

Preventing surgical site infections in intraoperative care from a nurses' perspective: A Literature review

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Degree Thesis

Bachelor's degree programme Nursing

2023

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Arcada University of Applied Sciences: Bachelor's degree programme Nursing, 2023.

Identification number:

26190

Abstract:

Surgical site infections (SSIs) pose a significant threat to patient safety, leading to prolonged hospital stays, increased morbidity and even mortality. Preventing SSIs has become a critical focus in healthcare settings worldwide. The aim of this thesis is to investigate the role of nurses in preventing bacterial contamination and surgical site infections (SSIs) in the operating theater environment. The thesis focuses on identifying the risk factors associated with the prevention of SSIs and the skills required of nurses to effectively perform their roles. This literature review was conducted using inductive content analysis approach through searching articles from CINAHL and Sage Journals databases. Articles published in English within the past five years were examined. The findings from the literature review revealed two main themes: preventing SSIs by managing external risk factors and managing and/or improving nurses' skills. Organizational structure, technology use and working conditions are crucial in preventing surgical site infections by managing external risk factors. Effective communication, positive attitudes and strong leadership skills are essential in preventing SSIs by managing and improving nurses' technical and non-technical skills. In conclusion, as surgical site infections can have devastating consequences, it is crucial to continue to provide educational programs to surgical nurses to improve their skills and attitudes towards safety culture. Nurses play a critical role in creating a culture of patient safety and their knowledge and skills are essential in preventing surgical site infections. Recent literature on SSIs prevention underscore the ongoing significance of this issue, indicating the necessity for further research.

Keywords:

Intraoperative care, nursing perspective, patient safety, surgical site infections prevention, surgical nursing practices

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1 Introduction

Surgical site infections (SSIs) pose a significant threat to patient safety, leading to prolonged hospital stays, increased morbidity and even mortality. In the quest to ensure optimal surgical outcomes, preventing SSIs has become a critical focus in healthcare settings worldwide. Within the complex and dynamic operating theater environment, nurses play a vital role in infection prevention and control (CDC et al., 2023).

In the fast-paced and high-stress intraoperative setting, preventing SSIs demands a comprehensive understanding of the multifaceted factors contributing to infection risks. Nurses, as integral members of the surgical team, are uniquely positioned to influence and implement infection prevention measures. Their involvement in perioperative care, from pre-operative patient preparation, through intra-operative surgical procedure, to post-operative wound management, presents numerous opportunities to diminish the risk of SSIs and promote patient well-being (World Health Organization, 2018).

Understanding the complex interplay between the operating theater environment, patient factors and nursing practices is crucial to developing targeted interventions and strategies for preventing SSIs. By investigating the role of nurses in this context, researching and analyzing SSIs and their prevention in the intraoperative care, provide an opportunity for the author, as being undergraduate registered nurse, to deepen the understanding of the topic due to the author's curiosity and passion for improving healthcare practices in intraoperative care. Additionally, it gives an opportunity to stay updated with the latest evidence-based practices, contribute to the existing body of knowledge surrounding infection prevention, and provide valuable insights to enhance patient safety and surgical outcomes, which further can demonstrate author's commitment to professional growth and contribute to her credentials as a competent and informed healthcare professional.

2 Background

Surgical site infections (SSIs) are one of the most common complications in surgical procedures. The incidence of SSIs varies depending on the type of surgery, patient risk factors and other factors. According to the World Health Organization, SSIs account for up to 25% of all hospital-acquired infections worldwide (World Health Organization, 2018). According to the Center of Disease Control and Prevention (CDC), SSIs occur in approximately 2-5% of patients undergoing surgery in the United States each year (CDC et al., 2023). In Europe the incidents of SSIs vary widely between countries with rates from 1,6% to 33,7% (Leaper et al., 2004). In developing countries SSIs rate is as high as 20% reported in some studies (Allegranzi et al., 2011). According to World Health Organization, the mortality rate associated with SSIs in low and middle-income countries is up to 20% (World Health Organization, 2018).

2.1 Surgical Site Infections

SSIs defined as infections that occur within 30 days of a surgical procedure or within one year if an implant is left in place, and can range from mild infections of the skin and subcutaneous tissues, like the incision site to more serious infections that involve the deeper tissues, organs or bloodstream. SSIs can be caused by a variety of microorganisms, including bacteria, viruses and fungi. The most common bacterial pathogens associated with SSIs are *Staphylococcus aureus*, coagulase-negative staphylococci, *Escherichia coli* and *Enterococcus* species (Weiner-Lastinger et al., 2020). SSIs result in increased disease, length of hospital stay and health care costs. In some cases, they cause mortality in patients, who undergo surgery. These infections among surgical patients can occur during and after the surgical procedure. Significant interventions can be taken by the nurses in preventing SSIs in pre-operative, intra-operative and post-operative periods (Allegranzi et al., 2016).

2.2 Nurses' interventions in intra-operative care

When it comes to preventing surgical site infections (SSIs) in the intraoperative care, nurses play a crucial role for the safety and well-being of the patients. Their duties involve not only assisting surgeons during procedures, but also ensuring that all equipment, instruments, incision area are properly sterilized and that the operating room environment remains as sterile

as possible. Nurses play a critical role in reducing the risk of SSIs by implementing evidence-based interventions and best practices (World Health Organization, 2018).

One of the key ways in which nurses prevent infections is through strict adherence to infection control protocols. These includes: using personal protective equipment such as gowns, gloves, masks and surgical hats; using proper hand hygiene techniques; using surgical washing and sterilization hand techniques; dressing up in a sterile way; cleaning and disinfecting surfaces before and after each procedure, instruments opening and table setting in a sterile way; properly sterilizing the incision area; delineating of the sterile field by covering the sterile drapes; ensuring a sterile area and aseptic working during the surgery; ensuring the safe use of surgical instruments; keeping a track on instruments and counting materials, such as sponges, needles and instruments used during the surgery to ensure that none are left inside the patient; verifying the number of instruments with circulating nurse; covering the surgical wound(s); properly disposing of hazardous waste. All these measures help to ensure that patients receive safe, high-quality care during their surgery time. Anesthesia nurses, as part of the surgical team in the operating room, must also closely monitor patients for vital signs and condition throughout the surgery. They should be alert for any signs of infection or complications, such as fever, increased pain, or redness around the incision site. Nurses should also communicate effectively with the surgical team and report any suspected cases or changes in the patient's condition (World Health Organization, 2018).

Another important aspect of the nursing role in infection prevention is patients' education and wound management on post-operative care. Nurses must educate patients on the importance of hygiene and infection prevention, as well as provide guidance on how to care for wounds and incisions, including dressings change, at home after the surgery, when to seek medical attention and how to recognize signs of infection (Karma et al., 2016).

In addition, nurses must maintain accurate records of all infections and report them to the relevant authorities. This information is critical in identifying and addressing any potential sources of infection, and improving overall patient outcomes (Karma et al., 2016).

3 Theoretical Framework

Nursing theories are laying on the core level and provide theoretical basis of all nursing practices. They are important in many aspects: provide a framework for understanding and analyzing nursing practices, guide the development of nursing interventions, identify the goals and objectives of nursing care. They contribute to the overall advancement of nursing as a profession (Wayne, 2023).

A nursing theoretical framework is essential in nursing research work because it provides a structural foundation for conducting research. Nursing theories provide a comprehensive understanding of the complex nature of nursing phenomenon, such as patient care, health promotion and disease prevention (Wayne, 2023).

3.1 Environmental Theory

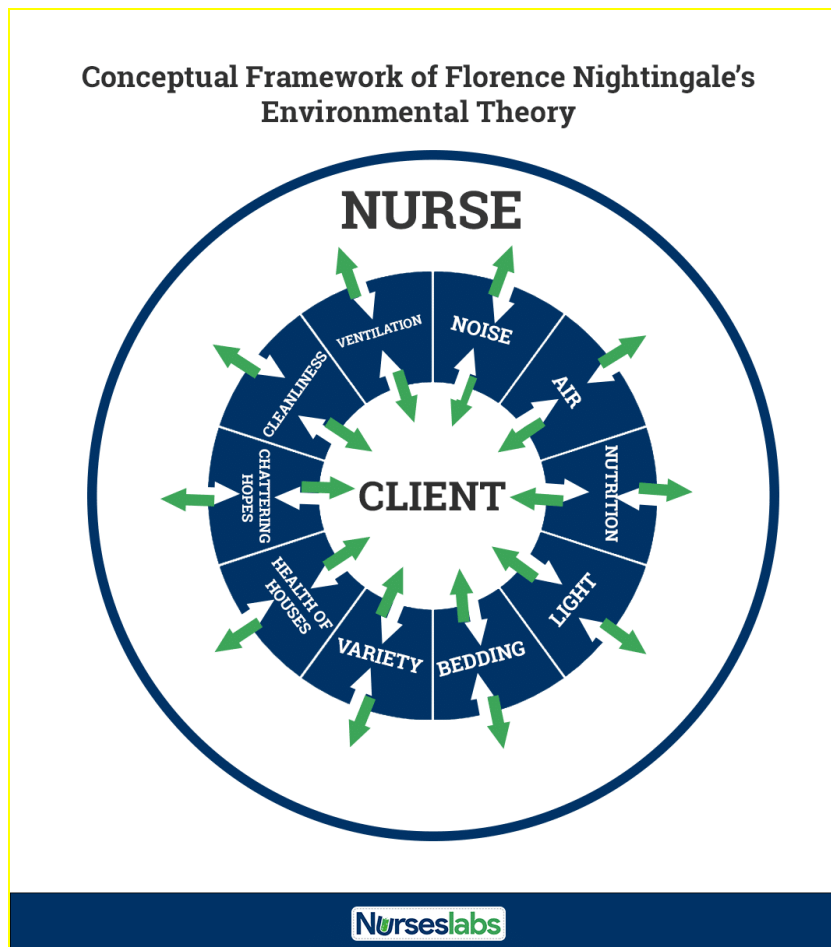
One of the most effective strategies for preventing SSIs is environmental control, which involves the elimination or reduction of microbial contamination in the operating room (OR), therefore, this thesis will strengthen with a nursing framework - Environmental Theory, which was first developed by Florence Nightingale. Environmental theory posits that the physical environment can have a significant impact on human health and wellbeing and focuses on the relationship between the environment and the patient's health outcomes. Florence Nightingale believed that the environment can either help or hinder the healing process and that the nurses' role is to create a healing environment that promotes health and wellness (Gonzalo, 2023).

Nightingale's Environmental Theory includes five key components: fresh air, pure water, efficient drainage, cleanliness and light. She believed that these components are essential to maintaining a healthy environment and preventing spread of disease. In addition, Nightingale emphasized the importance of a quiet and peaceful environment for patients to promote rest and healing. She also recognized the role of the nurse in assessing and improving the patient's environment, and in providing education to patients and their families about the importance of environmental factors in health and healing (Foster, 2013).

Research has supported the importance of Nightingale's Environmental Theory in promoting positive patient outcomes. For example, a study by Ulrich et al. (Ulrich et al., 2008) found, as

one of the key components of Environmental Theory, that patients in room with a view of nature has shorter hospital stays, fewer complications, and required less pain medication than patients in rooms without a view.

In picture 1 the sub-components and the relationship between environment, nurse and client of Florence Nightingale's framework can be seen.



Picture 1. Conceptual framework of Florence Nightingale's Environmental Theory

Florence Nightingale is considered the founder of modern nursing and her Environmental theory is still widely used in nursing practice today.

4 Aim and objectives of the study

The aim of this thesis is to investigate the role of nurses in preventing bacterial contamination and surgical site infections (SSIs) in the operating theater environment. Specifically, the thesis will focus on identifying the risk factors associated with the prevention of SSIs and the skills required of nurses to effectively perform their roles in preventing such infections.

The research questions guiding the thesis include:

1. What are the risk factors associated with the prevention of surgical site infections in the operating room?
2. What role do nurses play in preventing bacterial contamination and SSIs in the operating room?

5 Methodology

This thesis will perform an integrative literature review with qualitative method approach, analysis and synthesis of the existing literature and research studies on a particular topic. In a nursing bachelor thesis, a literature review is an important and valuable aspect of the research process as it helps to establish the current state of knowledge on a topic and identify gaps in the literature that can inform future investigations (Foster, 2013). There is already plenty of research conducted in the prevention of SSIs and many guidelines invented into the operating room and strictly followed by the surgical team, but still bacterial contamination is happening among patients, therefore many gaps there are for the further investigation (World Health Organization, 2018).

5.1 Inclusion and exclusion criteria

The inclusion and exclusion criteria were set based on the PICO approach(Aslam & Emmanuel, 2010), which can be seen in table 1, study design and date, to refrain from bias and be focus on the topic.

Population:	Perioperative registered surgical nurses
Intervention:	Nursing interventions in intra-operative period
Comparison:	Preventing/not preventing SSIs
Outcome:	Patient Safety

Table 1. PICO approach

Furthermore, the inclusion and exclusion criteria were set presented in table 2.

Inclusion criteria	Exclusion criteria
Any nursing interventions in perioperative period aimed in preventing SSIs	Any nursing interventions beyond operative period
Only articles published in English language	Any other publication languages, except English
No restriction regarding race, gender	Articles on neonatology and pediatric surgeries
No restriction regarding country	Paid articles

Publication date of the articles between years 2018-2023	Publication date of articles older than year 2018
Full text articles, including literature review	Articles with abstract only and duplicated literature

Table 2. Inclusion and Exclusion criteria

The data collection process had no limitations on race and gender when it came to selecting the population. However, articles related to neonatology and pediatric surgeries were excluded as they required a specialized approach and had specific requirements, while the focus of the study was on surgeries involving adult patients.

5.2 Data collection

In the beginning of data collection process the topic was examined and brainstorm main key concepts relevant for the further research. The four key concepts were identified: nurses' role, surgical site infections, intraoperative care and prevention of infections. Further, these key concepts were expanded into keywords, using MeSH (Medical Subject Heading) terms identification in CINAHL advanced search and used in the database search.

After identifying the most relevant keywords, an advanced search was conducted in the CINAHL and Sage Journals databases. Inclusion and exclusion criteria were applied, including a limitation on the publication date of articles between 2018 and 2023, as well as the requirement for articles to be in the English language (see chapter 5.1). Subsequently, 395 hits were obtained from CINAHL database. The same methodology was applied to the Sage Journals database, using identical keywords. A summary of the search history for both databases can be found in Table 3.

No.	Databases (total 2)	Search terms	Number of hits Total = 472 hits
1.	CINAHL	("nursing role*" OR "nursing care*" OR "nursing intervention*" OR "nursing responsibility*" OR "nursing skill*") AND ("surgical site infection*" OR "surgical wound infection*" OR "operating room*" OR "intra-	395

		operative infection*” OR “cross infection*” AND (“surgical site infection prevention*” OR “patient safety*” OR “risk factor”*)	
2.	Sage Journals	(“nursing role*” OR “nursing care*” OR “nursing intervention*” OR “nursing responsibility*” OR “nursing skill”*) AND (“surgical site infection*” OR “surgical wound infection*” OR “operating room*” OR “intra- operative infection*” OR “cross infection”*) AND (“surgical site infection prevention*” OR “patient safety*” OR “risk factor”*)	77

Table 3. CINAHL and Sage databases and hits summary

Following the task of identifying the appropriate search terms for the advanced searching procedure, the process of identifying relevant articles for the thesis ensued. Upon gathering the studies from the databases, the screening process was initiated, consisting of two stages: initial screening of the title and abstract, followed by a more detailed evaluation of the full text, as recommended by Foster (Foster, 2013). During the selection process, the focus has been solely on articles pertaining to the intraoperative period and nursing interventions aimed at preventing surgical site infections, based on the title and abstracts. Duplicate studies were removed. Following the collection of 29 articles for the deeper screening process, 12 articles were extracted and 17 articles left for the final data analysis process (see appendices).

5.3 Data selection

The literature search identified a total of 472 articles, out of which 29 research papers were identified as suitable for use of this review, showed in the “preferred reporting items for systematic reviews and meta-analysis” (PRISMA) flow chart (Page et al., 2021) (see diagram 1). The process of selecting articles poses several challenges and led to the decision to choose the most suitable ones – 17 articles. Focusing only on the intraoperative phase might result in overlooking relevant literature, as most SSIs are typically identified in the postoperative phase. Additionally, certain articles may not explicitly emphasize SSIs, but their content and findings could still be partially relevant to the occurrence of SSIs. Furthermore, some articles were published after 2018, while the research, data collection and analysis were conducted prior to that year, rendering the findings outdated or irrelevant.

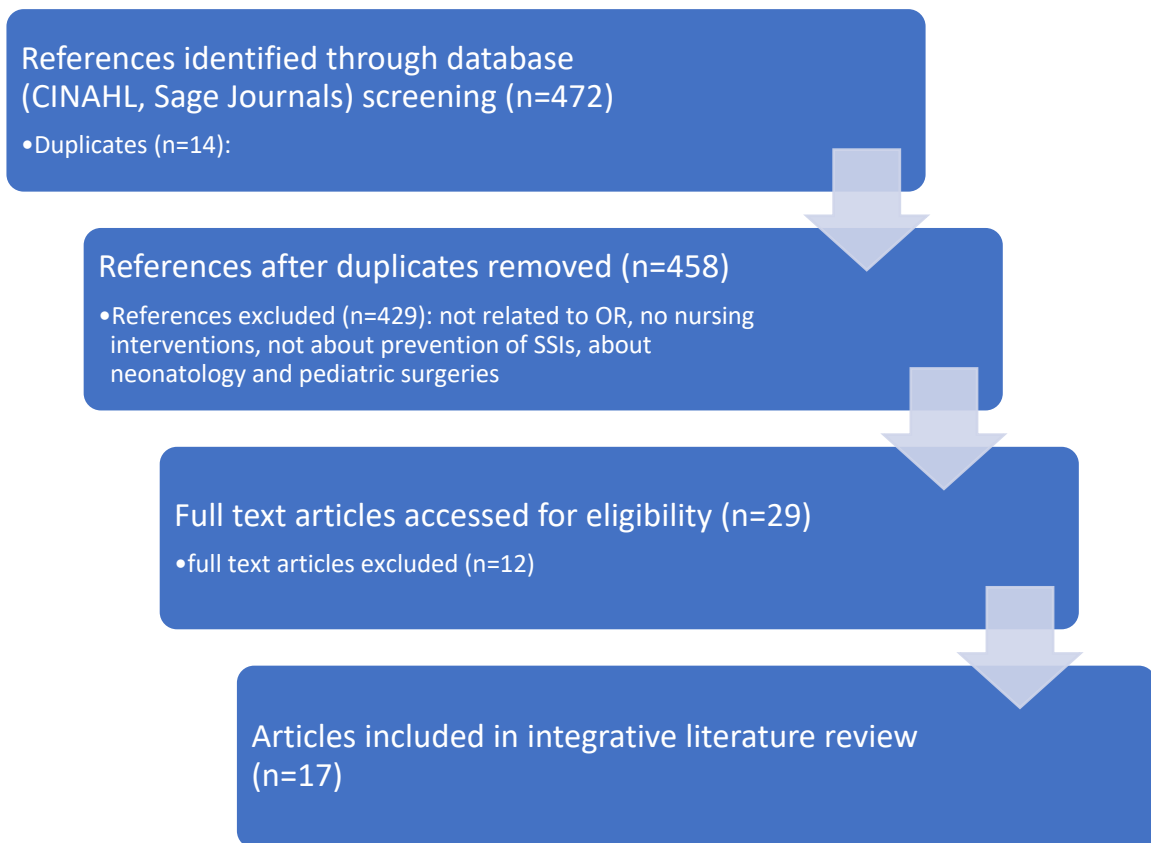


Diagram 1 PRISMA flow diagram.

The references and articles identified for this review comprises the secondary studies, including descriptive cross-sectional studies, scoping review, cohort studies, empirical studies, observational studies, historical studies and articles review.

5.4 Content analysis

Qualitative data analysis was used in an inductive way, which involved examining and interpreting non-numerical data to identify patterns, themes and insights, because the researcher was open to the new impulses and surprising information, while analyzing data. Qualitative data was obtained from different sources: interviews, observations, articles analysis and open-ended survey responses. This step of content analysis consists of data familiarization, which is reading the resource several times, and get familiar with the content (Elo & Kyngäs, 2008). Once the data has been comprehended, the author continue with the inductive approach using thematic analysis to identify common themes (see table 4).

The notes were taken and open coding system was used (see appendices). Then open codes were organized into themes and major categories based on the similarities, frequencies and relationships were extracted from themes. Further the major categories expanded into minor categories in the process of data categorization. After categorization process was completed, the evaluation process and information synthesis, obtained from the selected data, was started. Data interpretation is a deep-thinking process of a researcher, where he/she identifies certain patterns and relationships within the data, get insights, making sense of a collected data and come up with findings. This analysis process will also consist of summarizing the findings and then developing explanations and theories that can help to explain these findings. Data interpretation is crucial step in qualitative data analysis, because it allows to extract meaningful insights from complex, unstructured data with ensuring that the analysis is reliable and accurate and diminishing biases, like personal judgement and opinion of the researcher (Elo & Kyngäs, 2008).

Themes	Preventing SSIs by managing external risk factors			Preventing SSIs by managing nurses' skills	
Major categories	Organization related	Technology related	Working conditions	Non-technical (cognitive) skills	Continuous education/training
Minor categories	Organizational structure Hierarchical structure as a barrier for advocating Nursing team	Mobile devices Bio/Nanotechnology Technical nurses' skills	Day light Design of OR Nursing intervention Distraction	Negligence Interpersonal relationship Communication Personal nurses' attitude Ethical skill of being respectful Leadership Emotional Intelligence	Lack of knowledge No common guidelines No assessment for evaluation Educational interventions Policymaking solutions
References	2, 4, 14, 16, 17	3, 4, 9, 15	1, 2, 6, 9, 10, 16	1, 4, 5, 7, 8, 10, 12, 13, 15, 16	1, 3, 4, 5, 7, 8, 10, 11, 12, 13, 16

Table 4 Inductive data analysis results.

5.5 Ethical consideration

While conducting a literature review individually it is important to consider ethical issues such as fairness and transparency. Researcher must ensure that he/she has not plagiarized the work of others and have appropriately cited all sources (*International Ethical Guidelines for Health-Related Research Involving Humans*, 2016). To eliminate the plagiarism, every source of material that was used in this work was documented and a reliable, accurate list of references was created, using Mendeley Reference Manager. Transparency was prioritized in the data collection, analysis procedures and presentation of findings to ensure thoroughness in the study. The findings were accurately reported and any limitations and biases in the data analysis were acknowledged and addressed. The researcher adhered to the guidelines, templates and standards provided by Arcada University of Applied Sciences in conducting the study. These guidelines serve as a framework for ethical research practices upholding scientific integrity.

Before embarking on the literature reflection, an extensive review of the notes will be conducted to ensure a comprehensive understanding of the literature. Key themes from the literature will be identified, which may either align with the research questions or encompass broader themes within the field of study. Subsequently, a detailed analysis of the themes will be undertaken, highlighting their strengths and weaknesses in relation to the research questions. Personal assumptions and biases will also be examined to ascertain their potential impact on the interpretation of the literature. Identification of any gaps or areas requiring further investigation will be carried out, along with a reflection on how the present research can contribute to addressing these gaps.

6 Findings

There are numerous factors that impact patient safety and the quality of care in the perioperative nursing. The review of the available literature (see appendices) uncovered two main themes that effect patient safety: *preventing SSIs by managing external risk factors* and *managing and/or improving nurses' skills*. The findings of this review in relation to these two themes were examined.

6.1 Preventing SSIs by managing external risk factors

The theme on managing external factors was categorized into major categories: organization related, technology related and working conditions.

6.1.1 Organization

The organizational structure of healthcare facilities plays an essential role in preventing SSIs. The organizational structure can influence the communication, teamwork, and infection control practices of healthcare professionals. The findings from the literature suggest that an optimal organizational structure for preventing SSIs should be well-structured, flat, with clear lines of communication and collaboration among healthcare professionals (2, 4, 14, 17).

Minor categories within this major category is the importance of organizational structure and the hierarchical structure as a barrier for patient advocating for nurses. The literature suggests that the hierarchical structure of healthcare organizations can be a barrier to advocating for infection prevention measures. Nurses may be hesitant to challenge the authority of higher-ranking healthcare professional, such as surgeons, which can lead to a lack of adherence to infection prevention protocols. Optimizing the organizational structure of the operating room requires the involvement of all healthcare workers in prevention of SSIs, including surgeons, anesthesiologists, and other support staff. This can be achieved through the establishment of clear roles and responsibilities for each healthcare worker, regular communication and feedback, and the use of shared decision-making processes that involve all members of the healthcare team (14). Another study assessed how different functional zones' adjacencies within operating rooms can impact the circulating nurses' workflow and cause disruptions. The

study suggests that optimum adjacencies between major zones that circulating nurses regularly visit should be considered while designing ORs to make them more efficient and safer (2).

Another minor category is the importance of the nursing team in preventing SSIs. Nurses play a critical role in maintain sterile conditions, monitoring patients for signs of infection, and advocating for infection prevention measures. The primary outcome of one of the reviewed studies was surgical site infections during in-hospital visits, and secondary outcomes included other nursing-sensitive quality indicators. The results showed that the presence of a fixed nursing team in an OR reduced the incidence of SSIs in surgical patients, decreased the turnover time of surgical procedures, and improved surgeon satisfaction. Therefore, it is essential to optimize the organizational structure of the operating room to support the work of nurses and reduce the risk of SSIs (17). Another literature found that operating nurses face challenges in adapting to the new roles and feel unappreciated by other members of the surgical team, leading to insecurity and devaluation. Operating room nurses need more breaks to collect their thoughts and prioritize patient safety. Lack of time was considered the biggest threat to good nursing care in the OR, leading to inadequate knowledge of patient, dissatisfaction with work and increased stress. OR nurses experienced fatigue and emotional exhaustion over time. Healthcare organizations need to ensure the well-being of their staff and efficient teamwork for better patient care (4). The results of a big study with the sample of 890 surgical nurses in Sweden showed that well-functioned surgical team was the smallest category in the level of importance among surgical nurses (16).

6.1.2 Technology

Constantly developed and widely spread technology in nowadays plays a significant role in preventing SSIs. The use of mobile devices, such as mobile phones, is a minor category that can improve communication and reduce the risk of SSIs by ensuring that healthcare workers have access to the information they need to provide safe and effective care. Mobile devices can be used to access electronic health records, communicate with healthcare team members. However, while cell phones have become indispensable for purposes of professional communication, collaboration, documentation, references, education and photography, they also serve as reservoirs of pathogenic microorganisms that can become vector for nosocomial infections. The reviewed literature has shown that there is a lack of consistent, universal,

evidence-based cell phone cleaning guidelines for healthcare professionals in OR (3). Two other studies emphasized the great level of distraction due to mobile phones in OR (9, 10).

Another minor category within this major category is the potential use of biotechnology and nanotechnology to prevent SSIs. Biotechnology and nanotechnology can be used to develop new materials, coatings, and devices that are resistant to bacterial colonization and infection. On the other hand, with the integration of more complex technical systems, advanced biotechnology and nanotechnology, perioperative nurses are required to learn new equipment and procedures continually. This results in the phenomenon of technological stress, where nurses feel inadequate in their ability to fulfill their responsibilities, leading to dissatisfaction and ultimately stress. The tension between nursing philosophy of caring and technological requirements, as well as the increasing expectation for perioperative nurses to be competent in information technology is discussed in found literature, warning the technology could undermine patient care when technological proficiency takes precedence over the provision of care. OR nurses face difficulties in combining the technical environment of the OR with the humanistic approach of their initial education, leading to inadequate feedback and less contact with patients (4, 15).

Technical nurses' skills are also a minor category in this major category. Technical skills are essential for the effective use of technology in preventing SSIs. Nurses need to be trained in the use of electronic health records and mobile devices to ensure that they can access the information they need to provide safe and effective care (3, 4, 15).

6.1.3 Working conditions

Working conditions can also impact the risk of SSIs. One minor category is the importance of daylight in the infection prevention. The findings of one of the studies revealed that operating nurses feel differently about natural light compared to light from lamps. Optimizing the organizational structure of the operating room requires the recognition of the unique challenges that operating nurses face in their role. Operating nurses may experience high levels of stress and fatigue during long surgical procedures and being trapped into operating rooms, which can impact their ability to maintain sterile conditions and monitor patients for signs of infection. Natural daylight affected nurses' well-being and can help to reduce the level of stress and fatigue by improving the level of conciseness and energy, allowing healthcare workers to

identify potential sources of contamination and improve their ability to perform at work. The study concludes that daylight is an important component of the physical work environment and needs to be taken into consideration in new construction of operating departments. It is essential to provide operating nurses with the resources and support they need to effectively perform their role, such as regular breaks and access to daylight (6).

Design of the operating room is another minor category within this major category. The design of the operating room can impact the flow of people and equipment, the location of sinks and other infection prevention measures, and the ease of cleaning and disinfection. Therefore, it is important to design operating rooms that are optimized for infection prevention as introduced in the reviewed literature (2).

Nursing interventions is also a minor category within this major category. The reviewed literature pointed that based on the opinion of 890 surgical nurses in Sweden, proper skin disinfection protocols can significantly reduce the risk of SSIs and it is the most important nursing intervention in OR. The surgical nurses believed that the patients' skin is sterile after skin disinfection, which is not necessarily true, but it does significantly reduce bacterial growth. The results of the study showed that the most frequently mentioned important surgical nurses' interventions were skin disinfection, the OR environment and aseptic technique. Skin disinfection, is an essential nursing intervention and infection prevention measure that can reduce risk of SSIs, but such nursing interventions as well-functioning surgical team, communication, knowledge and work strategies were left out, that makes a concern in fulfilling these gaps (16). One more literature showed the negligence of operating room nurses in some nursing interventions that prevent SSIs (1).

Another minor category under major category of preventing SSIs in OR by managing external factors is distraction. Particularly distraction caused by mobile phones use in operating rooms can pose serious threat to patient safety. To measure this type of distraction, an instrument has been developed and psychometrically evaluated in Iran, which addresses a range of factors including perception, awareness, performance and patterns of mobile phone use. Identifying and minimizing distraction caused by mobile phones in operating rooms is critical for ensuring the safety of patients and medical staff (9).

6.2 Preventing SSIs by managing and/or improving nurses' skills

The theme on managing and/or improving nurses' skills was classified into two major categories: non-technical(cognitive) skills and continuous education/training.

6.2.1 Non-technical(cognitive) skills

The findings on non-technical nurses' skill highlighted six minor categories: negligence, interpersonal relationship, communication, personal nurses' attitude, ethical skill of being respectful, leadership and emotional intelligence.

The findings of some studies indicate that negligence of surgical nurses is a significant contributor to SSIs. The findings of the study revealed that although nurses were aware of the guidelines and suggestions for preventing SSI, there were variations in the rate of applying the guidelines' recommendations in the institutions. Compliance was generally good in area under nursing management, but it was lower in areas such as a bath with soap or with an antiseptic solution, decision to remove hair, keeping operating room doors closed and operating traffic. The study suggests that a range of care bundles, each consisting of a few specific suggestions, would be selected by the institutions and perioperative team in accordance with their surgery type and patient group. Several nurses reported that they were aware of the risks of SSIs but did not take appropriate measures to prevent them. They attributed this negligence to a lack of motivation, poor training and a high workload. The quantitative data also showed that some nurses scored low on questions related to the prevention of SSIs, indicating a lack of knowledge and skills (1).

Another minor category under this major category is interpersonal relationships between nurses, patients, and other healthcare providers that are crucial for preventing SSIs. Nurses who have positive relationships with their colleagues and patients are more likely to collaborate and communicate effectively, which helps to prevent SSIs. Conversely, nurses who have poor relationships with others were more likely to make mistakes or overlook important details. One of the studies explores the experiences of newly trained operating nurses in nursing care in the operating room. The study found a gap between theory and practice of operating nurses' experiences. They felt alone and insignificant. They also experience threats to safe nursing when they lacked time for patients and themselves, and they lacked feedback to improve care. According to the research, novel work structures in surgical units and effective teamwork can

facilitate the incorporation of insights from ward nurses into the practices of operating room nurses. This can provide them with the necessary support to feel comfortable, secure and recognized in their new roles (4).

Another study conducted on cognitive skills required of surgical nurses to rescue deteriorating patients highlights the importance of identifying the cognitive skills required for surgical patients, as there is no specific cognitive skill set in the surgical ward. The study opened up that inexperienced nurses make more errors in decision-making process than experienced nurses, which can cause delays in recognizing and managing physiological deterioration leading to adverse events. The article proposes that if knowledge of the cognitive skills used by experienced nurses to manage a deteriorating surgical patient can be identified and disseminated to less experienced nurses, it may strengthen their ability to identify potential problems early and escalate care appropriately (12).

Effective communication is essential for preventing SSIs. The studies found that nurses who communicated effectively with patients, colleagues and other healthcare providers were more likely to prevent SSIs. Good communication skills also helped nurses to identify potential risks and responded appropriately. These themes, which involve collaboration and communication, are closely connected to patient safety. Therefore, managing and improving surgical nurses' skills in non-technical areas such as communication, collaboration and respect is essential for preventing surgical site infections. Good communication and teamwork are important safety measures during surgery and create a feeling of good "flow" within the operating team (8, 10, 13, 16).

The study found that nurses' attitudes and personal attributes towards preventing SSIs were important. Nurses who had a positive attitude towards preventing SSIs were more likely to take appropriate measures to prevent them. Conversely, nurses who had a negative attitude or were complacent were more likely to overlook potential risks or take shortcuts (5, 7). The quantitative data showed that experienced nurses had negative attitudes towards patient safety, indicating a need for interventions to improve their attitudes. It is surprising, as safety culture is a deep-rooted concept, which originates in the concept of Environmental theory by Florence Nightingale. Based on the reviewed literature it is clearly defined that incorporating courses on safety culture into continuing education programs for surgical nurses can significantly improve their attitudes towards patient safety. The results of the study indicate that the educational

workshop had a positive effect on the attitudes of the OR nurses. Given that surgical nurses work in a highly complex environment with different healthcare professionals, such as surgeons, anesthetists and technicians, they need to be equipped with knowledge and skills to ensure patient safety (7). Another article discusses the impact of technology on perioperative nursing roles and the development of the technology stress. The surgical environment has integrated multiple and complex technical systems, which have led to the emergence of technology stress. Perioperative nurses are responsible for demonstrating quick mastery of these new technologies and sharing this information with their colleagues. However, the pressure of technology mastery has resulted in perioperative nurses feeling inadequate in their ability to fulfill their responsibilities, leading to dissatisfaction and finally stress. There are recognized tension for perioperative nurses between the nursing philosophy of caring and technological requirements. Surgical nurses have to balance technical skills and non-technical skills. In the context of technology, the role and responsibilities of the perioperative nurse become somewhat ambiguous and the question remains unanswered as to how much responsibility nurses should have for technology in the surgical environment (15).

A further essential minor category under category on preventing SSIs by managing nurses' skills is respectful communication and behavior. The study highlights the importance of non-technical skills in the operating room. These skills include cognitive and interpersonal skills that underpin technical proficiency (5,8). The study reveals that ethical values and respect for human dignity make operating room nurses responsible for decisions that are clinically and technically sound and morally appreciate. Nurses, who are respectful to their patients and colleagues are more likely to prevent SSIs, on the contrary nurses who are disrespectful or dismissive of others are more likely to overlook important details or make mistakes. The findings of the study indicate that respect and care for the patient and respect within perioperative team are the main ethical issues perceived as important by operating room nurses regarding non-technical skills. The lack of respect can influence the team negatively and is detrimental to patient safety (8).

Few literatures highlight that effective leadership is essential for preventing SSIs (10, 12, 13). The study lighted on that non-technical skills such as communication, situational awareness and teamwork are essential to ensure safe and efficient surgical practices. However, the literature shows that circulating nurses in Iran had moderate levels of non-technical skills, with situational awareness being their strongest domain and leadership being the weakest. Nurses

who has strong leadership skills were more likely to create a culture of safety and to ensure that everyone in the healthcare team is working together to prevent SSIs. Nurses who lacked leadership skills were more likely to work in isolation and to overlook important details (10). According to the author's assumption, the lack of strong leadership skills by nurses might relate to the hierarchical structure of the institution.

One of the articles emphasizes the importance of emotional intelligence in perioperative nurse leaders to improve patient outcomes, retain staff and promote a positive work culture. Nurses who possess emotional intelligence have the ability to lead a team towards organizational stability and engage staff to provide high-level safe patient care. Nurses who have high emotional intelligence are more likely to communicate effectively, collaborate with others and respond appropriately to difficult situations. Emotional intelligence is associated with transformational leadership style, and self-reflection, debriefing and mentoring can be useful tools for improving emotional intelligence in perioperative nurses (13).

6.2.2 Continuous education and trainings

The minor categories that were identified under this major category are: lack of knowledge, no common guidelines, no assessment for evaluation, educational interventions and policymaking solutions. Many studies found that training programs and continuous educational programs among operating nurses needed and can result in a significant reduction in the incidence of SSIs (1, 3, 4, 5, 7, 8, 10, 11, 13, 16).

The literature recommended that hospitals should establish protocols based on proven techniques to prevent SSIs. To encourage adherence to these guidelines, healthcare providers should be incentivized and the entire surgical team should receive structured in-service training (1).

The article concluded that to ensure a smooth transition from ward nursing to operating room nursing, recently trained OR nurses require assistance and encouragement, and a functional team appears to be the essential component in it (4). Furthermore, the literature pointed that hospital management needs to recognize the significance of continuous mentorship by experienced nurses for novice nurses, considering the shortage of nurses worldwide and the

increasing practice of replacing experienced nurses with less experienced ones to ensure the patient safety (12).

The study aimed to investigate the use of Nurse Anesthetists' Non-Technical Skills-Norway (NANTS-no) assessment tool in assessing and developing non-technical skills in clinical practice. Although there is no standardized assessment of non-technical skills in Norway, the Norwegian Association of Nurse Anesthetists has adopted the competency-based approach advocated by the International Federation of Nurse Anesthetist to improve professional competence. The study revealed that the student nurse anesthetists demonstrated significant development in non-technical skills and found that NANTS-no is reliable for assessing student nurse anesthetists' non-technical skills in clinical practice, which could have implications for the systematic assessment of non-technical skills in Norway and other countries (5). The reviewed article arises an issue of no standardized, comprehensive and research-based procedures for sanitizing mobile devices used by medical personnel in the operating rooms. The involvement of healthcare experts from various disciplines together with mobile phones manufacturers can be instrumental in creating educational materials and directives for minimizing bacterial colonization on mobile phones (1).

It is vital to address the issue of patient safety by providing regular educational programs to all nurses to create awareness and emphasize the importance of patient safety culture. As highlighted in the study, gender and education levels do not significantly affect attitudes towards patient safety culture. Thus, it is essential to provide equal opportunities and access to educational programs to all nurses regardless of their gender and education level (7).

Another literature pointed that nurses need to be trained to develop a caring atmosphere in the operating room, respect patients' dignity and collaborate effectively with their colleagues to create a safe environment (8). The study found that the assessment of circulating nurses' non-technical skills is a crucial aspect of preventing surgical site infections, therefore continuous training and development programs should be designed to enhance the non-technical skills of circulating nurses to ensure high-quality patient care and safety. Educational interventions and policymaking solutions can improve circulating nurses' non-technical skills and consequently prevent SSIs. It is important to recognize that deficiency in non-technical skills increase the risk of adverse events and surgical errors (10).

The study found that healthcare organizations should prioritize developing emotional intelligence among their nurse leaders to improve the quality of care provided to patients. Given the complex nature of the perioperative environment, perioperative nurse leaders should be trained to be self-aware and manage their emotions in high-stress situations. These skills can positively affect team cohesion, job satisfaction and retention. Furthermore, providing training and support to develop emotional intelligence in perioperative nurse leaders can promote a culture of safety, improve communication between team members and ultimately benefit patients. Therefore, healthcare organizations should invest in developing emotional intelligence training programs for their nurse leaders to improve the quality of care, retain staff and promote a positive work culture (13).

The literature focused on a specific surgical operation – tracheostomy in Saudi Arabia, and discovered that both pre- and post-graduation clinical training have a beneficial effect on the quality of care given to patients with tracheostomy. A significant proportion of nurses from the results of the literature reported caring for patients with tracheostomy and assisted ventilation, but only a small number of nurses indicated receiving proper training or keeping up-to-date with relevant guidelines. This finding reflects a lack of confidence among nurses in providing adequate care. As a result, continuous training and competency assessment are crucial for delivering optimal care for patients (11).

The results from reviewed literature identified gaps in perceptions of surgical nurses of the nursing interventions' importance in OR. While many of the interventions aligned with recommendations, there were some that did not. Consequently, these findings could serve as a valuable tool to pinpoint areas in clinical practice where evidence and knowledge are sufficient, highlighting the need for further education to address these gaps (16).

7 Discussion

The literature included in this review analyzed various types of deviations in the operational theater from the nurses' perspective, such as external factors, like environment and organizational structure, and internal factors, like nurses' skills, that contribute to inconsistencies in the standard surgical practices. These deviations can ultimately lead to SSIs of the patients. Despite being a well-defined and systematic processes of surgical practices, the integrative review studies found instances, where perioperative nurses encounter difficulties in adhering to the surgical procedures.

Environmental theory by Florence Nightingale was chosen as a theoretical framework for this thesis. Florence Nightingale's environmental theory provides a framework for understanding the importance of the environment in promoting health and preventing illness. In the context of preventing SSIs in ORs, Nightingale's theory emphasizes the importance of maintain a clean and sterile environment and creating a comfortable and calming environment, including patients and healthcare professionals. Surgical nurses play a crucial role in implementing these practices and ensuring that patient receive safe and effective care.

7.1 Organizational structure

Ten reviewed studies have investigated the optimal organizational structure of the operating rooms due to the influence of organizational structure on healthcare professionals' communication and effectiveness of infection practices. The findings from these papers suggest that a well-structured and flat organizational structure with clear lines of communication and collaboration among healthcare professionals is essential in preventing SSIs. Surgical team can work together to reduce the risk of SSIs and improve patient outcomes by providing clear communication channels, role clarity, standardization of processes, adequate staffing and continual education (1, 2, 3, 4, 8, 10, 13, 14, 16, 17).

A well-designed organizational structure should include clear communication channels between different members of the surgical team, including nurses. Effective communication is critical in preventing SSIs, as it helps ensure that all team members are on the same page when it comes to infection prevention practices. The review of one literature proved that the presence

of a fixed nursing team in an OR tend to reduce the incidence of SSIs by decreasing the turnover time of surgical procedures and improving surgeon satisfaction. The benefits of using a fixed nursing surgical team in reducing the incidents of SSIs can be improved through communication. Fixed nursing teams can develop a close working relationship with their surgical counterparts, which allows for improved communication and collaboration during surgery. This leads to better coordination and a more seamless surgical process, reducing the risk of errors that could lead to SSIs (17).

Two other studies identified that the modern technology has a significant impact on preventing SSIs by providing nurses with tools to improve communication, access information and prevent infections. These papers emphasized that mobile devices like cell phones provide nurses with access to electronic health records, communication with healthcare team members and educational resources. Nevertheless, there is a risk of contamination from microorganisms on cell phones, due to no universal, evidence-based cell phones cleaning guidelines and distraction in the OR due to mobile phones can be a challenge (3, 9, 10).

The hierarchical structure of healthcare organization can also act as a barrier to advocating for infection prevention measures, as it highlights in one reviewed literature. It creates power dynamics, where some team members have more authority and decision-making power than others. In the operating room, this can result in nurses feeling unable to speak up when they observe infection prevention practices that are not being followed. They may fear retribution from higher-ranking team members or feel that their concerns will not be taken seriously. Nurses may feel that they do not have the authority to make decisions when it comes to infection prevention practices. They may be required to follow specific protocols or procedures, regardless of whether they believed that they are effective or not. In hierarchical structures, changes can be challenging to implement, as it often requires approval from multiple levels of authority. This can be particularly problematic when it comes to implementing new infection prevention practices, as nurses may feel that their concerns and suggestions are not being taken seriously by higher-ranking team members. When there is a hierarchical structure in place, communication team members may be limited. Nurses may be reluctant to speak up and share their observations or concerns, while higher-ranking team members may not be receptive to feedback from those lower down the hierarchy (14). However, with a fixed nursing team, each member is accountable for their role in preventing SSIs. This can improve their

commitment to following infection prevention practices and their willingness to speak up, if they observe any deviations.

Optimizing the organizational structure of the OR requires the involvement of all healthcare workers. This can be achieved through the establishment of clear roles and responsibilities, regular communication and feedback, and shared decision-making processes that involve all team members of healthcare organization. An effective organizational structure should clarify the roles and responsibilities of each member of the surgical team, including nurses. This helps ensure that everyone understands their specific role in preventing SSIs and that there are no gaps in infection prevention practices. Nurses, with no doubt, play a critical role in maintaining sterile conditions, monitoring patients for signs of infection and advocating for infection prevention measures. A fixed surgical nursing team can help ensure that infection prevention practices are consistently followed in every surgical procedure. Because the team members are familiar with each other's roles and responsibilities, they can work together to ensure that all necessary infection prevention measures are in place (17). A standardized organizational structure can help ensure that infection prevention processes are consistently followed in every surgical procedure. When a team of nurses work together consistently, like in a fixed nursing team, they become familiar with the surgical protocols, practices and preferences of the surgical team. This allows for a more consistent approach to surgical procedures.

The organizational structure should ensure that there are enough nurses and other team members to provide adequate coverage during surgical procedures. Overburdened nurses may rush through infection prevention procedures, increasing the risk of SSIs. Additionally, as one literature showed, new, inexperienced OR nurses may face challenges in adapting to new roles and feel unappreciated by other members of the surgical team, leading to insecurity and devaluation. Nurses need support and good mentoring, as well as, more breaks to collect thoughts and prioritize patient safety, as lack of time is considered the biggest threat to good nursing care in the OR. OR nurses may experience fatigue and emotional exhaustion over time, leading to dissatisfaction with work and increased stress (4). Therefore, healthcare organizations need to ensure the well-being of their staff and efficient teamwork for better patient care. Additionally, another benefit of a fixed surgical nursing team is that this kind of structure can increase job satisfaction and retention by providing a sense of stability and continuity. This can result in fewer turnover and staffing issues, which can improve the overall quality of patient care and reduce the risk of SSIs.

Biotechnology and nanotechnology offer new materials, coating and devices that resist bacterial contamination. However, two papers stated that implementing advanced technology can lead to technological stress by surgical nurses and undermine patient care when proficiency in technology takes precedence over the provision of care. Additionally, surgical nurses may face difficulties in combining the technological environment of the OR with the humanistic approach of their initial education, leading to inadequate feedback and less contact with patients (4, 15).

An effective organizational structure should also provide opportunities for continual education and training for nurses and other surgical team members. This includes education on new prevention practices, as well as refresher courses on existing practices. Technical skills are vital for the effective use of technology in preventing SSIs, and surgical nurses must receive proper training to use advanced technology in OR to provide safe and effective care. Ultimately, the integration of highly developed technology in preventing SSIs requires careful consideration and balance between technical proficiency and humanistic care.

Additionally, while designing ORs to make them more efficient and safer, the structure of OR should be taking into consideration in terms of optimal adjacencies between major zones that particularly circulating nurses regularly visit, as showed in one of the papers (2). Therefore, the structure of the healthcare organizations should not only be well organized, but also well-designed.

One of the significant risk factors in terms of preventing SSIs is associated with the organizational structure of the OR, characterized by its hierarchical nature that can disrupt clear lines of communication and block effective teamwork. The hierarchical structure may hinder the exchange of crucial information and collaboration among healthcare professionals, thereby compromising patient safety. Another risk factor is the highly developed advanced technology present in the OR. While advanced technology offers numerous benefits and advancements in surgical procedures, nurses face the challenge of striking a balance between maintaining technical proficiency and delivering holistic patient care. The reliance on technology may inadvertently reduce the level of human interaction and give in the comprehensive assessment and attentive care that patient require. To address theses risk factors, several solutions can be implemented. Establishing a fixed nursing team within the OR can enhance communication,

familiarity and trust among team members, bringing up a more interrelated and effective working environment. Continuous training and mentoring programs for nursing staff can help enhance their technical skills, as well also emphasizing the importance of holistic care and patient-centered approaches. Furthermore, a well-organized and well-designed OR can optimize workflow, facilitate efficient communication and create an environment for effective teamwork and patient safety. Through implementing these solutions, healthcare organizations can diminish the risk factors associated with the organizational structure and advanced technology in the ORs. This promotes a culture of patient safety and ensures better prevention of SSIs.

7.2 Perioperative nurses' skills

The analysis of ten papers revealed non-technical, individual, cognitive nurses' skills that can impact on perioperative nurses' behaviors in preventing SSIs (1, 4, 5, 7, 8, 10, 12, 13, 15, 16). An interesting insight was driven that non-technical skills, which are cognitive and social skills necessary for safe and efficient nurses' practices in the OR, have received considerable attention in the last five years, within which a literature research was conducted, meaning that surgical nurses have to have specific skills to focus on for this specific professional area. Additionally, assessment of non-technical skills among operating theater staff is crucial, because deficiency in using these skills is a leading contributor to surgical errors.

Although the surgical count is typically regarded as a technical skill, it encompasses non-technical skills like communication, situational awareness and cooperation. Most of the articles pointed that effective teamwork and communication, which involve mutual respect among surgical team members, are crucial in shaping the culture of patient safety and ensuring the efficient functioning of healthcare facilities, while also being a crucial factor in minimizing surgical errors. Poor communication can hinder the processing of critical information and slow down the compliance with established policies and procedures (1, 2, 3, 4, 8, 10, 13, 14, 16, 17).

Negligence of the perioperative nurses related to a wide range of care bundles, each consists of a few specific suggestions that would be selected by perioperative team according to a surgery type and patient group, have a negative impact on nurses' ability of decision-making process, including access the situation, analyze risks and choose the most effective interventions to

prevent infections, and situation awareness, including patient conditions, environmental factors and team dynamics. This, specifically, was revealed in one of the reviewed articles (1). Nurses with strong situational awareness can detect signs of infection, recognize deviations from expected norms and respond promptly and appropriately. Fatigue and stress, leading to diminishing of concentration, lack of motivation, poor training and high workload was identified as a contributing factor to negligence. A lack of professional respect was identified in four literature as a behavior that can influence the team negatively and is detrimental to patient safety (5, 8, 13, 14). It is essential that every team member, regardless of their hierarchical position, feels empowered to express concerns and raise issues before, during or after surgery. The hierarchical nature of the operating rooms is often linked to difficulties in adhering to accepted surgical practices. Unexperienced or newly trained surgical nurses may also face challenges to confronting more experienced staff members regarding the surgical process due to hierarchical confrontations (4). Additionally, long-term collaboration among perioperative nurses, supportive mentoring from experienced surgical staff and fixed nursing team can lead to adaptations and shared understandings of the surgical process based on their collective work history and individual needs.

An interesting insight from the reviewed articles was the importance of creating a caring and ethical environment for patients that goes beyond technical proficiency. Four papers suggest that perioperative nursing should be perceived as a profession founded on caring and ethics while also emphasizing the importance of technical skills (5, 8, 9, 15). In the operating room, surgical nurses often need to strike a delicate balance between providing holistic care and utilizing their technical skills. The nature of the surgical environment, with its emphasis on precision, efficiency and adherence to protocols, can sometimes shift the focus more towards technical aspects, potentially overshadowing the holistic approach. Advanced technology and technical nursing skills can present both benefits and challenges for perioperative nurses in OR. While these advancements have the potential to improve patient care and outcomes, for example, silver nanoparticles can be used to create antimicrobial coatings on surgical instruments and implants (Qing et al., 2018), they can also create certain difficulties for nurses in this specialized setting. One challenge is the rapid jump, at which technology evolves in the healthcare field. Perioperative nurses must constantly adapt to new equipment, devices and software systems. Learning and integrating these technologies into their workflow can be time-consuming and require ongoing training and education. Additionally, technical malfunctions in advanced equipment can disrupt the flow of surgical procedures. If a device fails, it can lead

to delays, frustration and potentially compromise patient safety. Perioperative nurses must possess the knowledge and skills to troubleshoot and address technical issues promptly to minimize any negative impact on patient care. Moreover, the complexity of advanced technology may increase the cognitive workload for surgical nurses. They need to understand and operate sophisticated equipment and coordinate with multiple systems simultaneously. Managing these tasks while ensuring the patient's safety requires a high level of concentration and mental alertness. The potential for increased cognitive load can contribute to stress, fatigue and risk errors if not managed effectively. Another challenge is the potential for overreliance on technology. While advanced devices and systems can enhance efficiency and accuracy, they should not replace critical thinking and clinical judgment. Surgical nurses must maintain their clinical skills and continue to assess patients holistically, rather than relying solely on automated measurements. Holistic care states in the basis of nursing practices, however the focus on technical skills can become dominant and the holistic aspect may be de-emphasized in OR. One factor that contribute to this shift is the urgency and time sensitivity of surgical procedures. Surgical team must work efficiently to minimize surgical time and reduce the patient exposure to anesthesia. This time pressure may lead to a stronger emphasis on technical aspects. The hierarchical nature of the OR can further influence the balance between holistic care and technical skills. Surgeons are often seen as the leaders in the surgical team and their focus is primary on the technical aspects of the procedure. This emphasis can create a culture that values technical skills more than holistic care, shaping the behavior and priorities of surgical nurses. The ability to integrate technology with clinical expertise and to recognize the importance of both aspects is crucial to provide optimal patient care. Furthermore, the pressure to constantly adapt to new technology can create anxiety and feeling of overwhelmed. It is essential to provide adequate training, support, mentorship and supportive work environment to help nurses to navigate these challenges, build confidence in their technical skills and thus make room for holistic patient care. By providing ongoing education, support, collaboration and positive work environment, these challenges can be effectively managed, ensuring safe and efficient surgical care for patients with holistic approach.

In one of the reviewed articles the nurses' opinion on the situational awareness domain had the highest score, while leadership was the domain with the lowest mean score among circulating nurses' non-technical skills, and thereby downplay the role of the leader of the surgical nurse (10). However, six other articles argued that strong leaders among surgical nurses can create a culture of excellence in surgical site infection preventions (4, 8, 12, 13, 14, 15). Leadership

skills among surgical nurses are vital for effective functioning within the hierarchical structure of the OR. Leaders promote open and clear communication channels among the surgical team. They can articulate their ideas, concerns and suggestions clearly to higher-ranking personnel such as surgeons and anesthesiologists, as well as effectively relay instructions to other team members. Clear communication facilitates smooth coordination and reduces the chances of misunderstandings or errors. Strong leaders also enforce standardized protocols for prevention of surgical site infections and make sure that these protocols are consistently implemented. They coordinate effectively with other surgical team members, organize and delegate tasks, ensure that everyone understands their role and responsibilities.

Leadership skills together with good problem-solving skills enable surgical nurses to make informed decisions, even in a high-pressure situation. They can assess situations quickly, gather relevant information, think critically and choose the best course of action to ensure the smooth progression of the procedure. Leaders among surgical nurses prioritize ongoing education and training for surgical nurses. They identify knowledge gaps and provide the necessary resources to enhance the surgical team, like for unexperienced surgical nurses they can provide a good mentorship or set a role modeling for junior team members through professionalism, expertise and dedication. They uphold high standards of patient care and demonstrate positive behavior, such as effective communication, collaboration and ethical conduct. By being role models, they inspire others to develop their own leadership skills and contribute to a cohesive and efficient OR environment. At last, leadership skills empower surgical nurses to advocate for the best interest of their patients within the hierarchical structure. They can speak up when they notice potential risks or deviations, ensuring that patient safety remains the top priority.

Another interesting insight was driven from the reviewed articles that such behavior as emotional intelligence worth the emphasis in terms of crucial non-technical surgical nurses' skills in preventing surgical site infections. One article drew a parallel between emotional intelligence and leadership skills and how it reflects each other (13). By effectively managing emotions and recognizing the emotions of others often in high stressful situations in OR, surgical nurses can significantly enhance patient safety and promote positive surgical environment. Emotional intelligence equips surgical nurses with the ability to manage their stress effectively, promoting resilience and preventing burnout. One of the features of emotional intelligence is empathy. Nurses with high emotional intelligence more likely demonstrate empathy and understanding towards patients, when it comes to the question of

balance between technical and non-technical skills. They can anticipate patient needs, address concerns and provide support throughout the perioperative period. By establishing a trusting and compassionate relationship, nurses can help patients manage stress and anxiety, which in turn can positively impact their immune response and reduce the risk of SSIs. This reflects to the environmental theory of Florence Nightingale how positive environment can enhance the patient safety and states in the basis of nursing practices. Regarding the matter of harmonious work environment, emotional intelligence empowers nurses to navigate conflicts constructively, using effective communication and conflict resolution skills.

Based on the analysis of the reviewed articles, non-technical skills, such as communication, professional respect, leadership and emotional intelligence are crucial for the nurses in the perioperative settings.

Many reviewed articles opened up the importance of continuous education and trainings for the surgical nurses' team as paramount due to several risk factors, leading to SSIs, including lack of knowledge, lack of practice, insufficient technical and non-technical assessments for nurses and the absence of common guidelines (1, 3, 4, 5, 7, 8, 10, 11, 12, 13, 16). Medicine and surgical practices are constantly evolving, and new advancements are regularly introduced. Continuous education and trainings ensure that surgical nurses are up-to-date with the latest evidence-based practices, guidelines and technologies. It helps them acquire new knowledge, refine their skills and stay informed about best practices for preventing surgical complications, including SSIs. Technical assessments are essential to evaluate the competence and proficiency of surgical nurses. Without such assessments, it becomes challenging to identify any gaps in their technical skills. Continuous education and trainings provide opportunities for nurses to undergo assessments and receive feedback on their technical abilities. This enables them to address any deficiencies, enhance their proficiency and consequently improve patient outcomes.

Three reviewed papers emphasized the lack of non-technical skills assessments for surgical nurses (5, 10, 11) on the other hand one article pointed that the Applied Cognitive Task Analysis approach has been successfully used in various domains, including healthcare (12), and another article indicated the use of Intraoperative Non-Technical Skills (SPLINTS) assessment tool (8). However, the absence of formal assessments for these skills can hinder surgical nurses' development. Continuous education and training programs can include

assessments specially designed to evaluate and enhance non-technical skills among surgical nurses. Inconsistent guidelines, like no common evidence-based guideline for cleaning cell phones in OR (3), or lack of standardized protocols (1) can lead to variations in practice among surgical nurses. Continuous education and trainings provide an opportunity to establish and disseminate common guidelines for infection prevention and control within the healthcare organizations. By ensuring that all nurses receive standardized training based on evidence-based guidelines, the risk of SSIs can be minimized and patient safety can be improved.

8 Conclusions

This thesis has explored the crucial role of nurses in preventing SSIs in intraoperative care. Through an in-depth investigation from nurses' perspective, the study has shed light on the risk factors associated with SSIs, as well as the skills required of nurses to effectively perform their roles in infection prevention. Through this thesis, the author hopes to not only uncover the challenges faced by nurses in preventing SSIs, but also highlight the critical skills and competencies they require to address these challenges effectively. Ultimately, the findings of this thesis can inform the development of evidence-based guidelines, training programs and policies that empower nurses' outcomes and strengthening healthcare practices in the intraoperative care setting.

The findings of this thesis highlighted the significance of continuous education and training programs for surgical nurses. By staying updated with the latest evidence-based practices, guidelines and technologies, nurses can enhance their knowledge and skills in preventing SSIs. It is essential to emphasize the importance of both technical and non-technical skills, including effective communication, professional respect, empathy, leadership skills, emotional intelligence and stress management, in ensuring optimal patient outcomes and reducing the risk of SSIs.

Furthermore, the thesis has underscored the need for optimal organizational structure and standardized protocols and guidelines for infection prevention in the operating theater. Establishing consistent practices and promoting interdisciplinary collaboration among healthcare professionals are key to maintaining a safe surgical environment and minimizing the occurrence of SSIs.

Finally, the findings of this thesis contribute to the body of knowledge surrounding SSIs prevention in intraoperative care. They provide valuable insights into the risk factors associated with SSIs, the skills required of nurses, and the strategies that healthcare institutions can adopt to enhance infection prevention practices. By prioritizing the prevention of SSIs, the society can improve patient outcomes, reduce healthcare costs, and ensure the delivery of high-quality care in the surgical setting.

The majority of the selected articles for this literature review were published within the past three years, highlighting the ongoing concern and importance of preventing surgical site infections in intraoperative care. This emphasizes the need for further investigation in this area to address the current relevance of the issue. Given the limited research available, additional study necessary to explore SSIs prevention by perioperative nurses' team and to develop targeted educational interventions tailored to the unique demands of the perioperative environment.

8.1 Limitations of the study

While conducting research on preventing SSIs in intraoperative care from a nurses' perspective, it is important to acknowledge certain limitations that may impact the findings and conclusions of this thesis.

The findings of the thesis may have limited generalizability due to the reliance on a small sample size of only 17 reviewed articles and the specific healthcare settings examined. Different hospitals, regions or countries may have unique factors influencing SSIs and the role of nurse in infection prevention. Thus, the findings may not be universally applicable. Additionally, this review has limitations relating to exclusion of non-English language articles, therefore research papers written in other languages are missing.

The availability and quality of data related to SSIs and nurses' role in infection prevention can pose limitations. This thesis relies on some articles with retrospective data, medical records and self-perceptions of the author, which is a subject to biases or inaccuracies in data analysis. Also, the risk of selection bias is applicable, due to selection of specific group of nurses, surgical nurses. Certain characteristics or practices of the surgical nurses are not representative of the broader nursing population, potentially affecting the validity and generalizability of the findings. When examining the skills and competencies of nurses in preventing SSIs, self-reporting methods and surveys were used. However, respondents may provide answers that are socially desirable or may overestimate their compliance with infection control protocols. This can introduce bias and impact the accuracy of the findings.

Additionally, healthcare practices and guidelines evolve over time, so the findings of this thesis may become outdated if not continuously updated and reassessed. The research process itself

was limited by time constraints, preventing an in-depth analysis of all relevant factors influencing SSIs and nursing practices.

Acknowledging these limitations is important for maintaining the integrity and validity of the research. While they may impact the scope and generalizability of the findings, they also provide opportunities for the further research and improvement in the field of preventing SSIs in intraoperative care from nurses' perspective.

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10 Appendices

10.1 List of chosen articles

No.	Author, year, country, title	Study design	Sample	Results	Conclusion	Open Codings
1	Aktas F. O. & Damar H. T., 2022, Turkey, “Determining operating room nurses’ knowledge and use of evidence-bases recommendations on preventing surgical site infections” (Ogce Aktaş & Turhan Damar, 2022)	Descriptive and cross-sectional study	228 operating room nurses	Nurses had knowledge of the overarching guidelines, although there were discrepancies in the extent to which the recommendations were implemented. Enhancing compliance in certain areas, such as preoperative washing and minimizing the number of staff in the OR, is necessary to improve adherence to the guidelines’ recommendations.	Aligning clinical practice with guidelines is crucial, yet the findings of this study indicate disparities between the recommended application and actual practice. In such instances, a potential solution could involve implementing care bundles that encompass a select set of specific recommendations, tailored by institutions and perioperative teams to align with their specific surgery types and patient populations.	-internal risk factor -nurses’ negligence -use of guidelines
2	Bayramzadeh S. & et al, 2018, United States of America, “The impact of operating room layout on circulating nurse’s work patterns and flow disruptions” (Bayramzadeh et al., 2018)	Empirical study: behavioral mapping study	25 video records of surgeries	During 91% of the activities observed, the circulation nurses moved across multiple zones, with their workstations serving as a central hub from which they frequently traveled to various areas including both sides of surgical tables, the foot of the OR tables, supply zones. Flow disruptions involving the CN were predominantly found in transitional zones, according for 58,3% of all disruptions,	Despite variations in the layout of ORs, the consistent movement and flow disruption patterns observed emphasized the importance of specific adjacencies between major zones that CNs frequently visit. These optimal adjacencies should be considered during the design of ORs to enhance efficiency and safety.	-internal risk factor -organizational structure -working conditions -circulating nurses’ movements -design OR

				while 28% occurred in areas adjacent to the OR bed.		
3	Dowden A. et al, 2020, Canada, "Recommended cleaning practices for cell phones in the operating room" (Dowden et al., 2020)	Modified scoping review	8 articles review	Cell phones are widely spread across healthcare professionals; cell phones are reservoirs of pathogenic microorganisms that can cause bacterial contamination; no consistent universal, evidence-based cell-phone cleaning guidelines for healthcare professionals in OR.	Additional rigorous quantitative research is necessary to provide solid evidence and support recommendations regarding the disinfection of cell phones in the OR.	-cell phones in OR -disinfection challenge -no guidelines -technology -external risk factor
4	Eriksson J. & et al, 2020, Sweden, "Newly trained operating nurses' experiences of nursing care in the operating room" (Eriksson et al., 2020)	Case study with semi-structured interviews	10 operating nurses within max of 3 years' experience in OR, and 2-10 years' experience as RN.	Three key themes that captured the experiences of OR nurses as they navigate their new roles: a perceived disparity between theoretical knowledge and practical application, feelings of isolation and insignificance, the need to carve out their own place within the healthcare system. Also, a tendency to prioritize task completion over holistic patient care.	Effective restructuring of work within operating units and the establishment of cohesive teams can play a crucial role in facilitating a smooth transition for nurses moving from ward settings to the OR. Such organizational change can provide the necessary support to ensure that these nurses feel acknowledged, comfortable and secure in their new professional environment.	-internal risk factor -lack of support -lack of practice -interpersonal relationship -organizational structure
5	Flynn F. M. & et al, 2022, Norway, "Educating for excellence: a cohort study on assessing student nurse anesthetist non-technical skills in clinical practice" (Flynn et al., 2022)	A cohort study with a longitudinal design	20 student anesthetist nurses	Currently, there is a lack of standardized assessment tools for evaluating non-technical skills in clinical practice, despite their significance. The reliability of the structured behavioral assessment non-technical skills of student nurse anesthetists in clinical practice seems to be established.	The findings of this study have potential implications for the systematic evaluation of non-technical skills in Norway and other countries.	-evaluation of non-technical skills -no assessment -internal risk factor -no evaluation of skills -anesthetists nurses
6	Golvani G. & et al, 2021, Sweden, "Operating room nurses' experiences of limited access to	Case study with qualitative interviews	4 semi-structured focus groups of 15	The study identified two main categories: the impact of different types of light and the	Daylight is a crucial aspect of the physical work environment that should be	-external risk factor -lack of daylight can lead to depression, fatigue

	daylight in the workplace” (Golvani et al., 2021)		operating room nurses	importance of contact the outer world. OR nurses perceived daylight differently from artificial light, considering daylight important for well-being.	prioritized in future research and the construction of new operating departments.	-working conditions
7	Habahbeh A. A. & Alkhalaileh M. A., 2020, Kingdom of Sudi Arabia, “Effects of an educational programme on the attitudes towards patient safety of operation room nurses” (Hababbeh & Alkhalaileh, 2020)	An interventional one-group pre-/post-test	66 OR nurses	The study findings indicated that OR nurses initially had a negative attitude towards a patient safety culture, but attending the program resulted in a significant improvement.	Including safety culture courses in ongoing education programs could enhance nurses’ attitudes towards patient safety, empowering them to contribute significantly to the establishment of a patient safety culture.	-importance of educational program for OR nurses -personal attitudes of nurses -internal risk factor
8	Hanssen I. & et al, 2020, Norway, “Non-technical skills in operating room nursing: ethical aspects” (Hanssen et al., 2020)	Qualitative individual in-depth interviews	11 experienced perioperative operative room nurses	Three primary themes emerged from the analysis: patient respect and care, promoting patient safety and fostering respect within the perioperative team. These themes, encompassing collaboration and communication, are intricately linked to ensuring patient safety.	Respecting others and fostering a caring environment are fundamental ethical competencies in the OR. OR nurses view respect, patient safety and reciprocal politeness among team member as key ethical non-technical skills. Effective communication serves as a crucial safety measure during surgery and contributes to a sense of seamless coordination within the OR team.	-personal nurses’ skills -internal risk factor -good communication -respect
9	Hasanshahi M. et all, 2022, Iran, “Development and psychometric evaluation of a questionnaire or measuring distraction due to mobile use in operating rooms” (Hasanshahi et al., 2022)	A methodological study: literature review and face-to-face interview	208 operating room nurses and doctors	Initially, the study defined and developed a 29-item Likert scale questionnaire to assess distraction caused by mobile phone use. In the second stage, the questionnaire was reduced to 17 items. The instrument’s construct validity was examined through factor analysis.	The findings indicate that the developed tool is valid and reliable for measuring distraction causes by mobile phone use in OR.	-external risk factor -mobile phone disturbance -technology in OR

10	Kalantari R. & et al, 2022, Iran, "An observational study to assess circulating nurses' non-technical skills" (Kalantari et al., 2022)	An observational study	300 circulating nurses	Situational awareness received the highest score among the domains, whereas leadership had the lowest mean score. There was a moderate positive correlation between the mean score of non-technical skills and the years of experience as a circulating nurse.	While circulating nurses demonstrated a moderate level of non-technical skills, they scored low in certain behaviors while performing well in others. Implementing educational interventions and developing policies can be effective in enhancing circulating nurses' non-technical skills.	-non-technical skills(leadership) -internal risk factor -circulating nurse
11	Mahfoz T. M. B., 2022, Kingdom of Saudi Arabia, "Attitude and practices of tracheostomy care among nursing staff in Saudi Arabia" (Mahfoz, 2022)	Cross-sectional descriptive study, involving a self-administrated questionnaire	315 nurses	A significant portion (over 30%) of the nurses were responsible for caring for patients with tracheostomy, yet a large majority (more than two thirds) did not received sufficient training to effectively care for this specific patient group.	Ongoing training and assessment of competencies are essential for providing high-quality care. The level of confidence is influenced by the training nurses have received and the presence of assisted ventilation. It is important for future studies to encompass a national perspective on this topic to inform policies and practices.	-continuous training -personal nurses' skills -internal risk factor -risk from lack of knowledge
12	Marshall D. & Finlayson M., 2022, New Zealand, "Applied cognitive task analysis methodology: Fundamental cognitive skills surgical nurses require to manage patient deterioration" (Marshall & Finlayson, 2022)	An exploratory qualitative study with in-depth interviews: task diagram interview, knowledge audit interview and simulation interview.	6 experienced surgical nurses	The study identified five challenging cognitive tasks involved in managing a deteriorating patient: promptly recognizing signs of physiological decline, confirming the deterioration, initiating appropriate interventions, seeking medical assistance and providing necessary rescue measures.	To effectively address these cognitive challenges, nurses need to possess various cognitive abilities, including decision-making, leadership and management skills, patient advocacy, situation awareness and planning capabilities.	-non-technical skills -thread from lack of important cognitive skills -personal skills
13	Rhodes E. & Foran P., 2022, Australia, "Leading with emotional intelligence in perioperative	An integrative literature review	16 articles	Aspects of emotional intelligence identified as self-awareness, self-reflection, motivation, empathy, social	Emotional intelligence plays a crucial role in the effectiveness of perioperative nurse leaders, contributing to a productive, engaged and	-internal risk factor -personal skills (emotional intelligence) -lack of emotional intelligence skill among nurses-risk factor

	nursing” (Rhodes & Foran, 2022)			skills, which are the five key themes of the study.	satisfied workforce. It is associated with positive outcomes such as staff retention ja job satisfaction. Recognizing the significance of emotional intelligence in nurse leadership, it is imperative for perioperative nurses to comprehend its importance and develop this essential skill set to ensure its presence in future nursing leaders.	
14	Shoemark T., 2021, Australia, “Identifying barriers to patient advocacy in the promotion of safety culture” (Shoemark & Foran, 2021)	An integrative literature review	10 articles review	The literature acknowledges the crucial role of perioperative nurses in safeguarding patients from harm. The study emphasizes the intricate nature of the perioperative team environment and identifies hierarchical structures as obstacles to advocating for patient safety.	Implementing supportive and open communication strategies, free from fear, as advocated by organizational leaders, can enhance the capacity of perioperative nurses to serve as advocated for patients, and finally enhancing patient safety outcomes.	-Internal risk factor -Advocacy to the patient -Barriers hierarchical structure -Organizational risk factor
15	Smith J. & Palesy D., 2020, Australia, “Technology stress in perioperative nursing: an ongoing concern” (Smith & Palesy, 2018)	Observational cross-sectional studies	No	In the advanced surgical setting, possessing specialized knowledge of biotechnology and nanotechnology is essential for ensuring patient safety. Perioperative nurses continuously acquire knowledge about new equipment to effectively address existing and upcoming technological advancements. However, the growing reliance on technology has introduced challenges and stress within perioperative nursing practice. There is a legitimate concern that	Further research is needed to explore the effects of technology on perioperative nurses. This research can inform the development of specific strategies by administrators, educators and perioperative nurses’ leaders to help nurses manage stress related to technology in their work. It is important to review existing national standards regarding technology in the perioperative setting and clarify the roles and responsibilities of nurses in	-external risk factor -technology -stress from technology -risk from nursing focus shift towards technology

				increased emphasis on technology may diminish the level of human interaction with patients, resulting in a more technology-focused role for perioperative nurses.	this context. Also establishing new guidelines may be necessary to address this ongoing issue effectively.	
16	Wistrand C. et al, 2022, Sweden, "Important interventions in the operating room to prevent bacterial contamination and surgical site infections" (Wistrand et al., 2022)	Web-based cross-sectional survey with an open-ended question	890 OR nurses	Nurses identified 12 key interventions for preventing bacterial contamination and surgical site infections: skin disinfection, maintaining a clean OR environment, following aseptic technique, using appropriate OR clothing and draping, ensuring proper preparation and dressing, practicing basic hygiene, maintaining normothermia, effective communication, having adequate knowledge and employing efficient work strategies.	A significant number of interventions performed by OR nurses align with recommendations. However, further research and ongoing education are needed to enhance knowledge regarding the impact of skin disinfection.	-Nursing interventions in OR -Internal risk factor -Skin disinfection -non-technical skills -personal nurses' skills -promote education
17	Zhong H. & et al, 2022, China, "Effects of a fixed nurse team in the orthopedic surgery operating room on work efficiency and patient outcomes" (Zhong et al., 2022)	A propensity score-matched historically controlled study	5365 patients and 33 nurses	A lower incident of SSIs in patients, a lower time of surgical procedure, and improvement of surgeon satisfaction were associated with fixed nurse team compare to non-fixed nurse team.	The presence of fixed nurse team reduces the incidents of SSIs in surgical patients.	-organizational risk -internal risk factor -fixed nurse team in OR diminish incidents of SSIs

