straighteners**, to measure for *P aeruginosa* presence in seven hospitals that had experienced outbreaks of *P aeruginosa* bacteremia infections. *P aeruginosa* was detected in 14% of the 494 dismantled components. When compared to manual faucets, electronic faucets had significantly higher odds of having at least one component positive for *P aeruginosa*. Flow straighteners from electronic faucets were more complex than those from manual faucets and were composed of a centerpiece, collar, filter, and washer. The electronic faucet flow straighteners had a significantly higher median *P aeruginosa* count than the manual faucets (1,549 CFU compared to 3 CFU). The researchers used fluorescence microscopy to view the internal components of the electronic and manual faucets. Biofilms were detected on several different components from both faucet types but were most profuse on the electronic faucet's plastic flow straighteners and internal and external components of the metallic collars surrounding these straighteners.

The temperature of electronic faucets is not adjustable unless integrated with a **thermostatic mixing valve** or a manual temperature control lever. With a thermostatic mixing valve, when hot and cold water enter the mixing chamber, the valve senses the outlet temperature and adjusts the amount of incoming hot and cold water to deliver water with the set temperature and prevent scalding. Conversely, a manual temperature control lever does not respond to the changing temperature conditions in the mixing chamber on its own, so it must be adjusted to obtain the desired water temperature. The size of the mixing chamber and its distance from the tap outlet can also affect bacterial growth in water.[66,70] In a literature review, Bédard et al[70] concluded that a distance of less than 25 cm between the mixing valve and tap resulted in lower *P aeruginosa* growth.

In the study conducted by Charron et al,[66] the electronic faucets had a simple design and a manual temperature control lever, as opposed to a thermostatic mixing valve. Two versions of electronic faucet were evaluated: one with the lever located on the faucet body and one with the lever located just below the sink. The researchers found a greater presence of *P aeruginosa* in the electronic faucets with a lever located below the sink compared to those with a lever on the faucet body (31% to 14%). Additionally, they found a correlation between *P aeruginosa* positivity and stagnant hot and cold water volume in the mixing chamber of a faucet. Average mixed water volumes were 10 mL in electronic faucets with a body lever, 30 mL in electronic faucets with a lever below the sink, and 140 mL in foot-operated faucets.[66] The researchers concluded that electronic faucets with simple designs and smaller mixing chambers were not any more susceptible to *P aeruginosa* contamination than manual faucets. If a manual temperature control lever is used in an electronic faucet, the researchers recommended it be a part of the faucet and positioned to prevent accidental contact with hands during hand hygiene performance.

Additional research on electronic and manual faucet design and development of evaluation standards specific to their use in health care facilities is needed.[68]

5.4.2.

The interdisciplinary water management team may establish and implement a process and frequency for monitoring of high-risk sink hardware.[71,72] ***[Conditional Recommendation]***

The role of the interdisciplinary water management team is to identify ways to minimize the growth of waterborne pathogens.[72] Certain types of sink hardware have been shown to have a greater tendency for waterborne pathogen development than others. Setting control limits, in which a chemical or physical parameter must be maintained and monitoring for deviance from the parameters is recommended by both the Centers for Medicare & Medicaid Services (CMS)[71] and the CDC.[72] Monitoring helps verify that control measures are being maintained as designed and supports the need for corrective actions if a problem is found.

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The CMS does not require culturing for waterborne pathogens. Testing is done at the discretion of the facility unless required by law or regulation.[71]

5.4.3.

When the operation of the scrub sink is dependent on the building electrical service, connect the controls to the essential electrical system.[25,62] ***[Recommendation]***

In the event of electricity loss, electronic faucets may not be operable. Connection to the essential electrical system supports uninterrupted operation, which is necessary for hand hygiene performance.[25,62]

5.5.

In conjunction with the water management team, implement actions to minimize dispersal of potential waterborne pathogens from perioperative area sinks, faucets, and drains to surrounding environments, including

- installing sinks with basins deep enough to minimize splashing[25,62,65];
- minimizing surface area in contact with water[70];
- providing sufficient space between sinks and patients, sterile items, and medication preparation areas[65,73];
- installing splash guards[65];
- locating faucets so that they do not discharge directly above the drain[7,25,62,74,75];
- adjusting water pressure to reduce forceful discharge into the sink at maximum flow[25,62,65,73]; and
- implementing regular cleaning of sinks and surrounding areas.[76,77]

[Recommendation]

The sinks, faucets, and drains of hand hygiene and scrub stations can serve as reservoirs for waterborne pathogens.[76] When personnel are performing hand hygiene or surgical hand antisepsis, potentially pathogenic bacteria can be dispersed to nearby surfaces and supplies or to the hands and clothing of perioperative personnel.[73,75,77] A minimal distance between sinks and patient beds has not been established; however, installing sinks 1 m or more from the patient bed may be a practical approach.[65] Larger sink basins allow health care personnel to wash their hands without touching the sides or bottom of the bowl and minimize splashing.[65] The FGI recommends a nominal size of not less than 144 square inches and a minimum dimension of 9 inches in width or length.[25,62]

Hajar et al[73] conducted a non-experimental study to evaluate dispersal of gram-negative bacilli from the sink drain to the hands and clothing of health care workers as well as surrounding surfaces, during hand hygiene performance at automated patient sinks. The role of a plastic drain cover in preventing dispersal was also evaluated. Participants donned a clean plastic cover gown that would allow visual observation of splattering and performed a standardized hand wash using unoccupied patient room sinks in two intensive care units and five medical-surgical units. The health care worker's hands and the cover gown, sink bowl, adjacent countertop, and surfaces within 6 inches of the sink bowl were cultured for gram-negative bacilli both before and after hand hygiene. On completion of the initial protocol, the same sink and adjacent surfaces were disinfected, and a

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plastic drain cover was placed in the sink. The health care worker then donned a new cover gown, and the procedure was repeated.

After dispersal assessments were completed, the sink drains were cultured 1 inch below the strainer. If the sinks did not have gram-negative bacilli growth, they were not included in dispersal analysis. Of the 112 sinks used in this study, 109 were found to have gram-negative bacilli growth that included *Pseudomonas* species in the sink drain. In the colonized sink rooms with no drain covers, gram-negative bacilli were found on 12 countertops, 10 cover gowns, and six health care workers' hands. The use of a plastic drain cover significantly reduced the number of organisms recovered from countertops, cover gowns, and health care workers' hands. However, gram-negative bacilli were dispersed from two of the sinks with drain covers. On closer examination of these two sinks, the water inflow from the faucet was faster than the water outflow, causing water backup in the sink bowl. The researchers recommended that if drain covers are used, the sinks should be examined for potential water backup.[73]

In a simulated study with three identical hand washing sinks, Kotay et al[75] inoculated the sink drains with colonizing microorganisms and fluorescent markers (ie, green fluorescent protein with *Escherichia coli* [GFP-*E coli*]). For 30 seconds every hour, water was turned on along with dispersion of 1 mL of soap. Culture plates were positioned on the faucet, faucet handles, and surrounding counter surfaces to measure GFP-*E coli* droplet dispersion during faucet events. After 7 days of GFP-*E coli* colonization in drain lines, dispersion was greatest at settle plates on the counter, then the faucet, followed by the faucet handles. Of note, dispersion only occurred when the faucet was operated and diminished substantially within 30 minutes of the faucet being turned off. The researchers concluded that the shear forces of faucet water discharging onto the sink drain or bowl surfaces resulted in dispersion of bacteria. The researchers also noted that for dispersion to occur, bacteria had to be present on the drain or bowl surface.

Between the hours of 6 AM and noon at two university hospitals, Ta et al[77] found significant bacterial contamination, primarily with gram-negative bacilli, on 15 of 24 scrub sink faucets. When hand cultures were taken from 50 perioperative personnel after they performed a surgical hand scrub using CHG at these same sinks, 17 cultures had bacterial growth. However, the bacteria cultured from the hands were not the same as those cultured from the sink faucets. The researchers recommended that regular cleaning of scrub sinks be performed to limit the amount of bacterial growth in the surgical suite.

The CDC Environmental Infection Control guidelines recommend that sinks be cleaned and disinfected on a regular basis with an Environmental Protection Agency–registered product as determined by facility policy.[76]

One low-quality[74] and one moderate-quality study[75] showed that the location of the sink faucet in relation to the drain can have an effect on water dispersion, thereby increasing the risk of bacterial transmission. In a case study of a *P aeruginosa* outbreak attributed to the sinks in patient bathrooms, Stjärne Aspelund et al[74] found that each sink was designed so that the faucet water was directed straight into the sink drain, thereby enhancing splashing. This was replicated in a simulated hand hygiene study conducted by Kotay et al,[75] who found that when a pair of mannequin hands was present under the running faucet water, little to no fluorescent markers were noted on surrounding surfaces. However, after the simulated hands were removed, fluorescent marker dispersion was seen. The researchers noted that a limitation of their study was that the simulation did not truly replicate the hand hygiene practices of health care personnel, as hands do not always remain directly under the water. Instead, after hands are moistened, they are removed from the flow of water to rub soap in, which lets the running water directly contact the drain and cause splash back.

5.5.1.

A process for cleaning sink drains in perioperative areas may be established.[65,74,78,79] ***[Conditional Recommendation]***

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Sink drains can carry a considerable bacterial burden and have been described as a reservoir for nosocomial transmission of *P aeruginosa*,[74] and outbreaks of multidrug-resistant gram-negative bacilli (ie, carbapenemase-resistant *Enterobacteriaceae*).[78,79] Although these reports were not in perioperative areas, the pathogens isolated were organisms that can cause SSIs. Furthermore, the transmission reservoir for these pathogens can be health care workers' hands, making the studies generalizable to all health care areas including perioperative areas. Minimizing the contamination of water that reaches health care workers' hands could potentially reduce health care–associated infections.

Methods used to terminate bacterial outbreaks associated with drains have included changing plumbing, using replaceable U-drain plug holes, drain cleaning, and drain disinfection.[70,74,78,79]

Stjärne Aspelund et al[74] examined the link between 12 patients on three units who were infected with a metallo-beta-lactamase producing *P aeruginosa* (Pae-MBL) and the presence of Pae-MBL colonization and biofilm formation in the sink drains. Cultures from sink drains in 12 patient bathrooms were positive for Pae-MBL and had the same antibiotic susceptibility patterns as the isolates of infected patients, with seven sink isolates showing identical or closely related patterns to the patient isolates. Of note, Pae-MBL growth was not found in the faucet or water cultures of these sinks. The initial response by the organization was to replace the plumbing in all the colonized sinks, but some plumbing could not be immediately replaced. So, in those sinks, the drains were treated with 250 mL of 24% acetic acid once weekly, incubated for 30 minutes, and then flushed. The weekly treatment resulted in negative cultures and no additional transmission events. However, after all the plumbing from colonized sinks was replaced, follow-up cultures showed reappearance of the same *P aeruginosa* strain in three sinks, even though there had been no admissions of patients with the *P aeruginosa* strain. Additional cultures of the drainpipes going into the wall were performed, and the same strain *of P aeruginosa* was found in four of nine pipes. Because the acetic acid treatment had worked previously, weekly treatment was resumed for the positive sinks and resulted in negative cultures. The authors concluded that mature *Pseudomonas* biofilm may be eradicated with acetic acid, and this could be a strategy for preventing *Pseudomonas* transmission.[74]

In a literature review, Bédard et al[70] identified a drain cleaning program and prevention of drain plugging caused by low use as measures to control *P aeruginosa* growth in water.

Smolders et al[78] conducted an epidemiological analysis in an intensive care unit in Belgium to investigate patient infections and environmental contamination with carbapenemase-resistant *Enterobacteriaceae* (CRE), a multidrug-resistant gram-negative bacillus. The researchers found a positive and significant relationship between contaminated sinks and CRE in patients admitted to intensive care unit rooms. When sink drains were decontaminated with acetic acid (ie, 250 mL 25% acetic acid three times weekly), both the number of CRE-colonized sinks and the number of patients colonized or infected with CRE decreased considerably, leading researchers to recommend use of acetic acid as an inexpensive, widely available, and effective method for decontaminating sink drains.

In another epidemiological analysis to investigate a large *Klebsiella pneumoniae* carbapenemase (KPC)-producing *Escherichia coli* outbreak and increased carbapenemase-resistant *Enterobacteriaceae* (CRE) colonization incidence, Decraene et al[79] found that sinks and drains on affected units were colonized with multiple CRE strains, including the KPC-producing *E coli* strain. As a result, all sink traps containing KPC-producing *E coli* were replaced and horizontal cleaning of the pipework with a brush was performed to remove biofilm. However, KPC-producing *E coli* acquisition continued, as did isolation of the organism from sink and drain sites.

Units containing contaminated sinks and drains were closed and the plumbing infrastructures were replaced up to the drainage stack. Replaceable sink plugholes were also added to prevent water aerosolization in the sink U-bend and limit biofilm formation. When compared to the period before the plumbing intervention, CRE

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acquisition and KPC-producing *E coli* infections significantly decreased. However, on return to the closed units, CRE colonization of patients recurred in numbers like those before the intervention. Contamination of sinks with CRE also recurred, even before patients were readmitted. The authors purported the cause to be residual contamination after the plumbing replacement or reintroduction after replacement. The researchers determined that in outbreaks associated with drain contamination, replacement of plumbing was not always successful in eradicating causative organisms.

The negative aspects of drain cleaning may be the time, cost, and resources necessary for completion. However, benefits may include prevention of a health care–associated infection, saving cost and resources and increasing patient satisfaction.
6.

Towel and Alcohol-Based Product Dispensers

6.1.

At hand washing stations, provide enclosed paper towel dispensers that permit removal of towels without dispenser contact.[25,62] *[Recommendation]*

Enclosing paper towels within a dispenser that allows for single-towel removal without contacting the dispenser protects the towels from contact with the sink water and the dispenser from contact with the hands of individuals performing hand hygiene.

6.2.

Place alcohol-based hand hygiene product dispensers (eg, wall-mounted, table-top) in convenient locations as determined by the infection control risk assessment and in accordance with federal, state, and local regulatory requirements.[1,7,11] *[Recommendation]*

The infection control risk assessment identifies locations that improve accessibility to hand hygiene products and evaluates the convenience of locations for clinical use.[1]

Health agencies and professional organizations support placement of alcohol-based hand rub products at the point of use.[1,7,11] The WHO recommends that hand hygiene product dispensers be as close as possible, ideally in arm's reach, to where patient contact is taking place, to prevent personnel from having to leave the care or treatment zone.[7] The CDC[11] and the SHEA/IDSA[1] recommend having alcohol-based hand rub products available at the patient's bedside and in other convenient locations to promote hand hygiene adherence by personnel who perform a high volume of patient care.

Several studies and organizational experience reports found an increase of hand hygiene performance in the perioperative environment with the addition and strategic placement of alcohol-based hand rub dispensers. Locations included the anesthesia work area (ie, machine, cart),[80,81] IV poles located in ORs and on patient stretchers,[82] and OR doorplates.[83]

6.2.1.

Dispenser placement and storage of flammable alcohol-based hand hygiene products must comply with local, state, and federal regulations.[84-86] *[Regulatory Requirement]*

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The CMS states in §482.41(d)(2) that "facilities, supplies, and equipment must be maintained to ensure an acceptable level of safety and quality," including storage in compliance with fire codes.[84] The National Fire Protection Association makes recommendations for storage of flammable solutions.[86]

6.2.2.

Alcohol-based hand hygiene product dispensers should

- be at least 4 ft (1.2 m) apart;
- hold a maximum of 0.32 gallons (1.2 L) in rooms, corridors, and areas open to corridors;
- not be placed above an ignition source (eg, electrical outlet, switch) or within 1 inch (2.5 cm) of the ignition source; and
- not total more than 10 gallons (37.8 L) outside of a storage cabinet in a single smoke compartment.[86]

[Recommendation]

6.2.3.

Surgical hand rub and alcohol-based hand rub product dispensers may be placed inside the operating or procedure room. ***[Conditional Recommendation]***

6.3.

A process may be implemented for identifying and replacing empty alcohol-based hand hygiene product dispensers.[39] ***[Conditional Recommendation]***

Establishing a process for the identification of empty alcohol-based hand rub dispensers can help ensure that the product is continuously available for hand hygiene performance. Delegating the task to designated personnel and monitoring for compliance can strengthen the process.[39]

6.3.1.

Each time a new refill is installed, verify hand hygiene product dispenser function in accordance with the manufacturer's instructions.[86] ***[Recommendation]***

6.4.

Health care organizations may permit the use of personal dispensers of alcohol-based hand rub products approved for use by the health care organization.[7,11,39,87,88] ***[Conditional Recommendation]***

High-quality evidence and guidance from health agencies and professional organizations support the use of personal dispensers of alcohol-based hand rub products in the perioperative setting.[7,11,39,87,88]

In an RCT conducted at two medical centers, Koff et al[87] examined the effect of personal alcohol-based hand rub product dispensers worn by anesthesia professionals, circulating nurses, and observers (ie, on the belt, on the waist of scrub pants, around the neck) on hourly hand decontamination events and 30-day health care–associated infection rates. Wall-mounted and table-top dispensers were also available in the clinical setting, and both wall-mounted and personal dispenser devices were electronically monitored. The study was conducted during an 8-

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month period and included a total of 3,256 ORs (1,620 control; 1,636 intervention). The researchers found an eight-fold increase in hand decontamination events per hour with personal hand hygiene dispenser use compared to use of conventional wall-mounted devices. However, the personal hand hygiene system did not result in a reduction of 30-day health care–associated infections.

Parks et al[88] distributed personal alcohol-based hand rub dispensers to be worn by health care providers on a regional anesthesia team for a 3-week period at a large university hospital. The team consisted of anesthesia attendings, fellows, and residents (n = 8) and patient care nurses (n = 4). Nerve blocks were performed in the postanesthesia care unit and in a dedicated block room where wall-mounted and table-top alcohol-based hand rub dispensers were available. Significant improvement in hand hygiene compliance was found with the addition of the body-worn personal alcohol-based hand rub dispensers (34% to 63%). The greatest improvement in hand hygiene was found among nursing personnel and after patient contact by all providers. Because of the high patient volume and short, rapid turnover of patients receiving regional anesthesia, the researchers concluded that individual hand hygiene dispensers worn by a regional anesthesia team could improve hand hygiene.

The CDC recommends having alcohol-based hand rub available at the patient's bedside and in other convenient locations, including in individual containers carried by health care workers, to promote hand hygiene adherence by personnel who perform a high volume of patient care.[11]

The WHO supports the use of personal alcohol-based hand rub product containers when combined with wall-mounted dispensing systems to increase access to hand hygiene products at the point of care.[7] However, the WHO discusses the limitations of using personal hand hygiene products in the clinical setting:

- Many of the personal dispensers are not transparent and may be found to be empty when needed.
- The amount of alcohol-based hand rub may be so small (10 mL to 20 mL) that several containers per person are needed each day.
- The personal dispensers may not be cost effective, and maintaining the dispenser supply may be challenging if the organization is dependent on a single manufacturer.
- Using disposable dispensers may have a negative effect on the environment.
- The external surface of the bottle may become contaminated, although this may be negligible because of the excess spillage of the disinfectant and the overall short time until replacement.[7]

6.5.

Make hand hygiene accessible to patients and visitors in unrestricted areas (eg, waiting room, preoperative area, postoperative area) unless contraindicated for a specific patient population or individual patient.[1,7,84,89] ***[Recommendation]***

Providing opportunities to perform hand hygiene engages the patient and visitors in the mission of the perioperative team to prevent the patient from developing a health care–associated infection and may reduce the contamination of the patient's environment.

The SHEA/IDSA recommends conducting a point-of-care risk assessment to guide the placement of dispensers.[1] Based on the risk assessment, the health care organization may decide to provide patients and visitors with nontoxic hand hygiene products because patients who are cognitively impaired, those with behavioral health issues, or those with substance abuse problems may be injured by ingestion of alcohol-based hand rub. The WHO also recommends careful consideration for the placement of dispensers in areas with patients who are likely to ingest the product, such as disoriented older adult patients, patients receiving psychiatric care, young

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children, or patients with alcohol dependence.[7] The CMS states in §482.41(b)(7) and §416.44(b)(4) that a facility may install an alcohol-based hand rub dispenser "if the dispensers are installed in a manner that adequately protects against inappropriate access."[84,89]

7.

Product Evaluation

7.1.

Form an interdisciplinary team (eg, perioperative managers, perioperative team members, surgeons, infection preventionists, occupational health personnel, pharmacists) to evaluate hand hygiene products to be used in the perioperative setting.[90] ***[Recommendation]***

Input from an interdisciplinary team with diverse experience and knowledge of hand antiseptics is helpful during a review of research, clinical guidelines, and literature from product manufacturers.

7.2.

The interdisciplinary team should develop a mechanism for evaluation and selection of hand hygiene products.[7,90] ***[Recommendation]***

Developing a mechanism for hand hygiene product selection provides a structured process for product evaluation by the health care organization.

7.3.

Select products for hand hygiene and surgical hand antisepsis that meet US Food and Drug Administration (FDA) requirements for over-the-counter antiseptic products intended for use by health care professionals.[91] ***[Recommendation]***

The FDA Code of Federal Regulations Title 21 Part 310[91] mandates that the active ingredients in health care antiseptics be generally recognized as safe and effective (GRAS/GRAE) by requiring testing that is consistent, up-to-date, and reflects current scientific knowledge and increasing use patterns. Antiseptic products that meet these testing requirements are identified as having **monograph** status. Antiseptic products for which the testing requirements have not yet been completed are considered new drugs and require FDA approval through new drug applications (NDA) or abbreviated new drug applications (ANDA). However, deferred rulemaking was granted to allow for the development and submission of new safety and effectiveness data for six active ingredients:

- alcohol (ethanol),
- isopropyl alcohol,
- povidone-iodine,
- benzalkonium chloride,
- benzethonium chloride, and
- para-chloro-meta-xylenol (PCMX).[91]

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The monograph or **nonmonograph** status of these active ingredients will be determined after the completion and analysis of submitted studies.[91]

7.3.1.

Health care personnel should continue to adhere to facility infection control guidance for use of products containing the deferred six active ingredients.[92] ***[Recommendation]***

The FDA recommends no changes to use of currently available products containing these active ingredients (listed in Recommendation 7.3).[92]

7.3.2.

Non-antimicrobial and antimicrobial soaps may be selected for evaluation. ***[Conditional Recommendation]***

The CDC[11] and the SHEA/IDSA[1] recommend using either non-antimicrobial or antimicrobial soaps in the health care setting. Antimicrobial soaps are more effective in reducing the bacterial load on the hands.[11] However, in the perioperative setting, personnel perform hand hygiene and surgical hand antisepsis frequently. The use of antimicrobial soaps and surgical hand antisepsis products might contribute to skin irritation, especially when used frequently (See Recommendation 7.6).[11]

A benefit of using plain soap for hand hygiene is that it does not contain an antimicrobial agent that may be irritating to the skin for personnel who also perform surgical skin antisepsis. A potential harm for using plain soap is that there have been instances in which plain soap became contaminated, which could lead to the hands of personnel becoming colonized with gram-negative bacteria.[11]

7.3.3.

Do not select soaps containing triclosan for evaluation.[1] ***[Recommendation]***

The SHEA/IDSA recommends avoiding the use of soaps containing the antiseptic triclosan in the health care setting. Evidence is lacking to establish clinical benefits from the use of triclosan compared to other antiseptics. The harms of triclosan may include contamination of the environment (ie, air, water) and the potential for development of bacterial resistance with widespread use.[1]

7.4.

Evaluate the safety and efficacy of hand hygiene products.[7,11] *[Recommendation]*

The WHO[7] and the CDC[11] recommend evaluating the safety and efficacy of hand hygiene products during the product selection process.

The evidence review found no studies that evaluated the safety and efficacy of hand hygiene products in the perioperative setting.[1] However, several studies evaluated the safety and efficacy of products used for surgical hand antisepsis.

The evidence involving surgical hand antiseptic efficacy conflicts. In a systematic review, Tanner et al[2] found that no one surgical hand antiseptic was more effective than another for preventing SSIs. Some moderate-quality

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research indicates that alcohol-based antiseptics may be more effective for reducing bacterial counts on hands than aqueous-based solutions.[2,93-96] However, some high-quality studies have found that aqueous-based solutions are as effective as alcohol-based antiseptics for reducing bacterial counts.[50,97-99] Some of these studies indicated a preference for alcohol-based antiseptics because of efficiency and user acceptance.[50,51,99]

High-quality evidence on the effectiveness of CHG in surgical hand antiseptics also conflicts. Research indicates that aqueous CHG scrubs may reduce bacterial counts on hands more effectively than aqueous povidone-iodine.[2,99,100] However, when compared to aqueous PCMX, similar bacterial efficacy to CHG was found.[101]

With regard to alcohol-based CHG products, some high-quality research indicates that alcohol combined with CHG is superior to other alcohol-based surgical hand antiseptics.[95,102] Conversely, some researchers found that other alcohol-based antiseptics were equally or more effective than the alcohol-and-CHG combination surgical hand antiseptics.[103-105] Several health agencies and professional societies recommend the use of an alcohol-based hand rub for surgical hand antisepsis but do not indicate whether the product should have a sustained effect.[1,7,12,19,54] However, both the CDC guidelines for hand hygiene and prevention of SSIs[11,53] and SHEA/IDSA[1] recommend the use of alcohol-based hand rubs with persistent activity (ie, addition of CHG to alcohol) for surgical antisepsis.

Tanner et al[2] found the available evidence on surgical hand antisepsis to be of low quality. Another limitation of some evidence, as described in a laboratory study by Kampf et al,[106] is that studies assessing CHG without the use of neutralizing agents in the culture sampling fluid may be flawed by overestimation of efficacy.

With a gap in the evidence to guide practice, decisions about which surgical hand antiseptic to select for use in the practice setting are complex. This is an unresolved issue that warrants additional research. A variety of products may be necessary to meet the needs of various perioperative team members with skin sensitivities and allergies.

7.5.

Evaluate the compatibility of hand hygiene products with skin care products (eg, lotions, moisturizers) and types of gloves used at the facility.[7,11] ***[Recommendation]***

The WHO[7] and the CDC[11] recommend reviewing information from the manufacturer regarding any known interactions between products used to clean hands, skin care products, and gloves. Oil-containing lotions have been associated with altered integrity of latex rubber gloves, reduced persistent effects of hand antiseptics, and bacterial contamination of the lotion.[7,11]

7.6.

The interdisciplinary team may evaluate the irritant potential of hand hygiene products.[7,11] ***[Conditional Recommendation]***

The dermal tolerance of a hand hygiene product by health care personnel can affect their compliance with hand hygiene.[7] The CDC recommends that health care personnel be provided with not only efficacious hand hygiene products but ones with low irritancy potential. The authors noted that this is particularly important when hand hygiene or surgical hand antisepsis is performed multiple times during a shift.[11]

Antiseptic agents can cause drying and irritation. Lower antiseptic concentrations or the addition of skin conditioning agents (ie, emollients) may contribute to reduced skin irritation for certain hand hygiene and

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surgical hand antisepsis products (Table 1).[7,11] According to the WHO[7] and the CDC,[11] although plain (ie, non-antimicrobial) soap does not contain an antiseptic agent, it too can cause drying if used continuously.

Table 1. Antiseptic Efficacy and Irritancy Factors

Antiseptic Efficacy and Irritancy Factors[1,2]

Antiseptic ***Typical Concentration***	**Action Onset** ***Residual Effect***	**Factors Affecting Efficacy**	**Ways to Decrease Irritation***
Iodophors *0.5%-10%*	Intermediate *Disparity between studies on length*	Presence of organic material (eg, blood, secretions)	Combine with polymers (eg, povidone, poloxamers); lower the amount of free iodine available
Chlorhexidine *0.5%-4%*	Intermediate *Substantial*	Use of natural soaps, inorganic anions, **non-ionic surfactants**, lotions containing **anionic emulsifying agents**	Use of lower concentrations (< 4%)
Chloroxylenol *0.5%-4%*	Slow *Disparity between studies on length*	Use of non-ionic surfactants	None noted
Isopropanol *60%-95%*	Rapid *None*	Wet or dirty hands; insufficient volume applied**	Addition of skin conditioning agents (eg, 1%-3% glycerol)
N-propanol *60%-95%*	Rapid *None*	Not approved as a health care antiseptic in the United States	Addition of skin conditioning agents (eg, 1%-3% glycerol)
Ethanol *60%-95%*	Rapid *None*	Wet or dirty hands; insufficient volume applied**	Addition of skin conditioning agents (eg, 1%-3% glycerol)

* The antiseptics are listed in order from the highest to lowest irritant potential (ie, iodophors = highest, ethanol = lowest).

** If hands feel dry after rubbing for 10 to 15 seconds, an insufficient amount was probably applied.

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View Large

Because of the high task density of anesthesia provider work requiring hand hygiene, Birnbach et al[107] conducted an RCT to determine whether frequent use of alcohol-based hand rubs, with or without a moisturizer, would lead to skin health changes. The researchers enlisted 17 anesthesiology students. Nine used an alcohol-based hand rub without a moisturizer and eight used an alcohol-based hand rub with a moisturizer. The products were applied every 15 minutes for 8 hours for 5 sequential days. A dermatologist used a validated dermatitis scale to assess participants' hands before the study and at the end of 5 days. The scale measures hand eczema severity by providing a score of zero to 360 based on the indicators of erythema, papulation, vesicles, fissures,

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scaling, and edema in five parts of the hand (ie, fingertip, finger, palm, back of hand, wrist). A final score was formulated by summating scores from the five parts of the hand. In addition, the participants were asked to evaluate their hand health.

A significant increase in hand eczema severity from baseline to the end of the 5 days was seen in both groups, with no significant difference in scores between the groups. The researchers concluded that repetitive use of alcohol-based hand rubs might be associated with a change in skin health, and future studies are needed that include evaluation of repeated hand hygiene in an actual OR.[107]

In a matched quasi-experimental study, Lopes et al[108] investigated surgeons' skin tolerance and acceptance of two surgical hand scrub antiseptics (ie, 2% CHG, 10% povidone-iodine) compared to an alcohol-based surgical hand rub (ie, 57% ethanol and 22.5% n-propanol). For a period of 3 months, 33 cardiac and orthopedic surgeon participants were asked to complete surgical hand scrubs using their preferred antiseptic. Immediately prior to the second phase of the study, each participant attended a 4-hour workshop consisting of theoretical information and hands-on demonstrations of the alcohol-based surgical hand rub conducted by two RN research assistants who were trained in infection prevention. Participants were then asked to perform surgical hand antisepsis using only the alcohol-based surgical hand rub for the following 3 months.

Using WHO validated tools, the research assistants and surgeons independently evaluated the surgeons' skin tolerance of the antiseptics throughout the study period. The research assistants used a rating scale (zero = not present to 4 = large presence) to evaluate each surgeons' hands for redness, scaliness, fissures, and observable irritation. When comparing the alcohol-based surgical hand rub with either surgical hand scrub, the research assistants found minimal variation in skin redness, scaliness, fissures, and overall appearance, although redness was seen more frequently with the alcohol-based hand rub than with the CHG hand scrub. The surgeons used a Likert scale (1 = abnormal to 7 = normal) to record the appearance, integrity, humidity, and sensation of their skin after antiseptic use. Analysis of the surgeons' self-evaluations found no significant difference between use of CHG, povidone-iodine, or the alcohol-based surgical hand rub on the skin condition of their hands.[108]

Acceptability of the surgical hand antiseptics to the surgeons was evaluated through a WHO validated questionnaire that used a Likert scale to rate product characteristics and product preference. When assessing the smell, product texture, skin dryness, ease of application, and overall satisfaction, participants rated the alcohol-based surgical hand antiseptic as better than the surgical hand scrub with povidone iodine. However, except for the product texture, hand scrubbing with CHG rated similarly to the alcohol-based surgical hand rub. Seventy-three percent of the surgeons preferred the surgical hand rub product over the surgical hand scrub products.[108]

The antimicrobial activity of alcohol is through denaturing of the protein in microorganisms, ideally in the presence of water. Hand hygiene products with concentrations higher than 95% alcohol contain less water, thereby making the antiseptic less potent.[7,11] The percentage of alcohol in hand hygiene solutions recommended by health agencies and professional societies varies. The SHEA/IDSA[1] recommends at least 62% alcohol, the WHO[7] recommends 60% to 80% alcohol, and the CDC[11] recommends the product contain 60% to 95% alcohol.

7.6.1.

Transepidermal water loss may be used as a measurement of the irritant potential of a product.[7,11] *[Conditional Recommendation]*

Transepidermal water loss (TEWL) has been used as a tool for establishing the effects of skin irritants, detergents, and organic solvents on the skin barrier.[109] To measure TEWL, a probe with temperature and relative humidity sensors is placed on the skin surface. Low TEWL is indicative of intact skin and a fully functional barrier, whereas elevated TEWL is commonly a sign of a disrupted skin barrier, causing a loss of water through

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the skin.[109] On request, product manufacturers may be able to provide studies that incorporated TEWL measurement with the use of their product.[7,11]

7.7.

Evaluate the cost of hand hygiene products, but cost should not be the primary factor for selection.[7,11] *[Recommendation]*

The WHO[7] and the CDC[11] recommend evaluating cost during the selection of hand hygiene products. However, both organizations emphasize the importance of product effectiveness and user acceptance compared to cost.

7.8.

Conduct end-user evaluations to determine acceptability of the hand hygiene and skin care products to perioperative team members.[1,7,11] *[Recommendation]*

Acceptability of hand hygiene products is a key factor that influences compliance of health care personnel with hand hygiene.[1,7,11] The WHO,[7] the CDC,[11] and the SHEA/IDSA[1] recommend involving health care personnel in the choice of hand hygiene and skin care products.

7.8.1.

Determine the time frame and season for end-user evaluation of hand hygiene products. When more than one product is evaluated, establish a time period between product evaluations.[7] *[Recommendation]*

The WHO recommends conducting end-user evaluation for at least 2 to 3 weeks.[7] When more than one new product is being evaluated, the WHO recommends either a period of everyday product use or a 2-day period between product evaluations when feasible.[7]

The WHO recommends avoiding the testing of new hand hygiene products during seasons with low humidity because health care personnel may have more skin reactions in this weather, and the results of the end-user evaluation could be affected by this seasonal variation.[7] In a European field study, Girard et al[110] investigated factors that influenced the testing of alcohol-based hand rubs and found that test periods during colder seasons were significantly associated with skin reactions.

7.8.2.

Include the following in end-user evaluations:

- skin tolerance,
- skin reactions,
- ease of product use (eg, volume, dry time),
- feel (eg, consistency, texture),
- color, and
- fragrance.[7,11]

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[Recommendation]

As part of the end-user evaluations, the WHO[7] and the CDC[11] recommend that skin tolerance, skin reactions, ease of use, and the aesthetic preferences (ie, fragrance, color, texture) of health care personnel be considered in the selection of hand hygiene products.

7.8.3.

Include patients in end-user evaluations of hand hygiene products.[7] *[Recommendation]*

The WHO recommends that the patient's aesthetic preferences (ie, fragrance, color, texture, ease of use) be considered in the selection of hand hygiene products. Patients may be especially sensitive to the fragrance of hand hygiene products.[7]

7.8.4.

The interdisciplinary team should review written end-user evaluations. *[Recommendation]*

Written questionnaires or evaluations provide the interdisciplinary team with data to assess acceptability to end users.

7.9.

Evaluate hand hygiene product dispensers (eg, wall-mounted, table-top, personal) for sufficient, reliable function and delivery of the recommended product volume.[7,11] *[Recommendation]*

7.9.1.

The interdisciplinary team may evaluate automated wall-mounted dispensers.[7] *[Conditional Recommendation]*

Moderate-quality evidence is inconclusive regarding the benefits of automated wall-mounted dispensers. The theoretical benefit of automated wall-mounted dispensers is that they can be used without being touched and potentially contaminating the hands of the perioperative team member.[7]

In an observational study, Eiref et al[111] cultured 17 manual hand sanitizer dispensers in a 12-bed intensive care unit at an urban teaching hospital. The dispensers were disinfected daily. The researchers found that all dispensers were contaminated with bacteria, both from common skin flora and gram-negative bacteria, and that contamination was greatest on the lever. The results of this study implicated hand sanitizer dispensers as potential reservoirs for bacteria in the health care environment. The researchers recommended cleaning the dispensers to reduce contamination and suggested that using automated or pedal-operated dispensers may reduce the risk of dispenser contamination.

The WHO discusses that the downside to automated wall-mounted dispensers is that they have a higher chance for malfunction and are more expensive to maintain than non-automated dispensers.[7]

7.9.2.

Use dispensers of alcohol-based hand hygiene products that

- do not release products except when the dispenser is activated,

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- only activate when an object is placed within 4 inches (20 cm) of the sensor,
- only activate once when an object is left in place in the activation zone,
- do not dispense more product than the amount recommended by the manufacturer for hand hygiene, and
- are designed to prevent accidental or malicious activation of the dispenser.[86]

[Recommendation]
8.

Education

8.1.

Provide education on and verify the competency of personnel regarding

- the importance of effective hand hygiene in reducing the risk for health care-associated infections;
- fingernail and hand condition;
- whether jewelry can be worn in the organization's perioperative setting and under what conditions;
- performance of hand hygiene[1,7,11,39,44];
- delineation of the perioperative patient zone;
- performance of surgical hand antisepsis[50,112-115];
- recognition and prevention of hand dermatitis, including use of glove liners;
- use of hand hygiene products according to the manufacturer's instructions for use including how to read the product label; and
- use of moisturizing skin care products that are compatible with hand hygiene and surgical hand antisepsis products.

[Recommendation]

Lack of knowledge, experience, and education are factors associated with low hand hygiene compliance.[7,39] Guidance from health agencies and professional organizations support educating health care personnel on hand hygiene indications and performance as part of a multifaceted hand hygiene program (eg, education, training, observation, feedback).[1,7,11,12,39,44]

Several moderate-quality studies have found low compliance with hand hygiene protocols in the perioperative setting[30,31,33,34,81,116,117] and knowledge deficits among perioperative team members.[32,80,118-120] The literature review found that successful perioperative hand hygiene programs included an educational component that led to a significant increase in hand hygiene compliance,[40,81,116,119,121,122] decreased bacterial counts on the hands of personnel[119] and work surfaces,[80,119] and improved knowledge test scores.[116] High-quality

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evidence indicates that education improves compliance in surgical hand scrub[112] and surgical hand rub performance.[50,113]

Abdollahi et al[112] observed poor technique among 35 perioperative personnel performing surgical hand scrubs at a large heart hospital, such as incorrect order of the steps when scrubbing hands, insufficient coverage of arms, and incorrect time spent performing the scrub. As a result of this observation, precise steps for surgical hand scrub completion were posted next to scrub sinks. Hospital policy on scrub time, along with feedback from observations, were reviewed at department meetings. Several ergonomic adjustments were also made, including lowering the height of the scrub solution container, providing a basket for used brushes, and placing the clock in view of the scrub sink. The second audit of 35 perioperative personnel completed 2 weeks later showed improved compliance with the necessary steps (ie, from 47% to 70%).

In a quasi-experimental study to investigate the use of visual process maps to improve compliance with surgical hand antisepsis standards at a university hospital in Ethiopia, Forrester et al[113] had perioperative personnel enumerate the steps necessary for the completion of surgical hand antisepsis. Through the mapping process, barriers to performance were identified that included unavailability of water, antimicrobial soap, and alcohol-based hand rub. The group determined that an alcohol-based hand rub would be the best choice for surgical hand antisepsis. Personnel were then educated on the surgical hand rub steps using the developed process maps, which led to significant improvement in compliance with these steps (ie, from 24.1% to 67.6%). The researchers concluded that use of process maps could be a powerful strategy for improving the safe care of surgical patients.

In another quasi-experimental study to implement the use of a surgical hand rub by cardiac and orthopedic scrub personnel, Gaspar et al[50] offered 4-hour workshops multiple times to educate personnel on surgical hand rub use. Workshop participants used a fluorescent alcohol-based hand rub followed by a fluorescence apparatus to visualize coverage and identify how to improve their technique.

Two moderate-quality studies found that misuse of a surgical hand rub product may have contributed to an increase in SSI rates and that peer education in a skills lab may increase compliance with a surgical hand antisepsis protocol.[114,115]

Haessler et al[114] described an investigation of an SSI cluster at an academic, Level 1 trauma, tertiary care medical center. As part of the investigation, direct observations were performed of surgical hand antisepsis completed with scrub and alcohol rub products. Observers noted inadequate pre-washing when required (eg, for soiled hands), lack of use of a nail pick, and incorrect application of the alcohol surgical hand rub product. Interviews revealed the surgeons lacked understanding about using the alcohol rub product. After the misused product was removed and the surgeons received education on surgical hand antisepsis technique, the SSI rate returned to a level at or below the medical center's historical rates.

In a pilot study, Fichtner et al[115] examined the effect of a skills lab on the surgical hand scrubbing compliance of fourth-year medical students (N = 161) in Germany. Students randomly assigned to the intervention group underwent a 45-minute standardized peer training session of practical competencies on surgical hand scrubbing according to the European standard EN1500. Compliance was measured by hand coverage with a fluorescent surgical hand scrub antiseptic. The researchers found that the intervention group (n = 80) had significantly better hand coverage than the control group (n = 81), which received training after the test.

8.1.1.

A variety of educational modalities may be used to meet individual learning needs.[1,44] ***[Conditional Recommendation]***

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When developing education, it is important to tailor the content to meet the learning needs of the audience.[44] The environment in which learning occurs is also a factor in successful education. In a non-experimental study, which was part of the "Safe Hands Project" to improve hand hygiene in orthopedic procedures, Erichsen Andersson et al[123] found that the creation of a safe learning space and promotion of interdisciplinary dialog contributed to motivation and engagement of perioperative personnel in the improvement of hand hygiene performance.

Education that is concise, factual, engaging, and includes a variety of methods (eg, supervised activities, self-directed group sessions, mentored one-on-one instruction, short web-based modules) can be beneficial for perioperative teams.[44] Successful education components include those with interactive means (ie, simulation), visual elements (eg, handouts, posters), knowledge testing, and return demonstration.[1]

The literature review found four high-quality[14,80,119,124] and four low-quality[40,116,121,122] studies in which using more than one educational modality resulted in favorable outcomes. Education modalities that were used included demonstrations,[116,119] videos,[119] simulations,[14,40,80,121,124] fluorescent indicators,[14,80,124] presentations,[14,40,80,116,122,124] handouts,[119,122] and testing.[116,119]
8.1.2.

Provide additional education and competency verification when

- onboarding new team members,
- introducing new hand hygiene products,
- introducing new processes, or
- observing a variation in technique. [44,125]

[Recommendation]

8.1.3.

Provide ongoing education and training.[44] *[Recommendation]*

Ongoing education and training efforts reinforce positive behavior and a culture of safety.[44]
9.

Quality

9.1.

Participate in a variety of quality assurance and performance improvement activities that are consistent with the facility or health care organization plan to improve understanding and compliance with the principles and processes of hand hygiene. *[Recommendation]*

Quality assurance and performance improvement programs assist in evaluating and improving the quality of patient care and formulating plans for corrective action. These programs provide data that may be used to determine whether an individual organization is within benchmark goals and, if not, to identify areas that may require corrective action.

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9.2.

As part of a water management program, establish or enlist an existing interdisciplinary facility water management team that includes representatives from a variety of disciplines to develop a water pathogen plan that addresses the potential for bacterial colonization of sinks, faucets, and drains in the perioperative setting.[71,72] *[Recommendation]*

In June 2017, the CMS released a survey and certification memo that stated that health care facilities should develop and implement water management programs.[71] The CDC asserts it is essential that hospitals establish and maintain a water management program that is effective in limiting waterborne pathogens from growing and spreading in their facility.[72] Including members from a variety of disciplines in the water management team brings perspectives and knowledge to support all aspects of a water safety program.

9.2.1.

The interdisciplinary water management team members may include an infrastructure designer, a safety officer, an industrial hygienist, environmental service personnel, an epidemiologist, a facility engineer, a facility manager, an infection preventionist, a risk manager, and an accreditation manager.[65,72] *[Conditional Recommendation]*

9.3.

Identify barriers for performing hand hygiene in the perioperative setting and address these through interventions to improve hand hygiene compliance.[1] *[Recommendation]*

Identifying barriers to hand hygiene allows the health care organization to develop relevant interventions to improve hand hygiene compliance.[1] The SHEA/IDSA recommends identifying unit-specific barriers and creating interventions specific to the unit's needs.[1]

Pedersen et al[126] conducted two surveys at an academic medical center to examine the perceptions of barriers to hand hygiene among OR and endoscopy health care personnel. A total of 271 OR surveys (response rate 36%) and 29 endoscopy surveys (response rate 33%) were completed. The greatest barrier to hand hygiene performance identified by OR personnel was inconvenience (49%), whereas inconvenience (20%) and forgetfulness (20%) were the barriers identified by endoscopy personnel. Medical students surveyed in the OR stated that they felt pressured not to perform hand hygiene during their time in the OR. Survey responses identified both OR and endoscopy managers as poor hand hygiene role models.

The SHEA Research Network conducted a survey among three anesthesia provider groups (ie, the American Society of Anesthesiologists [N = 5,000], the AANA [N = 5,000], and the American Academy of Anesthesiologist Assistants [N = 1,761]) to identify barriers to hand hygiene.[39] Among the 712 responses received, the barriers identified included lack of time in emergency situations (58.3%), lack of time in general (44.2%), skin factors (35.8%), hand hygiene equipment not readily accessible (27%), and lack of support from OR personnel for hand hygiene–related workflow interruptions (15.5%).

9.4.

Monitor adherence to policies and procedures for hand hygiene as part of quality assurance and process improvement initiatives.[1,7,11] *[Recommendation]*

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Professional organizations recommend monitoring the adherence of health care personnel to recommended hand hygiene practices.[1,7,11] According to the WHO, monitoring hand hygiene adherence as a performance indicator serves several functions, including system monitoring, an incentive for performance improvement, outbreak investigation, and infrastructure design.[7] The type of measurement selected is dependent on a facility's available resources and commitment to using collected data productively.[1]

9.4.1.

Measure hand hygiene in the perioperative setting by direct observation.[1,7,11,29] ***[Recommendation]***

The SHEA/IDSA recommends performing direct observation audits of hand hygiene in the perioperative setting as a strategy to prevent SSIs.[29] The authors of several moderate-quality studies and organizational experience reports monitored hand hygiene compliance in the perioperative setting using direct observation.[30-33,40,45,116,117,120,127]

Limitations of direct observation are the risk for selection and observer bias[7] and that the method is subject to the Hawthorne effect.[1] Direct observation audits are performed by a human observer, either in person or by video recording, which can be labor-intensive. Video observations may be beneficial in the perioperative setting because of the high number of hand hygiene indications and numerous perioperative team members. However, video observations may also compromise patients' privacy.[1]

Rowlands et al[34] used video observations of anesthesia professionals to evaluate hand hygiene compliance using WHO criteria. Three perioperative team members (ie, an anesthesia professional, an anesthesiology resident, and a perioperative RN) reviewed the videos independently. An average of 149 hand hygiene indications were observed per hour of anesthesia time, along with low rates of hand hygiene performance. The researchers concluded that compliance with current hand hygiene guidelines was not feasible, as performance of hand hygiene according to WHO criteria would have taken more than the 60 minutes available during each hour of anesthesia.

9.4.2.

Other measures to evaluate hand hygiene practices may include product consumption or automated monitoring.[1,7,11,128] ***[Conditional Recommendation]***

Measuring product consumption, such as for alcohol-based hand rub products, provides an indicator of overall hand hygiene activity.[7] However, this method does not reliably measure hand hygiene based on indications,[1,7] and the CDC-recommended measurement of product volume used per 1,000 patient-days[11] is not a perioperative indicator of patient volume.

In place of direct observation of anesthesia professionals' hand hygiene compliance, Segal et al[128] used the weight of an alcohol-based hand rub container located on the anesthesia supply cart as a surrogate for frequency of hand hygiene performance. The container weight was measured before and after the surgical procedure and used to estimate the number of accesses (ie, pumps) per hour by dividing the change in container weight by the total time the patient was in the room. To validate that the estimated change in container weight reflected actual hand hygiene performance, video-assisted observation was implemented during selected cases (N = 26) to view hand hygiene episodes. A strong correlation was found between video observation of hand hygiene episodes and estimated hand hygiene frequency based on the container weight change. The authors concluded that this method was feasible and accurate to support a quality initiative to improve hand hygiene among anesthesia

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professionals, particularly because a single anesthesia professional normally cares for the patient during a given procedure.

Automated hand hygiene monitoring is an emerging technology that may detect hand hygiene indications during the patient encounter.[1,7] The evidence review found no literature to support or refute the use of **automated hand hygiene monitoring systems** in the perioperative setting. Additional research is needed to thoroughly evaluate the effect of automated systems and measurement of product consumption on hand hygiene monitoring, compliance, and outcomes.[39,44]

9.4.3.

Provide feedback on hand hygiene performance to perioperative team members.[1,7,11] ***[Recommendation]***

Health agencies and professional organizations recommend providing health care personnel with performance feedback when monitoring adherence to hand hygiene practices.[1,7,11] The WHO indicates that feedback may be more effective if provided more than once, when both verbal and written feedback are used, and when the audit and feedback are completed by a superior or colleague.[7]

One high-quality study[112] and three organizational experience reports[81,121,128] included feedback on hand hygiene and surgical hand antisepsis performance to successfully increase compliance in the perioperative environment.

9.5.

Use visual reminders to prompt hand hygiene performance among perioperative team members.[44,125] ***[Recommendation]***

The rapid pace and high-intensity workload of perioperative personnel may make hand hygiene a lesser priority or one that is simply forgotten. One action recommended by both the WHO[125] and APIC[44] is to place visual reminders at strategic locations in the workplace to prompt and remind health care workers about the importance and necessary indications for hand hygiene. To increase attention to the reminders, APIC recommends they be short, easy to read, engaging, and direct.[44]

The addition of visual reminders, both in paper and electronic format, has been used in high-quality studies and organizational experience reports to increase hand hygiene performance in the perioperative environment. Paper reminders included labels placed on the computer keyboard and top of the anesthesia supply cart,[122] signs placed above alcohol-based hand rub dispensers located in the anesthesia work area,[80] and a poster in each OR designating indications for hand hygiene in the patient zone.[42] Electronic reminders included messages sent intermittently to video monitors, the electronic anesthesia record, and anesthesia professionals' emails.[128,129] Although most of the studies were conducted with anesthesia professionals, generalization to the rest of the perioperative team seems plausible.

A different reminder approach was used in a prospective study with a repeated measure design conducted in the perioperative holding area of a large academic hospital. Beyfus et al[130] placed four automated volume dispensers (1.1 mL per dispensation) of alcohol-based hand rub in the holding area, alongside 54 existing manual wall-mounted dispensers. The automated dispensers were identified as #1, #2, #3, and #4 and were placed in high traffic areas for the duration of the study. Pictures of a set of eyes from an unnamed but recognized hospital leader were placed above dispensers #1 and #3, but not #2 and #4 for 2 consecutive weeks and then rotated during the next 2 weeks. This occurred a total of six times so that each dispenser had three periods with and three periods without the visual stimulus. At the end of each period, the volumes of alcohol-

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based hand rub dispensed were measured to determine if the visual stimulus influenced the volume dispensed. The researchers found a significant difference in the average volume dispensed during the six time periods from dispensers with the visual stimulus compared to those without the visual stimulus (279 mL compared to 246 mL). The researchers concluded that hand hygiene compliance might be enhanced in health care facilities with the right visual stimuli.
9.6.

Encourage patients and visitors to remind perioperative team members to perform hand hygiene before care. [1,7,11,131] ***[Recommendation]***

Moderate-quality evidence and guidance from professional organizations support encouraging patients and their family members to remind health care personnel to clean their hands before care episodes.[1,7,11,131] The WHO recommends a structured approach to incorporating patient engagement into the hand hygiene promotion strategy, including developing ownership and shared responsibility for the program at the health care organization, reviewing existing empowerment programs, and developing the program based on organization-specific factors such as culture, program implementation, and evaluation.[7]

The WHO conducted a global survey of patient experiences with hand hygiene (N = 459) and found that 29% of respondents had asked health care personnel to wash their hands, and 25% of the patients who asked health care personnel to wash their hands reported receiving a negative response to the request.[7] The survey found that patients were more likely to feel comfortable reminding health care personnel to wash their hands when encouraged by health care personnel. Patients with direct experience of a health care–associated infection were more likely to question the health care personnel.

Ottum et al[131] surveyed 200 patient respondents (response rate 94.8%) about their comfort in reminding health care personnel to perform hand hygiene. The study found that 99.5% of patients surveyed believed that personnel were supposed to wash their hands before and after providing patient care and that 90.5% believed in reminding health care personnel to wash their hands only if they forgot. However, only 14% of patients reported having asked personnel to wash their hands, with 64% comfortable reminding nurses and 54% comfortable reminding physicians. Patients who had worked in health care were significantly more likely to be comfortable asking personnel to wash their hands than patients who had not worked in health care. The implications of these findings are that the baseline beliefs of the patients about the importance of hand hygiene were universally high, which suggests that more education would be unlikely to empower their participation further. Thus, the researchers recommended focusing interventions on making patients more comfortable with asking health care personnel to wash their hands.

In a cross-sectional survey conducted at a university hospital in Spain, Sande-Meijide et al[132] found a significant difference among patients, patients' families, nurses, and physicians in support for hand hygiene promotion by patients. At the time of the survey, 407 patients were hospitalized; 232 patients and 105 family members completed the survey, for a 78% response rate. Of a total of 393 health care professionals asked to complete the survey, 79 physicians and 117 nurses completed the survey, for a 51.6% physician response rate and 49.8% nurse response rate. Of note, 95% of patient respondents were either hospitalized the year before the survey or were a family member of someone who had been hospitalized. Only 16% of patients and 10% of families reported having had previous experience with a health care–associated infection.

Among patients and their families, 49.9% were willing to remind health care personnel to perform hand hygiene. The main reason given by those not willing to ask health care personnel to perform hand hygiene was a fear of causing annoyance or receiving suboptimal care. Among health care providers, only 31.6% (41.8% of physicians and 24.8% of nurses) supported patient participation. Physicians' reasons for disagreeing with patient participation included patients' lack of knowledge and possible adverse effect on the physician/patient

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relationship. The main reason among 58% of nurses who did not support patient participation was that they believed patient participation was unnecessary as hand hygiene was a usual practice inherent to their work. The researchers concluded that to create a facilitating environment for patient empowerment, a cultural change in the health care professional and patient relationship is necessary.[132]
9.7.

Explore processes that improve workflow and reduce unnecessary hand hygiene indications (ie, recontamination after performing hand hygiene) in the perioperative setting.[7] *[Conditional Recommendation]*

The perioperative environment is unique and fast-paced, making optimization of hand hygiene critical. Better characterization of hand hygiene indications in the perioperative environment may lead to improved hand hygiene compliance.[87] Depending on the process of care provided, the number of hand hygiene indications can vary widely.[7] Protocol revisions may decrease unnecessary contact with the patient or patient's environment, thereby reducing the number of hand hygiene indications.[7]

Moderate-quality evidence supports decreasing the number of indications for hand hygiene by managing processes.[33,80,126,127] Although most of the literature reviewed was conducted with anesthesia professionals, recommendations from these studies could be generalized to all perioperative team members.

The high task density of anesthesia providers suggests that novel approaches to hand hygiene be investigated, along with guidance specific to hand hygiene in the anesthesia work area.[33,80,127]

In an 8-hour observational study of anesthesia professionals (N = 30), Munoz-Price et al[127] found that induction and maintenance resulted in frequent contact of providers' hands with both the environment and the patient. The mean contact by providers' hands during induction was 154.8 per hour and during maintenance was 60 times per hour. The researchers concluded that performing hand hygiene after every hand contact might not be a practical solution for interrupting microbial transmission. Instead, they recommended collaborating with infection control personnel to formulate clear and reasonable expectations for hand hygiene frequency during induction and maintenance of general anesthesia that do not interfere with the anesthesia professional's workflow or affect patient safety.

Porteous et al[80] conducted a simulation scenario crossover design study with 25 anesthesia providers in which a baseline general anesthesia induction simulation was conducted and then repeated using an evidence-based intervention bundle that included performing hand hygiene before accessing the anesthesia cart. At the start of each simulation, the tongue and oropharynx of a manikin were coated with fluorescent gel, and a fluorescent powder was applied to the manikin's cheeks and mandible. Each of the simulations was also video recorded and reviewed by an infection prevention nurse for the number of glove removals, the number of hand hygiene events, and any infection prevention actions completed that were not included in the bundle. After each simulation, a UV light source was used to identify fluorescence on 20 previously identified anesthesia work area sites (eg, ventilator controls, medication syringe, anesthesia cart front), and if fluorescence was found, the site was photographed.

The researchers concluded that limiting hand hygiene to specific "high impact" tasks such as administering medications or before touching anything on or in the anesthesia cart significantly reduced contamination of medication syringes and the anesthesia work area. They suggested that video observation of specific behaviors that increase or decrease workspace contamination may be helpful in identifying best practices. Then, after new practices are developed, the use of simulation can provide an opportunity to evaluate the new techniques rapidly and in a risk-free setting. However, they did caution that simulation may not completely emulate real clinical behavior.[80]

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Megeus et al[33] observed indications for hand hygiene of health care personnel participating in the anesthetic care of patients undergoing 94 surgical procedures in Sweden. The researchers observed that during induction, hand hygiene indications occurred consecutively and within a short period (mean 23.6 minutes) for an aggregated group mean of 77.5 indications per hour. In contrast, when hand hygiene indications for those providing anesthetic care were measured for the entire surgical procedure, a mean of 10.6 indications per hour was found. The researchers attributed the high incidence of hand hygiene indications to inadequate work processes by health care personnel. These included more personnel than necessary participating in procedures, frequent interruptions when carrying out aseptic procedures (eg, inserting a venous access line) that led to recontamination of hands or gloves, and several unnecessary hand hygiene events during the sequence of care.[33] The researchers concluded that additional studies are needed to evaluate hand hygiene improvement strategies that optimize anesthesia work processes.

In a survey of OR and endoscopy health care providers' perceptions of barriers to hand hygiene adherence as described in Recommendation 9.3, personnel indicated that having to frequently enter and exit procedure rooms was a barrier to hand hygiene performance.[126] The authors purported that the increased frequency of room entry and exit contributed to the health care provider's workload, making hand hygiene a lower priority. They suggested that a more effective workspace setup could decrease entry and exit frequency, thereby reducing the number of hand hygiene indications.[126]

Glossary

Alcohol-based hand rub: An alcohol-containing preparation (eg, liquid, gel, foam) designed for the hands to inactivate microorganisms and temporarily suppress their growth.

Anionic emulsifying agent: An emulsifier with a surface-active ion that is negatively charged. Examples include sodium stearoyl glutamate, sodium stearoyl lactylate, and potassium cetyl phosphate.

Antimicrobial soap: Soap containing an antiseptic at a concentration sufficient to inactivate microorganisms and temporarily suppress their growth.

Artificial nails: Substances or devices applied or added to the natural nails to extend or augment (ie, sculpt, shape) the wearer's nails. These include bonding, extensions, tips, gel and acrylic overlays, and wraps.

Automated hand hygiene monitoring system: A counting device or sensor that tracks product activation or frequency of use relative to specific events (ie, entering or exiting a room, use in the patient care vicinity).

Enhanced nail lacquer: A nail coating that improves adhesion of the product to fingernails and duration of the product. These include self-adherent colored plastic films, dipped nail coating, and ultraviolet-cured nail lacquer.

Flow straightener: A terminal component in faucets that produces a uniform flow of water without excessive splashing.

Glove juice method: A method for culturing the hands that involves donning a sterile glove, instilling an eluent solution (ie, a solvent used for separating material from a surface) into the glove, securing the glove at the wrist, kneading the gloved hand in a standardized manner for 60 seconds, and extracting the eluent fluid (glove juice) for culture.

Hand hygiene: Any activities related to hand condition and cleansing.

Hand washing station: An area that includes a sink, faucet, cleansing solutions, and a means for drying the hands.

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Invasive procedure: The surgical entry into tissues, cavities, or organs or the repair of major trauma injuries.

Monograph: A determination by the US Food and Drug Administration that an active ingredient is generally recognized as safe or effective (GRASE) for over-the-counter use because of evidence of effectiveness, safety, or both.

Nail lacquer: A nail coating applied to the nail plate to improve attractiveness (ie, color) and strength, but not for the purpose of nail plate extension or augmentation. Synonyms: nail polish, nail enamel, nail paint

Non-ionic surfactant: A surfactant with a surface-active ion that contains no charge. Examples include ethoxylated alcohols, alkyl-phenols, and fatty acid esters.

Nonmonograph: A determination by the US Food and Drug Administration that an active ingredient is not generally recognized as safe or effective (GRAS/GRAE) for over-the-counter use because of lack of evidence of effectiveness, safety, or both.

Perioperative patient zone: The delineation of the patient care zone for the perioperative setting that identifies the area around the patient that includes equipment in direct contact with the patient and equipment touched by non-scrubbed personnel after patient contact for the purpose of identifying hand hygiene indications. The equipment in the patient zone may include the positioning supports, patient linen, top of the OR bed, warming blanket, electrosurgical pad, electrosurgical unit, video tower, and vascular compression device.

Subungual: The area or space underneath a fingernail.

Surgical hand antisepsis: A hand wash or hand rub using a surgical hand antiseptic, performed preoperatively by the surgical team members to remove transient flora and reduce resident skin flora.

Surgical hand antiseptic: A product that is a broad-spectrum, fast-acting, and nonirritating preparation containing an antimicrobial ingredient designed to significantly reduce the number of microorganisms on intact skin. Surgical hand antiseptic agents demonstrate both persistent and cumulative activity.

Thermostatic mixing valve: An electronic device that regulates the temperature of water by mixing water from the hot and cold supply before it is released from faucet outlets.

Transepidermal water loss: Insensible loss of water from the skin, as a result of evaporation (in the absence of sweat). There is a direct correlation between the extent of skin damage and transepidermal water loss.

Ultraviolet-cured nail lacquer: Enhanced nail lacquer created by polymerization of methacrylate or acrylate that hardens when exposed to ultraviolet light. Synonym: gel polish

Water pathogens: Opportunistic pathogens of plumbing systems that can cause disease in humans. These pathogens grow in ambient-temperature (often stagnant) water; have a strong association with biofilms; and can be transmitted by aerosols, ingestion, or contact (direct or indirect). They include *Pseudomonas, Acinetobacter, Burkholderia, Stenotrophomonas, Legionella,* and nontuberculous mycobacteria.

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