JANET M. SERKEY, RN, JD, CIC
Risk Manager, Office of General Counsel,
Cleveland Clinic

GERRI S. HALL, PhD
Department of Clinical Pathology,
Section of Clinical Microbiology, Cleveland Clinic

Handwashing compliance: What works?

ABSTRACT

Health care personnel—particularly physicians—do a poor job of complying with national handwashing guidelines, yet handwashing is the cornerstone of infection control. New products designed to increase compliance are available, such as automated handwashing machines, but their clinical benefits have not been fully studied. The best solution for now may be to continue awareness campaigns and education programs, ensure access to sinks and appropriate antiseptic products, and promote the use of alcohol disinfectants when handwashing is not possible.

KEY POINTS

Antiseptic products are now preferred over handwashing with plain soap, which does not reliably prevent transmission of bacteria.

Because 100% compliance may not be realistic, interventions that improve compliance, such as the use of alcohol sanitizing products when handwashing is not possible, may be the best solution.

A number of barriers deter compliance, including lack of access to handwashing stations and lack of time.

Gloves are not a substitute for handwashing because they are not fully protective.

COMPLIANCE with national handwashing guidelines rarely exceeds 50%—and physicians are often cited as the least adherent. This dilemma persists despite the fact that handwashing has been the cornerstone of infection control for 150 years, ever since Dr. Ignaz Semmelweis discovered the source of "childbed fever": the hands of the physician.

Although new machines and gadgets can help increase compliance, aggressive advocacy by the hospital management is still key. We review the physiologic and bacteriologic characteristics of the hands, indications for a handwashing or disinfecting procedure, barriers to compliance, and strategies to improve compliance.

TYPES OF BACTERIA THAT GROW ON THE SKIN

The skin has three microenvironments—oily, wet, and dry—and the microbial population is remarkably stable in each (TABLE 1).[1] Gram-positive cocci constitute about 90% of the normal resident flora; gram-negative bacteria are less commonly found. However, if the skin remains moist, as it can when it is covered by gloves or dressings, gram-negative bacteria can thrive and remain on the skin for a long time.

Resident flora

The prevailing species of resident skin flora is *Staphylococcus epidermidis* (TABLE 1). On occasion, *S aureus* colonizes the skin, especially in the hospital environment.[2] The bacterial density of the resident flora is between 100 and 1,000 per square centimeter and remains stable for long periods of time.[2] Skin diseases, local antibiotics, disinfectants, and substantial climatologic changes can alter the stability of resident flora.[2]

TABLE 1

Where different organisms live on the skin

BACTERIA	REGION*		
	OILY	WET	DRY
Gram-positive cocci			
Aerobic	√√√†	√√√	√√√√
Staphylococcus epidermidis			
Staphylococcus aureus			
Micrococci			
Anaerobic	√√		√√
Peptococcus			
Peptostreptococcus			
Gram-positive rods			
Aerobic diphtheroids	√√√	√√√√	√√√
Corynebacterium			
Brevibacterium			
Anaerobic diphtheroids	√√√√	√√	√√
Propionibacterium acnes			
P granulosum			
P avidum			
Gram-negative bacteria	√	√	√
Primarily Klebsiellae (*Klebsiella, Enterobacter*)			
Moraxella, Acinetobacter			

*Oily regions = head, neck, trunk, upper back; wet regions = axillae, anterior nares, groin, intertriginous areas; dry regions = limbs, hands
†Quantitative estimates are in relative proportion

FROM LARSON EL, BRYAN JL. HANDWASHING AND SKIN. PHYSIOLOGIC AND BACTERIOLOGIC ASPECTS. INFECT CONTROL 1985; 6:14–23.

Transient flora

Transient flora such as *Pseudomonas aeruginosa* can be accidentally acquired through contamination of the hands. Generally, they do not multiply on the skin and usually die because of the physiochemical environment there, but this occurs inconsistently.[2] Because this mechanism is inconsistent, some transient pathogens survive long enough to be transmitted to patients. In fact, outbreaks of infection in critical care settings are often associated with transient flora on the hands of the critical care team.[3]

Even in the differing microenvironments of the hand, such as nail folds and web spaces, it is theoretically possible to isolate any microorganism from the hands after transient exposure.

HANDWASHING PROTOCOL

Correct procedure

To begin the standard handwashing procedure, wet the hands with running water and distribute soap or other sanitizing agent evenly over all surfaces. Next, apply mechanical friction by rubbing the hands together for 10 to 15 seconds, making sure that all fingers and webs and the back of the hands receive attention. (The 10 to 15 seconds are important to allow sufficient contact of the antiseptic agent and adequate friction.) Finally, thoroughly rinse and dry hands without recontaminating them.[4]

National APIC guidelines

National guidelines from the Association for Practitioners in Infection Control[4] recommend thoroughly washing with soap and water whenever the hands are visibly soiled, and either washing with soap and water or performing antisepsis with alcohol-based rubs even if the hands are *not* visibly soiled:

- Before and after patient contact
- After contact with a source of microorganisms (eg, body fluids and substances, mucous membranes, non-intact skin, or inanimate objects likely to be contaminated)
- After removing gloves.

These recommendations are deceptively simple and straightforward. Few would argue about the need to wash visibly soiled hands, and it is objectively easy to note whether the dirt is removed. However, when contamination is less obvious, the standard that hands must be washed (or disinfected by an antiseptic agent) before and after patient contact is fraught with difficulty. The busy clinician's decision is usually made after the contact with the patient, and it may depend on the intensity of the contact (what was touched and for how long).

SOAP AND WATER ARE MODERATELY EFFECTIVE

In an era of increasingly compromised patients, it is becoming clearer that skin antisepsis is preferable to simple cleansing to prevent infection. Washing with soap and water is only moderately effective in reducing the bacterial

burden, halving the release of skin bacteria every 5 minutes.[5] Both are suitable for removing surface bacteria in nonclinical settings. But as much as 20% of resident flora inhabit deep layers of the skin and cannot be removed or inhibited by washing with nonantiseptic handwashing products.[6]

Ehrenkranz[7] puts to rest the notion that bland soap handwashing reliably prevents hand transmission of transiently acquired bacteria. Reviewing the original work of Dr. Semmelweis, he notes that mortality from puerperal sepsis did not decrease until chlorine washes were enforced throughout an entire year. Ehrenkranz also reviewed a series of studies that demonstrated that hand antisepsis is at least 10 to 100 times more effective than regular soap in removing transient bacteria.

STUDIES REVEAL POOR COMPLIANCE

Studies of handwashing compliance during the past 20 years have observed an unchanging pattern: hospital personnel wash their hands after patient contact less than half the time. Physicians are usually the worst offenders.[8–10] Doebbeling and colleagues[10] found that although all critical care staff knew that a handwashing behavior study was underway and participated in aggressive educational programs, including videotape demonstrations, the compliance rate was only 48%.

42% of men left the bathroom without washing their hands

In a study in five Boston hospitals,[11] 143 persons were observed to see whether they washed their hands before leaving the bathroom. Forty-four persons (31%) did not. Only 37 (26%) used both soap and water. And men were worse than women: only 13.8% of women vs 42% of men left the bathroom without washing their hands.

BARRIERS TO COMPLIANCE

Lack of sinks, soap, and towels

It has been noted that handwashing compliance is better in private hospital rooms, where sinks and sanitizing products are readily accessible, than in open wards where they may be more scarce.[12] It is important to note that the Occupational Safety and Health Administration's (OSHA) Bloodborne Pathogens Standard mandates that personal protective equipment—which includes handwashing equipment—be readily available.

Lack of time

Effective handwashing takes at least 1 minute. Is there enough time in the day for adequate handwashing? No, according to Voss and Widmer.[13] They calculated the time consumed for handwashing in an intensive care unit with 12 health care workers, with standard handwashing (40 to 80 seconds) compared with an alcohol rub (20 seconds). One hundred percent compliance with standard handwashing was reckoned to consume 16 hours of nursing time for the day shift alone, compared with 3 hours for the alcohol rub.

The authors postulated that substituting an alcohol rub for some of the handwashings would result in 100% compliance without interfering with the quality of patient care.[13] However, proof of this hypothesis awaits rigorous testing in a clinical setting.

Understaffing and overcrowding

In a study of an outbreak of *Enterobacter cloacae* in a neonatal intensive care unit, Harbarth et al[14] concluded that cross-transmission was abetted by understaffing (fewer infections developed during better staffing patterns) and overcrowding (eg, 25 neonates in a unit designed for 15). In another study of risk factors for nosocomial primary bloodstream infections, the study patients were significantly more likely than control patients to have been hospitalized during a 5-month period in which the nurse-to-patient ratio was lower.[15]

The tantalizing conclusions of these studies are that health care professionals devote less time or care to handwashing when staffing is inadequate.

Poor appreciation of the consequences

Health care professionals may not appreciate the potential effects of noncompliance. A report from the Institute of Medicine entitled "To Err is Human"[16] considered noncompliance with handwashing guidelines an error that contributes to the already endemic nosocomial infection rate in that is usually accepted as normal risk in health care institutions.

The Centers for Disease Control and Prevention (CDC) reported that 30% of nosocomial infections are preventable,[17] and infections that are preventable by adequate handwashing probably constitute part of that risk.

Dry skin

Frequent washing can leave skin dry and cracked. In addition, it can alter the skin's normal protective flora, depending on the frequency, composition of the product used, mechanical friction, rinsing, drying method, and use of lotion.[1] As a result, frequently washed hands may be more vulnerable to infection depending on skin type, the duration of the handwashings, and the products that are used.

GLOVES ARE NOT THE ANSWER

Some health care professionals believe that wearing gloves over unsanitized hands will protect other health team members and patients. In reality, gloves do *not* replace handwashing because they may not be fully protective. Food and Drug Administration (FDA) regulations permit 40 defects per 1,000 gloves before a batch of examination gloves is rejected.[18] These small unapparent defects, tearing of gloves (which occurs frequently during use), and soiling of hands while removing dirty gloves can allow hands to be contaminated.[19]

Failure to change gloves between patient contacts creates an additional cross-contamination risk. While the wearing and changing of gloves has not been well studied, one report documented increased transmission of methicillin-resistant *S aureus* in a critical care unit, related to failure to change gloves between patient contacts.[20]

According to the CDC,[19] wearing gloves can only:

- Protect the hands of health care personnel from gross contamination from blood and other body fluids, excretions and secretions, mucous membranes, and non-intact skin (the OSHA Bloodborne Pathogens Standard mandates compliance to prevent exposures in the workplace)
- Prevent transmission of resident flora to patients
- Prevent cross-transmission of transient flora from one patient to another.

EDUCATION IS EFFECTIVE BUT TEMPORARY

Outbreaks of nosocomial infections can be interrupted when interventions include reinforcement of correct handwashing.[3] However, the effects may be only temporary.

In a well done, quasi-experimental study, Larson and colleagues[21] attempted to address "predisposing, enabling, and reinforcing factors" to improve the frequency of handwashing in a large medical center. Predisposing factors (knowledge and beliefs) were addressed by focus group sessions with the staff. Enabling factors (skills and equipment) addressed in training sessions included the use of automated sinks on the experimental unit. During 300 hours of observation, 2,624 handwashings were recorded. Although the frequency of handwashing increased, the improvements disappeared within 2 months.

McGuckin et al[22] conducted a 6-week interventional study in four community hospitals. Patients were educated within 24 hours of admission about the importance of asking their health care workers to wash their hands. Although patients were more reluctant to ask physicians than nurses, handwashing compliance increased. A major limitation of this approach is that patients in critical care units are often unable to query their care providers.

Workers wash hands less when staffing is inadequate

NEW GADGETS AND MACHINES: ARE THEY HELPFUL?

Recent innovations include automated handwashing sinks that can be customized to run for a programmed length of time, control water temperature, and dispense the correct amount of washing agent.

Some systems emit an audio signal to ensure the proper amount of time is spent on handwashing. For example, the WashBuddy emits two audible signals. The first one directs users to begin washing their hands. The second signal, which sounds 15 seconds later, directs users to clear and rinse their hands.[23]

Some systems use computers to record handwashing. One prototype handwashing monitor is designed to be marketed to the food industry to aid compliance with an FDA mandate that the "... person in charge shall assure

TABLE 2

Is soap enough? Four studies found variable results

INVESTIGATORS	YEAR	PRODUCTS COMPARED	METHOD	OUTCOMES AND CONCLUSIONS
Cardoso et al[30]	1999	Plain soap 70% Ethyl alcohol 10% Povidone-iodine 4% Chlorhexidine gluconate	Healthy volunteers' fingertips contaminated with *Acinetobacter baumannii*	70% ethyl alcohol and 10% povidone-iodine may be the best for removing *A baumannii* from heavily contaminated hands
Bettin et al[31]	1994	Liquid soap Chlorhexidine gluconate	Healthy volunteers contaminated with *Clostridium difficile* on bare hands and gloved hands	No difference in residual counts on bare hands, but on gloved hands residual counts were lower following chlorhexidine gluconate
Faoagali et al[32]	1999	4% Chlorhexidine gluconate 1% Triclosan handwash	Glove juice was collected from nursing and medical personnel in an acute clinical ward and compared	Both reduced total hand bacterial count; 4% chlorhexidine gluconate was consistently more effective in reducing the total count but was not effective against methicillin-resistant *Staphylococcus aureus*; 1% triclosan eliminated it
Doebbeling et al[10]	1992	60% Isopropyl alcohol hand-rinsing agent 4% Chlorhexidine gluconate	8-month multiple-crossover trial; 1,894 adult patients in 3 intensive care units, followed prospectively for nosocomial infection	Fewer infections when 4% chlorhexidine gluconate was used compared with alcohol and soap; although handwashing compliance was greater during the chlorhexidine periods, the highest compliance achieved was < 50%

that employees are effectively cleaning their hands, by routinely monitoring employee handwashing."[24]

Computer-based monitoring of handwashing compliance in the health care setting is being developed. Acceptance and effects of electronic monitoring have not been determined in this setting, but its development will surely continue, and cost, benefit, and acceptance will be researched in the next few years.

Automated handwashing machines, which are typically self-contained wall units that wash and sanitize hands, are also under development. With the CleanTech system, health care workers place their hands in cylinders and a machine washes them using a high-powered, low-volume spray in cycles of up to 20 seconds.[25] The efficacy and acceptance of such a system for surgical scrubbing has not been determined.

DOES IT MATTER WHICH PRODUCT IS USED?

Does the product used to wash hands make a difference if the best compliance is less than 50%? Maybe not.

Purchasing agents, who have their eye on the bottom line, are persuaded by the cost as well as the efficacy of a product. Most products are appealingly advertised as having the capacity to decrease the risk of acquiring HIV and hepatitis B virus; less politically-charged microbes are less often highlighted in advertising messages. Marketing brochures usually quote in vitro data that are interesting but not very useful for product comparisons because the testing methods and pathogens selected are not standardized.

Some clinical studies of handwashing products contain outcome data, but again hand-

washing methods and the interpretation of compliance are not standardized. Regardless of how compliance is defined, poor compliance further limits the interpretation of these studies. It is arguable that the best products are those that increase compliance and sustain it long after the research period, though such results have rarely been conclusively demonstrated.

Besides surgical scrubs, what hand antiseptics most effectively decontaminate the hands? Of a sample of four studies published during the last decade, which tested products against specific organisms (TABLE 2), only one[10] measured patient outcomes. Agents studied included plain soap, alcohol preparations of various types, povidone-iodine, 1% triclosan, and 4% chlorhexidine gluconate. Results varied with test conditions. The study that measured infection outcomes (in three intensive care units) claimed a reduction in infections with the use of 4% chlorhexidine gluconate compared with alcohol and soap.

However, Goldmann and Larson,[26] in an accompanying editorial, advised caution in interpreting the results. They pointed out that hospital personnel used much smaller volumes of alcohol than chlorhexidine, which may have skewed results. Alcohol requires enough solution to wet the hands thoroughly to be effective, which may not have occurred. They emphasized that the important observation was that hospital personnel needed to improve both their handwashing and their use of barriers (gloves).

Clinical leadership sets the standard by example

RINGS AND ARTIFICIAL NAILS IMPEDE BACTERIA REMOVAL

No product may be effective if the health care provider is wearing jewelry or artificial nails, which impede removal of bacteria and serve as niduses for bacterial accumulation.[27] Even natural nails that are overly long can harbor bacteria and impede their removal.

In a laboratory study of 100 health care workers divided into two groups (those wearing and those not wearing rings), the mean total skin bacterial colony counts for the workers with rings were higher both before and after handwashing.[28] Evidence has recently been used to support an association between artificial or long fingernails in an outbreak of *Pseudomonas aeruginosa* in a neonatal intensive care unit.[27]

A MULTIFACETED SOLUTION

Methods that yield "better" compliance such as the intermittent use of alcohol solutions are a step towards "best" and ought to be encouraged. Encouragement comes in many forms but requires active participation of top management to ensure that enough supplies (alcohol disinfecting agent, soap, towels, and sinks and faucets in good repair) are always available in convenient places in accord with OSHA standards. Clinical leaders must set the standard through their example at the bedside, reminders to colleagues, and monetary support for handwashing campaigns to regularly stimulate awareness and compliance among the staff.

Unfortunately, nosocomial infection rates can be reduced but not eliminated. Robert Gaynes, MD, chief of nosocomial infection surveillance activity in the CDC's Hospital Infections Program, recognized that not all nosocomial infections are preventable, particularly when they involve an invasive device.[29]

Because the largest component of the handwashing compliance problem is human behavior, it perhaps may be unrealistic to expect 100% compliance. This is in contrast to other errors that are more amenable to automated intervention, such as medication error, where 100% compliance can and should be achieved.

REFERENCES

1. **Larson E.** Handwashing and skin. Physiologic and bacteriologic aspects. Infect Control 1985; 6:14–23.
2. **Rotter M.** Handwashing, hand disinfection and skin disinfection. In: Wenzels R, editor. Prevention and control of nosocomial infections. 3rd ed. Baltimore: Williams and Wilkins; 1997:691–709.
3. **Bryan JL, Cohran J, Larson EL.** Handwashing: a ritual revisited. Crit Care Nurs Clin North Am 1995; 7:617–625.
4. **Larson E.** APIC guideline for handwashing and hand antisepsis in health care settings. Am J Infect Control 1995; 23:251–269.
5. **Larson E, Butz AM, Gullette DL, Laughon BA.** Alcohol for surgical scrubbing? Infect Control Hosp Epidemiol 1990; 11:139–143.
6. **Simmons BP.** CDC guidelines for the prevention and

control of nosocomial infections: guideline for hospital environmental control. Am J Infect Control 1983; 11:91-115.

7. **Ehrenkranz NJ.** Bland soap handwash or hand antisepsis? The pressing need for clarity. Infect Control Hosp Epidemiol 1992; 13:299–301.
8. **Albert RK, Condie F.** Hand-washing patterns in medical intensive-care units. N Engl J Med 1981; 304:1465–1466.
9. **Watanakunakorn C, Wang C, Hazy J.** An observational study of handwashing and infection control practices by healthcare workers. Infect Control Hosp Epidemiol 1998; 19:858–860.
10. **Doebbeling BN, Stanley GL, Sheetz CT, et al.** Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units. N Engl J Med 1992; 327:88–93.
11. **Stender J, Rosenberg FA.** Study of handwashing procedures in the bathrooms of Boston-area hospitals. Am J Infect Control 1998; 26:451–452.
12. **Freeman J.** Prevention of nosocomial infections by location of sinks for handwashing adjacent to bedside [abstract 60]. 33rd Interscience Conference on Antimicrobial Agents and Chemotherapy; 1993 Oct. 17–20; New Orleans, LA.
13. **Voss A, Widmer AF.** No time for handwashing!? Handwashing versus alcoholic rub: can we afford 100% compliance? Infect Control Hosp Epidemiol 1997; 18:205–208.
14. **Harbarth S, Sudre P, Dharan S, Cadenas M, Pittet D.** Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding, and poor hygiene practices. Infect Control Hosp Epidemiol 1999; 20:598–603.
15. **Robert J, Fridkin SK, Blumberg HM, et al.** The influence of the composition of the nursing staff on primary bloodstream infection rates in a surgical intensive care unit. Infect Control Hosp Epidemiol 2000; 21:12–17.
16. **Kohn LT, Corrigan JM, Donaldson MS (editors); Committee on Quality of Health Care in America, Institute of Medicine.** To Err Is Human: Building a Safer Health System. Washington DC: National Academy Press; 2000.
17. **Haley RW, Culver DH, White JW, et al.** The efficacy of infection surveillance and control programs in preventing nosocomial infections in US Hospitals. Am J Epidemiol 1985; 121:159–167.
18. Medical devices; patient examination and surgeons' gloves; adulteration—FDA. Final rule. Fed Regist 1990 Dec 12;55(239):51254-51258.
19. **Garner JS.** Guideline for isolation precautions in hospitals. The Hospital Infection Control Advisory Committee. Infect Control Hosp Epidemiol 1996; 17:53–80.
20. **Maki DG, McCormick RD, Zilz MA.** An MRSA outbreak in a SICU during universal precautions; new epidemiology for nosocomial MRSA; downside for universal precautions [abstract]. Proceedings of the Third Decennial International Conference on Nosocomial Infections; 1990 July 31 – Aug 3; Atlanta; 1990. p. 26.
21. **Larson EL, Bryan JL, Adler LM, Blane C.** A multifaceted approach to changing handwashing behavior. Am J Infect Control 1997; 25:3–10.
22. **McGuckin M, Waterman R, Porten L, et al.** Patient education model for increasing handwashing compliance. Am J Infect Control 1999; 27:309–314.
23. Handwashing signal for soap dispensers. http://www.caretek.com/wash_buddy.html.
24. HyGenius Handwashing Control and Monitoring Service. http:// www.hygenius.com.
25. CleanTech System. http://www.meritech.com
26. **Goldmann D, Larson E.** Hand-washing and nosocomial infections. N Engl J Med 1992; 327:120–122.
27. **Moolenaar RL, Crutcher JM, Joaquin VH, et al.** A prolonged outbreak of *Pseudomonas aeruginosa* in a neonatal intensive care unit: did staff fingernails play a role in disease transmission? Infect Control Hosp Epidemiol 2000; 21:80–85.
28. **Salisbury DM, Hutfilz P, Treen L, Bollin GE, Gautam S.** The effect of rings on microbial load of health care workers' hands. Am J Infect Control 1997; 25:24–27.
29. Use patient safety furor as opportunity to educate public on infection control. Hospital Infection Control 2000; 27:17-21.
30. **Cardoso CL, Pereira HH, Zequim JC, Guilhermetti M.** Effectiveness of hand-cleansing agents for removing *Acinetobacter baumannii* strain from contaminated hands. Am J Infect Control 1999; 27:327–331.
31. **Bettin K, Clabots C, Mathie P, Willard K, Gerding D.** Effectiveness of liquid soap vs. chlorhexidine gluconate for the removal of *Clostridium difficile* from bare hands and gloved hands. Infect Control Hosp Epidemiol 1994; 15:697–702.
32. **Faoagali J, George N, Fong J, Davy J, Dowser M.** Comparison of the antibacterial efficacy of 4% chlorhexidine gluconate and 1% triclosan handwash products in an acute clinical ward. Am J Infect Control 1999; 27:320–326.

ADDRESS: Janet M. Serkey, Office of General Counsel, H18, The Cleveland Clinic Foundation, 9500 Euclid Avenue, Cleveland, OH 44195; e-mail serkeyj@ccf.org.