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Major Article

Important interventions in the operating room to prevent bacterial contamination and surgical site infections

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Key Words:

Infection control
 Perioperative
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 Cross-infection

Background: The aim of this study was to explore interventions that Swedish operating room (OR) nurses considered important for the prevention of bacterial contamination and surgical site infections (SSIs).

Methods: A web-based cross-sectional survey with an open-ended question was answered by OR nurses and analyzed using summative content analysis and descriptive statistics.

Results: The OR nurses (n = 890) worked within 11 surgical specialties and most of them worked at university hospitals (37%) or county hospitals (53%). The nurses described twelve important interventions to prevent bacterial contamination and SSI: skin disinfection (25.9%), the OR environment (18.2%), aseptic technique (16.4%), OR clothes (13.4%), draping (9.8%), preparation (6.1%), dressing (3.6%), basic hygiene (3.4%), normothermia (2.1%), communication (0.7%), knowledge (0.3%), and work strategies (0.2%).

Discussion: Skin disinfection was considered the most important intervention in order to prevent bacterial contamination and SSI. The responses indicated that many OR nurses believed the patients' skin to be sterile after the skin disinfection process. This is not a certainty, but skin disinfection does significantly decrease the amount of bacterial growth.

Conclusions: This study shows that many OR nurses' interventions are in line with recommendations. Although, knowledge regarding the effect of skin disinfection needs further research, and continued education.

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BACKGROUND

Patient safety and prevention of surgical site infections (SSIs) are of international concern.^{1,2} Swedish law (SFS:2017:30) states that patients should be given health care with good standards on equal terms.³ The clinical work in Swedish operating rooms (ORs) is designed to have high hygiene standards⁴ in order to prevent bacterial contamination. SSIs are a major problem in terms of suffering for

patients and high costs for society.² In Sweden the healthcare system is primary funded through general taxation and it holds an explicit public commitment to ensure the health of all citizens. The responsibility for health and medical care lies within 21 regions. A great number of publicly and privately owned health and medical care facilities are to be found, and the patients are free to contact specialists directly but the majority are referred to the specialized care by the healthcare centers.⁵ According to a review published in 2012 the hospitals in Sweden are grouped into country hospitals (approximately 70 hospitals), and university hospitals (n = 7). The private healthcare sector is relatively small, consisting of 6 hospitals.⁶

There are international differences concerning which profession is responsible for patient preparation in terms of skin disinfection and draping of the patient within the OR. In Sweden, the OR nurse is responsible for hygiene procedures including the cleanliness of the OR, ventilation, sterile materials and instruments, patient preparation (skin disinfection and draping), and maintaining aseptic technique during surgery. OR nurses in Sweden have a minimum of 4 years of education, comprising a 3-year bachelor's degree in nursing followed

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by a 1-year OR nursing program which includes both theoretical courses and clinical rotation and results in a professional title and a master's degree.⁷

OR departments use many strategies to prevent SSIs, such as compliance with national guidelines. Swedish OR nurses have a Handbook for Health Care which guides them in using and implementing the correct strategies and interventions.⁴ However, in clinical work the guidelines and local regulations that are determined in order to prevent bacterial contamination may sometimes be neglected. The underlying reasons for not conforming to guidelines might lie within the individuals' opinions on what is important. SSIs have historically decreased, but despite enhancements, there is much to learn about the different factors involved in decision making during clinical work.

The aim of this study was to explore which interventions Swedish OR nurses considered to be important for the prevention of bacterial contamination and SSIs.

METHOD

Study design and participants

This is the second part of a descriptive cross-sectional survey. In December 2015 and January 2016, information about the study along with a link to a web-based survey was distributed by e-mail to 2,264 of the approximately 4,000 OR nurses in Sweden. The e-mail addresses of the remaining nurses could not be found due to the hospitals' lack of response. The inclusion criterion was having a specialist degree as an OR nurse, and the exclusion criterion was no longer working actively as an OR nurse. All participants are hereafter referred to as nurses.

Questionnaire

Results from the first part of the survey, which contained 38 closed-ended questions, were published in 2018.²⁶ This second part had one open-ended question. The questionnaire as a whole addressed the daily activities nurses performed to prevent bacterial growth, such as preparing the patient's skin (n = 12 items), maintaining the patient's temperature (n = 10 items), and preparing OR materials (n = 10 items). The questionnaire also included 6 sociodemographic questions covering age, type of hospital, work experience, educational level, surgical specialty, and what region of Sweden they worked in. The open-ended question which forms the focus of the present analysis was "Which of the clinical interventions that you perform do you consider important in preventing surgical site infection?"

Ethical conduct of research

The study was performed in accordance with the Helsinki Declaration.⁸ Ethical approval was not required according to Swedish law concerning ethical review of research involving humans, since the study did not involve patients, and no sensitive data were elicited.⁹ That is, no information was obtained regarding political opinions, ethnicity, religion, union membership, philosophy, health, or sexual preferences. An introduction letter was included to outline the survey objective and inform respondents that participation was voluntary. By answering the questionnaire, the nurses agreed to participate. The data were stored in data files in depersonalized form, and the results are presented at group level with no possibility of individual identification.

Data analysis

Summative content analysis

The answers to the open-ended question were analyzed using summative content analysis. This type of analysis combines quantitative and qualitative analysis, including a latent analysis, thus going beyond the mere word count of a strict quantitative content analysis.¹⁰ The text was hand searched for words or combinations of words describing interventions that the nurses performed clinically and stated to be important in preventing bacterial contamination or SSI. The frequency of each identified word and/or combination of words was calculated in order to determine how often they occurred. Each intervention was counted as a single unit, meaning that even if a nurse used several words or combinations of words associated with the same intervention, they were all considered a single unit. Frequency counts by type of intervention were calculated and compared to the total number of words coded for each category. By counting the words in the data, patterns were identified and codes were contextualized. The codes were scrutinized for differences and similarities, resulting in 12 subcategories representing a manifest pattern. A continual comparison of the codes and the content of each subcategory was conducted throughout the analysis.

The codes and the 12 subcategories were also analyzed in a more latent manner. During this phase, the subcategories were scrutinized in order to find relationships between them, resulting in 3 categories each comprised of subcategories sharing a common meaning. All 3 authors conducted an individual analysis of the text, and disagreements between their analyses were discussed until consensus was reached.

Statistical analysis

Data were analyzed manually or by using descriptive statistics computed in version 22.0 of the SPSS software package (SPSS Statistics; IBM, Armonk, NY, USA). Descriptive statistics were calculated for all variables in terms of mean, number, percentage, and standard deviation.

RESULTS

Participants

In total, 967 of 2,264 nurses answered the questionnaire (response rate: 43%). Of these 967 nurses, 77 were excluded due to not working as OR nurses but rather, for example, as chief of staff. The nurses represented more than eleven different surgical specialties including orthopedic, thoracic, vascular, and general surgery (Table 1).

FINDINGS

The latent analysis resulted in 3 categories covering the manifest content included in the 12 subcategories and 3,522 codes (Table 2): *infection control*, *preventing indirect contamination*, and *the surgical team*. Since the category *infection control* included 57.7% of the total number of codes (n = 2033), it was considered the most important way for the nurses to prevent bacterial contamination and SSI. This was followed by 41.1% *preventing indirect contamination* (n = 1,448 codes), and finally 1.2% *the surgical team* (n = 41 codes).

A few nurses (n = 19) said it was difficult to rank anything as more important than anything else when it came to bacterial contamination and SSI. These nurses believed that everything was equally important. One of them described:

Table 1
Characteristics of the responding operating room nurses in Sweden (n = 890)

	Mean (SD)
Age	47 (9.8)
Y of experience	16 (12.0)
	n (%)
OR nurses, male	57 (6.4)
OR nurses, female	833 (93.6)
Level of education	
Licensed OR nurse	455 (51.0)
Licensed OR nurse BSc	196 (22.0)
Licensed OR nurse MSc or higher	239 (27.0)
Type of hospital	
University hospital	332 (37.2)
County hospital	475 (53.4)
Private hospital	22 (2.5)
Other*	61 (6.9)
Surgical Specialty	
Orthopaedic surgery	285 (32.0)
General surgery	283 (31.8)
Thoracic surgery	70 (7.9)
Gynaecologic surgery	61 (6.9)
Ear, nose, and, throat surgery	50 (5.6)
Urologic surgery	31 (3.5)
Neurologic surgery	30 (3.4)
Hand surgery	23 (2.6)
Vascular surgery	16 (1.8)
Plastic surgery	15 (1.7)
Eye surgery	14 (1.5)
Other*	12 (1.3)

OR, operating room; SD, standard deviation.

*Missing information

“All actions together are very important. If you deviate from your routine, the risk of a postoperative surgical site infection is greater.”
(nurse no. 608)

Infection control

The 5 subcategories *skin disinfection*, *aseptic technique*, *draping*, *dressing*, and *normothermia* were all interpreted as interventions undertaken by the nurses in order to uphold infection control and thus prevent bacterial contamination and the emergence of SSI.

Table 2

An overview of the categories, subcategories, exact number, and percentage of codes including examples of codes showing interventions performed clinically by operating room (OR) nurses in order to prevent bacterial contamination and surgical site infection (SSI)

Category	Subcategory	Number of codes (n)	Percentage of all codes (%)	Examples of codes
Infection control	Skin disinfection	911	25.9	Descutan, preoperative skin disinfection and done in an appropriate manner, letting the disinfectant air dry, soaked cotton swabs, no infected wounds preoperatively
	Aseptic technique	578	16.4	Maintaining sterility, replacing unsterile material, correct implant handling, wiping off blood from the sterile goods
	Draping	345	9.8	Thorough sterile draping with no gaps, leaving as little skin uncovered as possible, using double layers of draping
	Dressing	126	3.6	a dressing that is tight and adapted to the nature of the wound, adhere draping as soon as possible, dense, and functional draping
	Normothermia	73	2.1	maintaining the body temperature, warm blankets, minimizing temperature loss, keeping the patient warm
	Total	2,033	57.7	
Preventing indirect contamination	OR environment	642	18.2	Minimizing the number of door openings, using as few personnel as possible, no running around, optimized ventilation
	OR clothes	473	13.4	Proper dressing, mask, helmet, surgical gown, sterile gloves, changing gloves
	Preparation	214	6.1	Covering the sterile goods, checking the instruments, ensuring undamaged packaging
	Basic hygiene	119	3.4	Hand disinfection, following basic hygiene routines
	Total	1,448	41.1	
The surgical team	Communication	24	0.7	Both written and verbal information, informing the team, good communication with colleagues
	Knowledge	9	0.3	Knowledge of postoperative infections, keeping yourself updated, informed about the procedure
	Work strategies	8	0.2	Optimizing the surgical time, working effectively, working without stress
		41	1.2	
	Total	3,522	100	

Skin disinfection

Skin disinfection was the intervention that was described the most frequently, with almost 26% of all codes belonging to this subcategory. It was therefore interpreted as the intervention that the nurses considered most important for preventing bacterial contamination and SSI. The nurses described disinfecting the skin using different types of skin disinfectant not only preoperatively but also postoperatively, just before the dressing was applied.

“Skin disinfection with alcohol, on a large enough area, with predetermined strokes and appropriate pressure and time. Let the skin air dry.” (nurse no. 56)

The performance of the skin disinfection was described using terms such as “thorough,” “adequate,” “careful,” “correctly,” “mechanical,” “according to guidelines,” “methodically,” and “effective.” Other actions undertaken by the nurses interpreted as being connected to skin disinfection were preoperative cutting of hair and the inspection of the patient’s skin, checking for example that there were no open wounds or eczema lesions in the surgical area.

Aseptic technique

The nurses described using an aseptic technique in order to prevent bacterial contamination and SSI; 578 of the 2,033 codes related to this subcategory. Aseptic technique was maintained during surgery by keeping the sterile goods sterile, removing the draping after the dressing was applied, supervising other persons in the surgical team to ensure that they did not contaminate anything in the sterile field, and quickly replacing any contaminated item with a new, sterile one. One of the nurses described this as follows:

“Vigilant supervision during surgery so that nothing becomes unsterile, and if so ensure that it [the unsterile item] is replaced and any unsterile areas are disinfected and draped over.” (nurse no. 78)

Along with this, the nurses described additional interventions that they performed in order to uphold an aseptic technique: the use of antibacterial sutures, avoiding touching implants, a thorough preoperative hand disinfection of their own hands including the checking

of other team members' hand disinfection, and cleaning the sterile goods during surgery in order to avoid bacterial growth.

Draping

The draping subcategory included several interventions (n = 345) that the nurses described undertaking to prevent bacterial contamination and SSI. The use of incision drapes to protect the surgical area and transparent plastic film to cover open wounds was considered important, as was fastening the sterile draping close to the surgical area in order to leave as little as possible of the patient's skin uncovered. The nurses believed that it was important that the draping was employed correctly, and that it should stay in place throughout the procedure. They described this with statements such as *"the draping of the surgical area is tight and lasts throughout the surgery"* (nurse no. 956), *"constantly checking the draping throughout the surgery and reinforcing it if needed"* (nurse no. 780), and *"that it (the draping) fits correctly and tightly"* (nurse no. 885).

Dressing

A properly attached dressing was the subject of 3.6% of the codes. According to the nurses, important aspects included choosing a dressing suitable for that specific surgery, applying the dressing in a sterile manner, and applying the dressing closely and tightly against the skin with no creases that could allow bacteria to contaminate the surgical wound.

"A dressing that fits well and does not need to be changed in the first place, and not starting to loosen the draping until the dressing is applied" (nurse no. 208)

Some of the nurses also stressed the importance of choosing a dressing that was gentle and appropriate for sensitive skin, and that would not cause blisters or eczema. They also believed that it was important for the dressing to be left in place for a long period of time postoperatively, and that it was better to reinforce the dressing than to change it.

Normothermia

The subcategory of maintaining the patient's body temperature during surgery contained only 2.1% of the codes, and so was the least mentioned intervention interpreted as belonging to infection control. The interventions described by the nurses included heating blankets, blankets that were run through with a warm airflow, pre-heated skin disinfectant, covering the patient's body with duvets, and warm fluids. This was described as a shared responsibility, performed in collaboration with the registered nurse anesthetist in the surgical team.

Preventing indirect contamination

Preventing indirect contamination involved the nurses in controlling interventions in order to decrease the risk of bacterial contamination and SSI. These were subcategorized as *OR environment*, *OR clothes*, *OR preparation*, and *basic hygiene*.

OR environment

Regarding the OR environment, the nurses considered it important for the hygiene level in the OR to be satisfactory and the doors of the OR to be kept closed; or, at least, opened only when absolutely necessary during preparation for surgery and the surgery itself. This subcategory was the second largest of all, consisting of 642 codes (18.2%). One example given of appropriate practice was that when there was a lack of an instrument in the OR, the personnel in the OR

should use the phone to ask someone outside the OR to bring the missing instrument instead of opening the doors and fetching it themselves.

"Use the phone in the OR as your means of communication [with staff outside of the OR], do not run in and out. Plan your work and make sure that the equipment you might need is in the OR, use reach-through cabinets as much as possible." (nurse no. 629)

Interventions aimed at minimizing bacterial shedding included minimizing the number of staff members and the equipment in the OR, as well as optimizing the ventilation and moving around slowly in the OR.

OR clothes

The subcategory of OR clothes contained 473 codes (13.4%) and described interventions connected to the clothes that were worn in the OR. The nurses believed that it was important for all personnel working in the OR to be dressed appropriately in tightly woven clothes or clean air suits, including using a mask and helmet, with sterile gowns and gloves for the personnel actively working with or around the surgical area, such as the surgeons, assistants, or nurses. Some of them stated that the work suits they used should be made from a tightly woven fabric or made from disposable materials for 1-time use, in order to minimize bacterial shedding and thereby prevent bacterial contamination and SSI.

Other strategies included wearing a sterile surgical gown and gloves, and using double sterile gloves in order to prevent bacterial cross contamination if one of the gloves was punctured or torn. It was important that the sterile gloves were changed not only if they were punctured or torn, but also if the surgery continued for a long period of time (ie several hours), or before handling implants or attaching the dressing.

"You should change the gloves after cementation, contact with infected material, and if they are heavily soiled." (nurse no. 54)

OR preparation

The nurses described several interventions (n = 214 codes) connected to preparation, such as checking that the instruments were sterilized before taking them out of their packaging, and ensuring that the packaging was undamaged. This was done by *"checking the date marking, packaging, and sterilization indicators on sterile material"* (nurse no. 374). The nurses stated that they felt it best to set up and cover the sterile goods before the patient arrived at the OR if possible, and that it was important for the preparation to be done in a sterile manner.

Basic hygiene

Adhering to basic hygiene routines was mentioned 119 times, giving a total of 3.4% of all codes. This included following local routines as well as written guidelines. The nurses stated that it was important for basic hygiene to be upheld by all members of the OR staff: *"The importance of sterility throughout the surgery, and being responsible for ensuring that everyone in the OR follows the hygiene regulations"* (nurse no. 650). Basic hygiene also included thorough hand disinfection.

The surgical team

Having a well-functioning surgical team was the smallest category, comprising only 41 codes (1.2%). Nevertheless, it contained important interventions described by the nurses in the form of *communication*, *knowledge*, and *work strategies*.

Communication

Only 24 of the 3,522 codes belonged to the communication subcategory. Communication included both communicating with other members in the surgical team while in the OR, and communicating with staff from the surgical ward or the patient. Examples of communicating within the OR included the nurses taking on a teaching role in relation to all staff categories, or raising awareness of the importance of the World Health Organization's surgical safety checklist. One of the nurses stated that:

"I encourage the surgeon to inject the local anesthetics subcutaneously while the wound is open in order to avoid several small punctures next to the wound." (nurse no. 605)

Communication with staff from the surgical ward or the patient involved the provision of information regarding how the surgical site and dressing should be cared for in order to maintain good hygiene and thereby reduce the risk of SSIs. Information could be given to the patient both verbally and in writing.

Knowledge

Logical thinking, long work experience, keeping oneself updated on new routines, and being well informed regarding the patient by reading their medical chart comprised 9 of the 3,522 codes. One nurse stated that it was important to have *"knowledge of postoperative wound infections in order to be able to prepare oneself properly"* (nurse no. 865).

Work strategies

Work strategies was the smallest of all the subcategories, containing only 8 codes (0.2% of all codes). Of these 8 codes, 6 described the strategy of *"keeping the total surgical time as short as possible."* Two of the nurses stated that they needed to be given the proper amount of time to prepare the skin disinfection of the surgical area, in order to allow them to perform their work well, and without stress.

DISCUSSION

The 3 categories of interventions mentioned most frequently when the nurses described what they considered important to prevent bacterial contamination and SSI were skin disinfection (25.9%), the OR environment (18.2%), and aseptic technique (16.4%).

The responses indicated that many nurses believed the patients' skin to be sterile after the skin disinfection process. This is not a certainty, but skin disinfection does significantly decrease the amount of bacterial growth.^{11–16} Awareness of the importance of the OR environment for reduction of bacterial air contamination was one of the most frequently described interventions to be controlled by the nurses. The nurses' responses showed good knowledge of how to ensure high air quality within the OR and the factors affecting air quality. The nurses described a calm environment, few people, and no opening of doors as important factors in order to minimize bacterial air contamination. This is in concordance with studies on environmental factors affecting bacterial contamination within the OR, which have shown that factors such as few people within the OR,^{17,18} calm movements,¹⁹ and no opening of the OR doors¹⁷ are important to keep the bacterial contamination at a low level. Aseptic technique was also considered important. This was described in many ways, for example in terms of making sure to change gloves with holes or gloves that were damaged in some way. Studies indicate that the indicator gloves are important to use in order to discover holes.^{20,21}

Nurses also described the use of incision drape as an intervention to reduce bacterial contamination and to prevent SSI. There

is no evidence in the literature that the use of incision adhesive drape reduces the number of SSIs,²² and one study even found that it may increase bacterial contamination.¹⁶ Identifying areas of clinical practice with insufficient evidence is paramount for patient safety. However, it is challenging to implement processes to remove non-cost-effective or ineffective practices based on tradition, as well as to implement a new intervention or strategy.²³

METHODOLOGICAL CONSIDERATIONS

The retrieval of OR nurses' e-mail addresses depended on the ability of the different counties and regions to disclose e-mail lists, which limited the sample size. However, the survey had respondents from all counties and regions in Sweden, dispersed over 64 different hospitals.

The combination of qualitative content analysis together with quantification of the codes that appeared in the text strengthens the results, as the qualitative and quantitative approaches supported each other¹⁰ and provided a broadened perspective.²⁴ Representative quotations and examples of codes have been provided in order to help the reader to judge whether the analysis is reasonable in relation to the raw data.²⁵ A standardized open-ended question was asked of all participants, thus giving consistency in the data collection, and increasing the dependability of the results.²⁵

CONCLUSIONS

By providing quotations in addition to the numbers the understanding regarding which interventions Swedish OR nurses consider as most important in order to prevent bacterial contamination and SSIs have deepened. Although most of their interventions were in line with published data and recommendations, some others were not. The results may therefore be useful in identifying areas where evidence and knowledge is lacking in clinical practice, indicating where continued education and scientific efforts is needed to fill these gaps.

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