Surgical Head Coverings: A Literature Review 1.2 CE

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Purpose/Goal

To provide the learner with knowledge of best practices related to wearing surgical head coverings in the OR.

Objectives

1. Discuss how surgical personnel may transmit microorganisms to the OR environment.
2. Describe the evidence related to microorganisms in the hair of surgical personnel.
3. Describe the evidence related to head and ear coverings in the OR environment.
4. Discuss how microorganisms found in the hair can be related to surgical site infections (SSIs).

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Lisa Spruce, DNP, RN, CNS-CP, CNOR, ACNS, ACNP, FAAN, has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.

The behavioral objectives for this program were created by Kristi Van Anderson, BSN, RN, CNOR, clinical editor, with consultation from Susan Bakewell, MS, RN-BC, director, Perioperative Education. Ms Van Anderson and Ms Bakewell have no declared affiliations that could be perceived as posing potential conflicts of interest in the publication of this article.

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ABSTRACT

Microorganisms that cause surgical site infections may either be present on the patient's skin or mucous membranes or transmitted to the patient by health care personnel, the environment, or other items in the perioperative setting. This literature review analyzes the evidence used to support the recommendation that perioperative personnel should cover their heads, hair, and ears in the semirestricted and restricted areas. A literature search produced 27 articles related to bacterial shedding from skin and hair, pathogenic organisms present on the hair and ears, and case reports of infectious organisms passed from health care providers to patients. Although there is no conclusive evidence that wearing a head covering can help prevent surgical site infections, the potential benefits to patients when compared with the risks suggest that perioperative team members should cover their heads, hair, and ears in the semirestricted and restricted areas to provide the best possible protection for surgical patients. *AORN J 106 (October 2017) 306-316.*
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Key words: *surgical site infection, surgical attire, head coverings, surgical cap, skin shedding.*

In its annual *National and State Healthcare Associated Infections Progress Report*,[1] the Centers for Disease Control and Prevention announced that there had been a 17% decrease in surgical site infections (SSIs) related to the 10 procedure types tracked between 2008 and 2014, including a 17% decrease in SSIs after abdominal hysterectomy procedures and a 2% decrease in SSIs after colon surgery.[1] Although these data represent improvement, a health care–associated infection point-prevalence survey from 2011 estimated that more than 150,000 SSIs still occur annually in acute care hospitals in the United States.[2]

Surgical site infections can be caused by endogenous microorganisms that are present on the patient's skin or mucous membranes or by exogenous microorganisms from the external environment, health care personnel, surgical instruments, or other materials.[3] Many of these organisms are developing resistance to antibiotics, which makes them particularly dangerous to patients.[4]

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PURPOSE

Maintaining a high level of cleanliness and hygiene in the perioperative setting is important for protecting patients from microorganisms that could cause an SSI. One reason that perioperative personnel wear surgical attire is to reduce the patient's exposure to microorganisms that are shed from the skin and hair. Some members of the perioperative team, however, have questioned the evidence supporting the need to completely cover the hair and ears as a means of promoting environmental cleanliness and protecting the patient from potential harm.[5]

Recommendation III in AORN's "Guideline for surgical attire" states: "Personnel entering the semirestricted and restricted areas should cover the head, hair, ears, and facial hair."[6(p121)] Intervention III.a. further states: "A clean surgical head cover or hood that confines all hair and completely covers the ears, scalp skin, sideburns, and nape of the neck should be worn."[6(p121)] This article reviews and identifies the extant literature that supports the recommendation for clean surgical

head coverings and explores the following question: *Does completely covering the hair and ears of perioperative team members in the OR reduce a patient's risk of developing an SSI?*

LITERATURE SEARCH METHODS

In preparation for an update to AORN's "Guideline for surgical attire" in 2014, a clinical research librarian employed by AORN conducted a literature search on surgical attire of the MEDLINE and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases and the Cochrane Database of Systematic Reviews for meta-analyses, systematic reviews, randomized controlled and nonrandomized trials and studies, case reports, letters, literature reviews, and guidelines. The librarian also searched the Scopus database, although not systematically. The search was limited to literature published in English from January 2008 through June 2013; however, relevant articles published outside this time limit were included because of a lack of current literature. The key words from the initial search were inclusive of terms relevant to all types of surgical attire.[6] Only literature relevant to head coverings was considered for inclusion in this article.

For this literature review, AORN's clinical research librarian performed a supplementary search on head coverings in the same databases to identify any additional sources published from July 2013 through November 2016. The search terms included *cross infection*, *infectious disease transmission*, *professional-to-patient*, *surgical wound infection*, *bacterial load*, *bacteria*, *bacterial infections*, *fungi*, *fungus*, *MRSA*, *MSSA*, *staphylococci*, Staphylococcus, *enterococci*, Enterococcus, *fomites*, *nosocomial*, *operating room*, *operating theater*, *surgical suite*, *ambulatory care facilities*, *surgicenters*, *outpatient surgery*, *surgical attire*, *hood*, *head covering*, *bouffant*, *scrub attire*, *cap*, *skullcap*, *protective clothing*, *hair*, *sideburns*, *dandruff*, *parasitology*, *dermatitis*, *seborrheic*, *epithelial cells*, *skin squames*, *scalp*, and *dermatoses*. Studies not conducted in surgical settings were excluded from this second search.

APPRAISAL METHODS

AORN creates guidelines using the inclusion criteria set by the National Guideline Clearinghouse and develops them based on a systematic review of the evidence. This review includes an additional literature search to identify any evidence that was not included in the initial literature search conducted when the guideline was created. An evidence appraiser and I reviewed and critically appraised each article using the AORN Research and Non-Research Evidence Appraisal Tools.[7,8] From the original 2014 search, we reviewed 40 abstracts, 30 of which were from full-text articles, and included 23 articles in the literature review. From the second search, we reviewed 38 abstracts, 10 of which were from full-text articles, and included four articles in the literature review (Figure 1). We independently evaluated and appraised the literature according to the strength and quality of the evidence and then agreed on an appraisal score for each article (Supplementary Table 1).

FINDINGS

I divided the literature into the following categories based on topic:

- bacterial shedding and airborne contamination,
- organisms in the hair,
- head covering and bacterial count,
- ear covering and bacterial count, and
- case reports.

The evidence is summarized in the following sections.

Bacterial Shedding and Airborne Contamination

The human body and inanimate surfaces in the surgical environment are major sources of microbial contamination and transmission. Reducing a patient's exposure to microorganisms that are shed from the skin and hair of perioperative personnel may reduce the patient's risk for SSIs.[6] Several studies have addressed shedding of microorganisms from the human body. Humans shed up to 10 million particles from their skin every day.[9] Approximately 10% of the shed skin squames carry viable microorganisms.[9] Studies have shown that the natural process of walking releases approximately 1,000 skin scales per minute and that during exercise, between 1,000 and 60,000 particles are released per minute.[10,11]

Several studies have demonstrated that personnel can be linked to contamination of the environment with airborne bacteria because of skin shedding.[12-17] Lidwell et al[18] collected air samples in 15 hospitals during joint surgeries to determine the number of bacteria-carrying particles in the air. They found between 51 and 539 bacteria-carrying particles per cubic meter and noted a strong correlation between infections in the joints and the level of air contamination. Edmiston et al[19] conducted a study that found coagulase-negative staphylococci in 51% of air samples (n = 36) taken within 0.5 to 1 m of surgical incisions and *Staphylococcus aureus* in 39% of the air samples (n = 27) taken within 0.5 to 1 m of surgical incisions. The researchers used pulsed-field gel electrophoresis to match the microorganisms to the DNA of the staff members who were present during the surgical procedure.

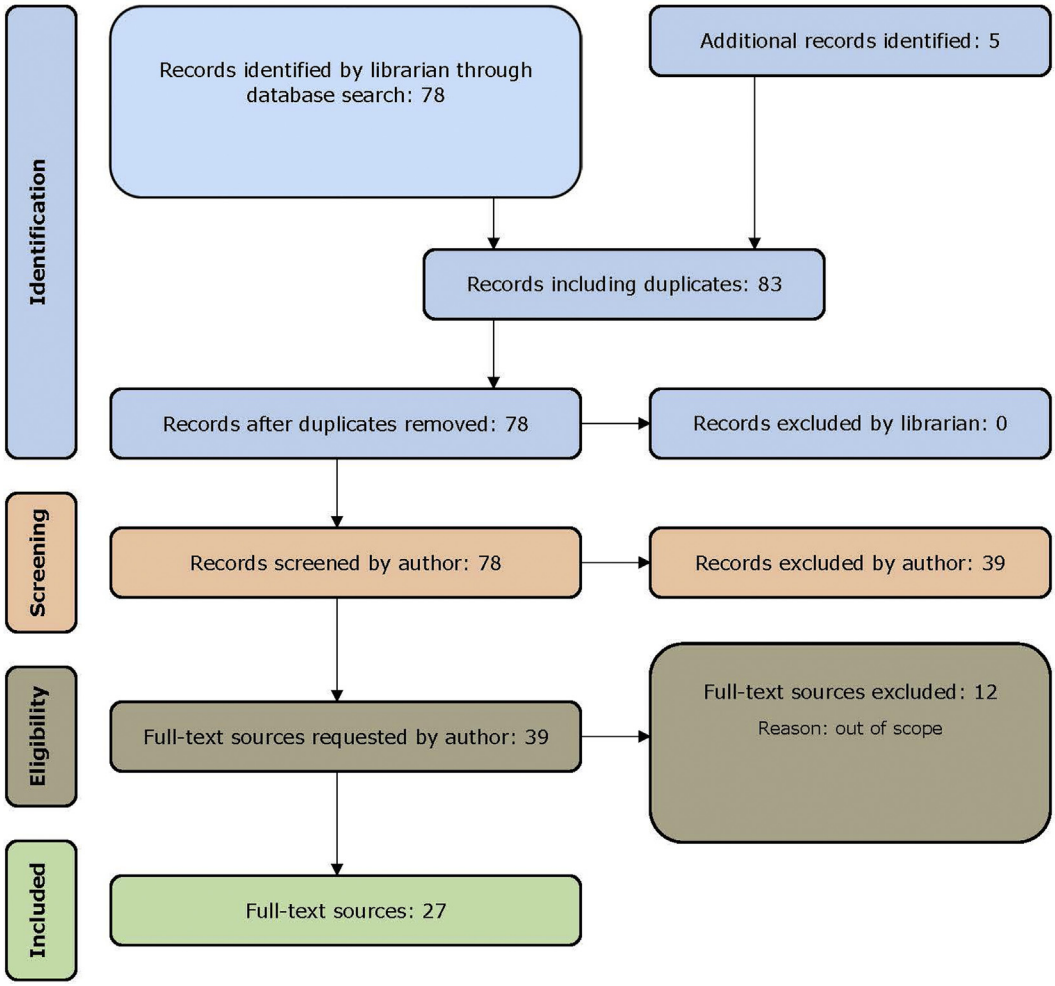

Figure 1. Flow diagram of the combined literature search results from 2014 and 2017. *Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement.* PLoS Med. *2009;6(7):e1000097. doi:*10.1371/journal.pmed.1000097.

Organisms in the Hair

The literature review identified five studies that examined organisms found in the hair.[20-24] An older (greater than 10 years old) study by Noble[20] demonstrated that 10% of individuals who had no contact with a hospital setting carried *S aureus* in their hair. In another older study, Summers et al[21] conducted direct hair sampling and nasal swabbing of both anterior nares and discovered pathogenic organisms in the hair of 72% of outpatients (N = 100), 61% of inpatients (N = 422), and 46% of medical and nursing personnel (N = 164) who participated in the study. The most common pathogen the researchers found was *S aureus*, which they found more often in the participants' hair than in the nares. The researchers also found a significant number of *Escherichia coli* and *Streptococcus viridans*. The researchers recommended that the hair of patients and health care workers be completely covered during minor and major surgical procedures and when dressing surgical incisions.[21]

Mase et al[22] examined the adherence of *S aureus* and *Staphylococcus epidermidis* to human hair by taking human hair from a volunteer and treating it with cultures of *S aureus* and *S epidermidis*. The researchers used detergents common to conventional shampoo products to try to remove the adherent bacterial cells, followed by a thorough rinsing three times with distilled water. The researchers noted that the conventional shampoo treatment removed neither the *S aureus* nor *S epidermidis* cells. They concluded that these organisms were difficult to remove from the hair and could be a source of multidrug-resistant staphylococci and a source of health care–associated infections.

In one study, SSIs were directly tied to health care workers who carried *S aureus* on their hair. Huijsmans-Evers[23] tested 3,039 OR and hospital personnel with a dispersal test to determine who dispersed *S aureus.* The researcher also looked for evidence of postoperative SSIs during a four-year period.

The researcher identified 122 staff members as dispersers of *S aureus*, which was found in the scalp hair of 21.5% of 2,688 individuals whose hair was tested and in the beards and mustaches of 15.5% of the 84 individuals with facial hair. By phage typing all the postoperative incisions that did not heal normally, the researcher determined that nine of the people who were dispersers caused 19 postoperative SSIs.

In 2011, Eisen[24] conducted a literature review that examined the evidence for the effectiveness of different aspects of surgeon's garb, including head coverings, in the outpatient dermatologic surgery setting. Eisen noted that hair can carry pathogenic organisms and that both patients and health care workers carry pathogenic organisms. He concluded that it was unclear whether covering hair to prevent shedding of airborne bacteria was useful in preventing SSIs.

Head Covering and Bacterial Count

Five studies addressed head covering and bacterial count in the OR.[25-29] Collectively, these studies determined that there is bacterial shedding from the hair, ears, and scalp. There is mixed evidence, however, regarding the efficacy of head coverings to contain bacterial shedding and whether completely covering the hair affects SSI rates. McHugh et al[25] and Salassa and Swiontkowski[26] conducted literature reviews examining surgical attire and concluded that there was little evidence that head coverings worn by OR personnel reduced SSI rates. McHugh et al[25] noted that wearing surgical head coverings decreased bacterial contamination of the surgical field, however.

Several researchers examined the efficacy of different types of hair coverings. Ritter et al[27] evaluated microbiologic contamination in the OR when participants used different head coverings (ie, cloth cap, cloth hood, hair spray with no head cover, hair spray with a cloth cap, hair spray with a cloth hood, no cover). The researchers found that the type of head covering (ie, cap, hood, no cover) did not significantly affect the contamination of the OR environment. Hair spray did decrease microbial fallout. Humphreys et al[28] examined the effectiveness of a head covering (ie, hood covering the head, side of the face, and chin) and use of ventilation on bacterial air counts and found that the head covering did not lead to a reduction in bacterial air counts. Friberg et al[29] studied the efficacy of a helmet system and a hood by measuring air counts of bacteria and dust particles and the bacterial sedimentation rate. They concluded that the hood was as effective as the helmet system for bacterial containment: both reduced bacterial contamination of the incision area compared with no head cover. There was no difference in the amount of dust particles whether the head was covered or not. Researchers in these studies continued to recommend complete covering of the hair while in the OR to decrease patient risk.

Ear Covering and Bacterial Count

Owers et al[30] conducted an experiment to identify more accurately which exposed facial areas on perioperative personnel could potentially pose a risk of incision contamination. The researchers swabbed the foreheads, eyebrows, and ears of 20 perioperative staff members using standard microbiology swabs. The results showed a significantly greater number of bacterial colonies cultured from the ears than from the forehead or eyebrows. The researchers recommended that exhaust helmets be worn during arthroplasty procedures or, if this was not possible, that ears be covered by "standard theatre hats,"[30(p231)] because ears are a significant source of shedding that could pose the potential for incision contamination.

Case Reports

Five case reports were found in the literature search.[31-35] Three of the case studies were older (1975–1991) and highlighted outbreaks of SSIs that were caused by health care workers who were carrying pathogenic microorganisms in their hair.[31-33] Dineen and Drusin[31] reported on 12 postoperative SSIs, 11 of which were associated with a single surgeon carrying *S aureus* in his hair. The surgeon was then required to cut his hair short, shampoo daily with povidone-iodine shampoo, and wear an adequate hair covering in the OR. There were no additional outbreaks until the surgeon stopped following these requirements; five new infections were then associated with the surgeon. Mastro et al[32] reported on a prolonged outbreak of group A β-hemolytic streptococcus postoperative SSIs in 20 patients during a three-year period. Culturing of samples from personnel identified a surgical technologist as the carrier. The surgical technologist did not directly participate in the procedures but had entered the OR and was shedding organisms from lesions on her scalp. Richet et al[33] investigated an outbreak of *Rhodococcus bronchialis* sternal-incision infections after coronary artery bypass graft surgery. The researchers tied the strain of *Rhodococcus* causing the infections to that carried by an RN circulator who was found to be colonized with the organism on her scalp, hands, and vagina. The nurse spread the organism by touching her scalp before touching the patients.

Two more recently published case studies both highlighted the same outbreak of SSIs that were caused by a surgeon who was carrying a new strain of mycobacteria (*Mycobacterium jacuzzii*) on his facial skin, eyebrows, and hair; he had contracted the bacteria from a hot tub.[34,35] This outbreak involved 10

patients who underwent breast implant surgery at an outpatient surgical center in Israel during a two-month period. Eight of the women had the same surgeon and developed SSIs. After the outbreak, the surgeon began using a shampoo containing triclosan; subsequent cultures were negative for the organism. The infections had significant consequences for the patients. Some patients had to take a prolonged course of antibiotics or undergo debridement or subsequent surgery to replace or remove their implants, and two underwent several surgeries for the development of fistulas. This case demonstrates the possibility of human-to-human transfer of potentially dangerous organisms and the importance of decreasing patient exposure to the skin and hair of perioperative team members.

DISCUSSION

There is no conclusive evidence that hair covering prevents SSIs. Most evidence surrounding surgical head coverings is older than 10 years, and no study focused on head coverings has been conducted in the past five years. No randomized controlled trials scientifically demonstrate that there is a direct correlation between hair shedding and SSIs; it would be difficult to conduct randomized controlled trials on this topic because the patients would be placed at risk in this type of study. The literature supports the hypothesis that there is a risk to patients: SSI outbreaks directly related to the shedding of pathogenic organisms from health care workers' skin and hair have occurred.

The evidence is clear that human beings are colonized with many bacteria,[9-11] that microorganisms are shed into the air,[12-19] and that airborne bacteria can be a cause of SSIs.[23,31,32,34,35] Hair contains microorganisms and potentially pathogenic bacteria that have been implicated in SSIs.[20-24] These organisms are difficult to remove with conventional shampooing.[22] There is conflicting evidence as to whether hair covering reduced the amount of bacteria present in the air, but researchers have continued to recommend complete covering of the hair in the surgical setting.[25-29] One study that focused on the bacterial contamination of the ears recommended complete covering of the ears in the surgical setting.[30] Case studies demonstrate that human-to-human transmission of bacteria can be directly attributed to SSI outbreaks.[31-35] Based on the collective evidence, covering the hair and ears to prevent shedding seems prudent to minimize the risk of harm to patients, and AORN therefore continues to recommend completely covering the hair and ears when in semirestricted and restricted areas.[6]

Multiple organizations in addition to AORN recommend full head coverings in the perioperative setting. The Centers for Medicare & Medicaid Services Infection Control Worksheet, which is used to determine compliance with the Infection Control Conditions of Participation, states that surgical caps or hoods that cover all head and facial hair must be worn in semirestricted and restricted areas.[36] The World Health Organization highly recommends that surgical personnel cover their hair during surgery, but it does not make specific recommendations about the type of hair covering.[37] The Association of Surgical Technologists states that the surgical head cover should cover all head and facial hair and recommends against wearing any head covering that does not completely cover the hair.[38] In their 2017 guideline on preventing SSIs, the Centers for Disease Control and Prevention state that a new disposable or hospital-laundered head covering that fully covers all hair on the head and all facial hair must be worn when entering the OR.[39]

Clinical Implications

If patient safety is the number-one priority for health care facilities, health care leaders should enforce the covering of perioperative team members' hair and ears to help decrease the possible risk to patients. Although the evidence is older, there also has been no recent evidence to disprove the findings of the older evidence. When developing clinical practice guidelines, the benefits of a recommendation should be assessed against any harms that it could cause. Perioperative team members covering their hair and ears provide potential benefits to patients, and it causes no harm to either the patients or the health care providers to implement and enforce this practice.

Future Research

Future research should be conducted to determine whether wearing surgical head coverings affects bacterial contamination of the OR environment that could contribute to the development of SSIs.

CONCLUSION

This literature review reveals that there has been no recent research conducted on surgical head coverings and their effect on SSI rates. There is no conclusive evidence that covering the hair prevents SSIs. The literature has established that there is a serious risk to patients if they are exposed to the skin and hair of individuals working in the perioperative setting, and case studies have demonstrated a causative relationship between exposure and SSIs. Therefore, to decrease patient risk and promote patient safety, perioperative team members should fully cover their hair to contain hair and skin squames.

SUPPLEMENTARY DATA

The supplementary material associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.aorn.2017.08.001.

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Continuing Education: Surgical Head Coverings: A Literature Review 1.2 CE

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PURPOSE/GOAL

To provide the learner with knowledge of best practices related to wearing surgical head coverings in the OR.

OBJECTIVES

1. Discuss how surgical personnel may transmit microorganisms to the OR environment.
2. Describe the evidence related to microorganisms in the hair of surgical personnel.
3. Describe the evidence related to head and ear coverings in the OR environment.
4. Discuss how microorganisms found in the hair can be related to surgical site infections (SSIs).

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QUESTIONS

1. One reason that perioperative personnel wear surgical attire is to reduce the patient's exposure to microorganisms that are shed from the skin and hair.
   a. true b. false

2. Humans shed up to _____ million particles from their skin every day; approximately _____ of the shed skin squames carry viable microorganisms.
   a. 5; 10% b. 10; 10%
   c. 10; 5% d. 5; 5%

3. During the natural process of walking, humans shed approximately _____ skin scales per minute.
   a. 1,000 b. 10,000
   c. 60,000 d. 20,000

4. In a study by Mase et al, after treating human hair with cultures of *Staphylococcus aureus* and *Staphylococcus epidermidis*, detergents used in conventional shampoo products
   a. removed *S aureus.*
   b. removed *S epidermidis.*
   c. did not remove *S aureus* or *S epidermidis.*
   d. removed *S aureus* and *S epidermidis.*

5. Huijsmans-Evers tested 3,039 OR and hospital personnel with a dispersal test for *S aureus* and tracked postoperative SSIs and identified *S aureus* in participants'
   1. beards.
   2. scalp hair.
   3. mustaches.
   4. axilla.
   a. 1 and 3 b. 1, 2, and 3
   c. 1, 3, and 4 d. 1, 2, 3, and 4

6. In a study examining different types of head coverings, Ritter et al found that _____ decreased microbial fallout.
   a. cloth hoods b. hair spray
   c. cloth caps d. no head cover

7. Owers et al swabbed different parts of the heads of 20 perioperative staff members and the greatest number of bacterial colonies were cultured from the
   a. forehead. b. scalp.
   c. eyebrows. d. ears.

8. Outbreaks of SSIs have been caused by health care workers carrying microorganisms in their hair, including
   1. *Mycobacterium tuberculosis.*
   2. *S aureus.*
   3. group A β-hemolytic streptococcus.
   4. *Streptococcus pyogenes.*
   5. *Rhodococcus bronchialis.*
   6. *Mycobacterium jacuzzii.*

   a. 1, 3, and 5 b. 2, 4, and 6
   c. 2, 3, 5, and 6 d. 1, 2, 3, 4, 5, and 6

9. There is no conclusive evidence that hair covering prevents SSIs. The literature, however, supports the hypotheses that there is a risk to patients and that SSI outbreaks have occurred that are directly related to the shedding of pathogenic organisms from health care workers' skin and hair.

   a. true b. false

10. AORN recommends completely covering the hair and ears when in the semirestricted and restricted areas based on evidence that
    1. human beings are colonized with many bacteria.
    2. airborne bacteria can be a cause of SSIs.
    3. microorganisms are shed into the air.
    4. microorganisms in the hair can be difficult to remove with conventional shampoo.
    5. hair contains microorganisms that have been implicated in SSIs.
    6. human-to-human transmission of bacteria can be directly attributed to SSI outbreaks.

    a. 1, 3, and 5 b. 2, 4, and 6
    c. 2, 3, 5, and 6 d. 1, 2, 3, 4, 5, and 6

Continuing Education: Surgical Head Coverings: A Literature Review 1.2 CE

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OBJECTIVES

To what extent were the following objectives of this continuing education program achieved?

1. Discuss how surgical personnel may transmit microorganisms to the OR environment.
   Low 1. 2. 3. 4. 5. High
2. Describe the evidence related to microorganisms in the hair of surgical personnel.
   Low 1. 2. 3. 4. 5. High
3. Describe the evidence related to head and ear coverings in the OR environment.
   Low 1. 2. 3. 4. 5. High
4. Discuss how microorganisms found in the hair can be related to surgical site infections (SSIs).
   Low 1. 2. 3. 4. 5. High

CONTENT

5. To what extent did this article increase your knowledge of the subject matter?
   Low 1. 2. 3. 4. 5. High
6. To what extent were your individual objectives met?
   Low 1. 2. 3. 4. 5. High
7. Will you be able to use the information from this article in your work setting?
   1. Yes 2. No
8. Will you change your practice as a result of reading this article? (If yes, answer question #8A. If no, answer question #8B.)

8A. How will you change your practice? (*Select all that apply*)

1. I will provide education to my team regarding why change is needed.
2. I will work with management to change/implement a policy and procedure.
3. I will plan an informational meeting with physicians to seek their input and acceptance of the need for change.
4. I will implement change and evaluate the effect of the change at regular intervals until the change is incorporated as best practice.
5. Other: _____

8B. If you will not change your practice as a result of reading this article, why? (*Select all that apply*)

1. The content of the article is not relevant to my practice.
2. I do not have enough time to teach others about the purpose of the needed change.
3. I do not have management support to make a change.
4. Other: _____

Supplementary Table 1. Summary of the Literature Evidence

Authors (Date)	Evidence Type	Sample and Setting (Country of Origin)	Study Findings	Limitations	Evidence Level and Quality[a]
Davies and Noble[1] (1962)	Nonexperimental, descriptive	50 air samples from obstetric, medical, and surgical wards (United Kingdom)	• A large number of skin cells from human carriers were present in the air, demonstrating skin shedding of bacteria present on desquamated skin	Study is older and was not conducted in a perioperative setting	III B
Dineen and Drusin[2] (1973)	Case report	2 postoperative SSI case reports in a hospital setting (United States)	• A surgeon was associated with 11 severe postoperative SSIs, and a staff nurse on the hospital ward was associated with 5 minor SSIs	Older case report	V A
Edmiston et al[3] (2005)	Nonexperimental, descriptive	70 air samples from vascular surgical procedures during an 18-mo period (United States)	• Coagulase-negative *Staphylococcus* were recovered from 86% of the samples; 51% from within 0.5-1 m of the surgical incision • *S aureus* was recovered from 64% of air samples; 39% within 0.5-1 m of the surgical incision • 11 perioperative team members were shedding 8 strains of *S epidermidis* and 2 strains of *S aureus* from their nares	Air contamination was not tied to surgical infection rates or risk; older study	III B
Eisen[4] (2011)	Literature review	N/A	• Hair can carry pathogenic organisms, but the usefulness of covering hair is unclear	Small number of cited studies on the topic	V A
Friberg et al[5] (2001)	Quasi-experimental	30 sham surgeries testing types of head coverings (Sweden)	• Covering the hair with helmets and hoods was found to be as effective at containing bacteria as helmet aspirator systems	Did not correlate hair covering with SSIs; older study	II B
Howard and Hanssen[6] (2007)	Literature review	N/A	• The authors discuss the importance of minimizing bacterial contamination in the	N/A	V B

(continued)

Supplementary Table 1. *(continued)*

Authors (Date)	Evidence Type	Sample and Setting (Country of Origin)	Study Findings	Limitations	Evidence Level and Quality[a]
			OR to combat the laxity of adhering to basic principles of antisepsis		
Humphreys et al[7] (1991)	Quasi-experimental	Bacterial sampling of the air surrounding 6 participants wearing head gear with ventilation, ventilation with no head gear, head gear with no ventilation, and no ventilation nor head gear (United Kingdom)	• The wearing of head gear was not associated with a reduction in air bacterial counts, but counts were lower with ventilation	Variation of air counts between methods; simulated environment; small sample size; not correlated with SSIs; older study	II C
Huijsmans-Evers[8] (1978)	Quasi-experimental	3,039 participants tested for dispersal of bacteria (the Netherlands)	• 122 participants dispersed *S aureus* from their scalps and beards; participants with skin lesions dispersed more • 9 dispersers caused 19 postoperative SSIs	Single facility; older study	II B
Lidwell et al[9] (1983)	Nonexperimental	Air sampling from first incision to final closure in 19 hospitals during joint surgeries (United Kingdom)	• There was a strong correlation between the air contamination and the joint sepsis rate	Older study	III B
Mase et al[10] (2000)	Quasi-experimental	Human hair obtained from a volunteer (Japan)	• Human hair was treated with a culture of *S aureus* and *S epidermidis*, which could not be removed by repeated washing with detergents	Hair from only 1 volunteer; not correlated with SSIs; older study	II B
Mastro et al[11] (1990)	Case report	An investigation of a prolonged outbreak of 20 postoperative SSIs during a 3-y period (United States)	• The outbreak was caused by human carriers colonized with and shedding group A β-hemolytic streptococcus	Single site; older case report	V B
McHugh et al[12] (2014)	Literature review	N/A	• There was little evidence that head covering reduced SSI rates, but it did decrease contamination of the surgical field	Limited evidence	V A

Supplementary Table 1. *(continued)*

Authors (Date)	Evidence Type	Sample and Setting (Country of Origin)	Study Findings	Limitations	Evidence Level and Quality[a]
Nelson[13] (1987)	Expert opinion	N/A	• The article emphasized airborne contamination of ORs	Low level of evidence; older article	V C
Noble[14] (1966)	Quasi-experimental	1,250 hair samples tested for the growth of *S aureus* (United Kingdom)	• The study demonstrated that people can carry *S aureus* on their hair	Older study; not correlated with SSIs	II B
Noble[15] (1975)	Nonexperimental, observational	38 men and 34 women tested for dispersing bacteria into the air (United Kingdom)	• Skin cells were dispersed into the air, but few pathogens were found • Men dispersed more skin cells than women	Older study; not correlated with SSIs	III B
Owers et al[16] (2004)	Quasi-experimental	20 members of the OR staff had their foreheads, eyebrows, and ears cultured (United Kingdom)	• A significantly greater number of colonies were cultured from the ears than from the forehead or eyebrows	Small sample size from a single facility; not correlated with SSIs; older study	II B
Rahav et al[17] (2006)	Case report, case-control study	An outbreak of 15 SSIs in women undergoing insertion of breast implants and a subsequent case-control study that included all women who underwent breast surgeries in the same facility (Israel)	• 1 surgeon who was carrying a new strain of mycobacteria was the cause of the outbreak • The case report identified the colonization of human skin and human-to-human transmission	Single facility and 1 specific patient population may not be generalizable; older study	III A
Richet et al[18] (1991)	Case report	An SSI outbreak in 1 facility traced to a perioperative nurse (United States)	• 7 sternal-incision infections were identified in patients undergoing open heart surgery during a 7-mo period • Outbreak was tied to a perioperative nurse who was colonized with the bacteria causing the SSIs	Single facility and 1 specific patient population may not be generalizable; older case report	V A

(continued)

Supplementary Table 1. *(continued)*

Authors (Date)	Evidence Type	Sample and Setting (Country of Origin)	Study Findings	Limitations	Evidence Level and Quality[a]
Ritter et al[19] (1975)	Quasi-experimental	30 individuals were tested in various environmental conditions in the OR to determine airborne contamination (United States)	• The major source of environmental contamination in the OR is people	Older study; controlled environmental conditions; may not be generalizable	II B
Ritter et al[20] (1980)	Quasi-experimental	8 participants tested with 6 combinations of head coverings (United States)	• The types of head cover used did not significantly affect environmental contamination • Hairspray use decreased microbial fallout	Small sample size; not correlated with SSIs; older study	II B
Salassa and Swiontkowski[21] (2014)	Literature review	N/A	• There was mixed evidence regarding the efficacy of head coverings to contain bacterial fallout from the ears, scalp, and hair	Did not include studies that determined whether hair covering reduces SSI rates	V A
Scheflan and Wixtrom[22] (2016)	Case report	Report of the Rahav et al[17] case report focusing on the aspects of infectious disease (Israel)	• The report highlights the human-to-human transfer of mycobacteria	N/A	V A
Sciple et al[23] (1967)	Quasi-experimental	3 healthy participants studied once a week for 3 wk to determine bacterial shedding (United States)	• Viable particles were recovered from all 3 participants in variable numbers	Small sample size; laboratory setting; not tied to SSI rates; older study	II B
Stocks et al[24] (2010)	Nonexperimental	22 hip or knee arthroplasty procedures performed in 2 ORs had air samples taken to determine the density of airborne particles at the surgery sites and various OR personnel behaviors on the amount of airborne bacteria (United States)	• Particle and colony-forming units increased with longer surgery duration and more staff members present	Single facility; not tied to SSI rates	III A

Supplementary Table 1. *(continued)*

Authors (Date)	Evidence Type	Sample and Setting (Country of Origin)	Study Findings	Limitations	Evidence Level and Quality[a]
Summers et al[25] (1965)	Quasi-experimental	Hair and nares of 100 outpatients, 422 inpatients, and 164 nursing and medical personnel were sampled to determine the presence of *S aureus* (United Kingdom)	• Bacteria were grown from the hair of all the participants • *S aureus* was the most common isolated pathogen	Older study; not tied to SSI rates	II B
Walter and Kundsin[26] (1973)	Expert opinion	N/A	• Emphasized the role of the environment and airborne contamination as a potential hazard to patients	Older study	V B
Whyte et al[27] (1976)	Quasi-experimental	2 men and 1 woman tested for dispersal of bacteria while exercising (United States)	• All participants dispersed bacteria, but amounts varied according to the individual, type of clothing worn, and time of sampling	Small sample size; laboratory study; not tied to SSI rates; older study	II B

NOTE. Studies are identified as "older" if greater than 10 years old.

N/A = not applicable; SSI = surgical site infection; *S aureus* = *Staphylococcus aureus; S epidermidis* = *Staphylococcus epidermis.*

[a] The AORN Research and Non-Research Evidence Appraisal Tools were used to appraise the quality of the evidence. *Evidence rating. AORN.* https://www.aorn.org/guidelines/about-aorn-guidelines/evidence-rating. *Accessed June 27, 2017.*

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