



Occupational Protection Interventions for Nursing Staff in the Operating The- atre

A Literature Review

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Abstract

During surgery, caregivers are in a highly concentrated state of mind, working under increased stress and being exposed to sharp instruments, radiation, and blood for long periods of time. These include physical, chemical, biological, physiological, and psychological hazards. If hospitals do not have regulations in place, safety equipment and nurses are not aware of safety issues, irreparable damage may be caused to the nurses themselves and may affect the recovery of patients.

The aim was to explore the issue of occupational protection for nursing staff in the operating theatre. The purpose was to reduce the health risks to nurses working in the operating theatre and to provide the best possible working environment, including the equipment and facilities in the operating theatre, the hospital system, and the awareness of the nurses themselves.

This study used a literature review approach to explore occupational protection intervention for nurses in the operating theatre. The authors used PICOS criteria as inclusion and exclusion criteria for the articles used in the study, searching a large amount of data from PubMed and CINAHL databases. 9 articles were selected by author 1 and 10 by author 2. The process of data analysis followed an integrated approach, providing summaries suitable for compilation and invasion. The analysis of the data followed a content analysis approach.

This review found four protective interventions for nursing staff in the operating theatre. The protective interventions include protection from surgical smoke: using smoke aspirators and suction systems, providing knowledge of surgical smoke, standardizing operating procedures; protection from radiation: training for nursing staff, using appropriate shielding ;protection from sharps injuries: using double gloving and blunt suture needles, using of sharps with safety devices, reducing scalpel injuries interventions, "hands-free" technique, administrative controls, management, and handling of sharps; protection from infection during surgery: protective equipment, appropriate behaviors, an efficient ventilation system.

Hospital management could establish rules and regulations for nursing staff protection Interventions in the operating theatre, develop nursing staff protection protocols; provide financial support; provide on-the-job training for nursing staff; and set up surveillance teams

Keywords/tags (subjects)

Occupational protection; Nursing staff; Operating theatre

Miscellaneous (Confidential information)

None

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1 Introduction

During surgical procedures, nursing staff are in a state of high mental concentration, have an elevated level of work stress and are exposed to sharp instruments, radiation, and blood for extended periods of time. These include physical, chemical, biological, physiological, and psychological hazards. If the hospital does not have the relevant regulations, safety equipment and nurses are not aware of the safety issues, irreparable damage may be done to the nurses themselves and the patient's recovery may be affected.

It is interesting that the hazards associated with ionizing radiation raise concerns about exposure of operating theatre staff. The incidence of cancer among orthopaedic surgeons exposed to medical radiation is 29%, compared with 4% among orthopaedic surgeons not exposed to medical radiation, so specific Interventions are needed to reduce the radiation dose to patients and nursing staff (Bratschitsch et al., 2019).

Furthermore, surgical smoke has been found to be harmful and carcinogenic to humans and increases the risk of infection. Surgical smoke contains blood, chemicals, tissue particles, bacteria, and viruses. Operating theatre staff have a potential risk of physical, cytotoxic, and genetically toxic injuries. Physical injuries include skin and mucosal diseases, central nervous system diseases, infectious diseases, and cancer. It is important to improve the health of surgical nurses by providing them with adequate knowledge about surgical smoke, better self-protection strategies against surgical smoke, and improved hospital environments with better smoke removal equipment and standardized work processes (Yu et al., 2022).

Similarly, radiation protection is an important principle for some hospital departments, such as radiology and operating theatre. In addition to the practical benefits of radiation, side effects should be considered, as ionizing radiation increases the risk of DNA damage and cancer in nurses and other surgeons. Due to the increasing use of radiation in operating theatres, an accurate and suitable tool for the assessment of radiation protection of operating theatre staff should be developed (Mohebbi et al., 2021).

At the same time, as new corona pneumonia spreads around the world, operating theatres and equipment used by infected patients, such as surgical instruments, gases, etc. are classified as high-risk groups for infection. During the pandemic, surgical procedures were therefore included in the high-risk groups. During these operations, nursing staff came into direct contact with the blood, tissue, and body fluids of patients with new coronary pneumonia. In addition, the risk of transmission of new coronary pneumonia is higher in the operating theatre than in other regions. It is therefore necessary to protect the operating theatre nurse, to take protective intervention in the operating theatre and to obtain detailed information on the surgical treatment of patients with new coronary pneumonia (Gümüs & Basgün, 2021).

The purpose of this literature review is to explore occupational protection issues for nursing personnel in the operating theatre. The aim of this literature review is to reduce the health risks to nurses working in the operating theatre and to provide the best possible working environment, including the equipment and facilities in the operating theatre, the hospital system, and the awareness of the nurses themselves.

2 Background

2.1 Nursing and Nursing Staff

International Councils of Nurses refines nursing as *“Nursing encompasses autonomous and collaborative care of individuals of all ages, families, groups, and communities, sick or well and in all settings. Nursing includes the promotion of health, prevention of illness, and the care of ill, disabled and dying people. Advocacy, promotion of a safe environment, research, participation in shaping health policy and in patient and health systems management, and education are also key nursing roles.”* (ICN, 2002)

There are five levels in the nursing profession, ranging from low to high. Each level has unique duties, jobs, and work environments. First off, a Certified Nursing Assistant is a lower-level member of the patient medical team who works under the direction of a registered nurse to complete crucial patient-centered activities. Despite not being a nurse, a certified nursing assistant collaborates closely with nurses, doctors, and other healthcare professionals. Answering call buttons, alerting nurses of

emergencies, keeping an eye on patients' needs, reporting any issues to other medical professionals, and assisting patients with daily requirements like eating, bathing, and dressing are all typical duties of this position. Adjust the patient's position in bed. Assist in lifting the patient from the bed to the examination table, operating table, or stretcher. Certified Nursing Assistant can work in an inpatient hospital environment, but it is more common in long-term residential facilities, rehabilitation centres and adult day care centres (McHugh & Lake, 2010).

Licensed Practical Nurse is a nurse who performs basic patient care tasks and helps patients stay comfortable. They work under the supervision of Registered Nurse and other medical professionals. They assist Registered Nurse and doctors to keep detailed records, maintain clear communication between the entire nursing team, and understand the procedures and how to care for patients with patients and their families (McHugh & Lake, 2010).

Registered Nurse means that you have obtained a license to engage in nursing. Registered Nurse manages actual patient care in a variety of environments, including hospitals, medical offices, nursing homes and other facilities. They work with doctors and other members of the medical team to provide the best treatment. They also help educate patients and their families about health issues. Some responsibilities of Registered Nurse include managing and monitoring drugs, patient admission and discharge, coordinating with other medical workers, formulating and implementing nursing plans, inserting and managing intravenous catheters, performing hospice care, performing physical examination, performing vital signs and identifying abnormalities, preparing bedside surgery and surgery for patients, reviewing and maintaining medical records, supervising and guiding new nurses and nursing students (McHugh & Lake, 2010).

Nurse practitioners, clinical nurse specialists, nurse anaesthesiologists, and nurse midwives are other examples of advanced practice registered nurses that have the ability to assess, diagnose, and manage patient issues as well as order tests and write prescriptions. The duties of a Certified Nurse Practitioner include disease prevention, diagnosis, treatment, and management of both acute and chronic illnesses. For patients in family clinics, paediatrics, new-borns, the elderly, mental health, female health, and gender-related groups, they offer initial, ongoing, and comprehensive care. Patients, nurses, nursing practices, healthcare systems, and organizations all fall under the purview of the clinical nurse specialist. The Clinical Nurse Specialist is responsible for the diagnosis and

treatment of the health status of individuals, families, groups and communities, disease management, health promotion and prevention of diseases and dangerous behaviours (McHugh & Lake, 2010).

Moreover, Certified Registered Nurse Anaesthetist is prepared to provide comprehensive patient anaesthesia care and anaesthesia related care for individuals throughout the life cycle, which is provided in different environments, including hospital operating theatres. Certified Nurse-Midwife provides women with comprehensive primary health care services throughout the life cycle, including gynaecological care, family planning services, pre-pregnancy care, prenatal and post-natal care, delivery, and new-born care. Such care is provided in different environments, which may include families, hospitals, delivery centres and various outpatient care environments, including private offices and community and public health clinics. Doctor of Nursing Practice is a senior nursing role of clinical practice and leadership (McHugh & Lake, 2010).

Nursing in operation theatre is one part of surgical nursing. Surgical nursing has different areas of specialization such as orthopaedics, ophthalmology, obstetrics, aesthetics, and other areas requiring surgical intervention. Surgical nurses work closely with the surgical team, so the work of surgical nurses is complex. Operating theatre nurses work before and after the operation (NHS, 2017).

In addition, surgical nurses are responsible for the health of the patients being operated on. The surgical nurse must examine the patient who has just been operated on to ensure that he or she is in good condition. They are also responsible for ensuring that all other treatments necessary for the patient's full recovery are carried out. They may also be trained in post-operative counselling, as they will be in close contact with the patient during the rehabilitation phase (NHS, 2017).

2.2 Operation Theatre and Intraoperative Nursing

The operating theatre, as the place where surgery is performed on patients, is a very important healthcare setting in hospitals. The operating theatre is used for operations requiring a clean, neat, and sterile environment. The operating theatre is a sterile area, it has four distinct zones - a protection zone, a cleaning zone, a sterile zone, and a disposal zone. The operating theatre is divided into these areas to provide patients with the highest standards of medical care so that the

operation is performed in a sterile environment and patients can recover without infection (Gupta et al., 2015, p. 190-194).

The protection zone forms a barrier between the clean area and other less clean areas of the hospital. The area includes common rooms and lockers for surgeons, doctors, and staff. There is a meeting room for staff and doctors. This area includes staff changing rooms, a dispatch room, toilets, storage, and a patient reception area. Here the patient and the staff remove their footwear and change to the operating theatre dress (Gupta et al., 2015)).

The cleaning zone is located around the sterile area and are only accessible to those who change coats and are ready to transport patients and cleaners from the tent cart to the surgical stretcher in the storeroom. This area includes a storage area for clean surgical equipment, a waiting area for patients before surgery, a post-operative rehabilitation room for patients, a gypsum room, a blood storage room, a mobile X-ray machine, a dark room, a staff room, and an anaesthesia room (Gupta et al., 2015, p. 190-194).

In sterile area, there is an Anaesthesia Section and a Disinfection Supply Section. The operating theatre is surrounded by a central sterile working area, the operating theatre itself. The highest purity and sterility are provided here. The disposal area is a passageway for the disposal of old equipment and surgical waste. This area should have separate access to the outside corridors. Access to the treatment area is only possible from one direction (Gupta et al., 2015, p. 190-194).

The intraoperative nursing refers to the transfer of a surgical patient to the operating theatre, performing anaesthesia, completing surgery, and then transporting the patient to the recovery room (Sue C. & Patricia Kelly Ladner, 2005, 764). Upon arrival in the operating theatre, must present all relevant documents and necessary information, examine the patient's medical history for special information, and recommend a verbal verification if possible (Fiona McArthur-Rouse & Sylvia Prosser, 2008, 20).

The intraoperative nurse is a specialist registered nurse who assists the surgical team in performing surgery. Intraoperative nurses specialize in aseptic technique and are responsible for scrubbing, circulating or anaesthetic care. In addition, they supervise other members of the surgical

team and work activities in the operating theatre, coordinate operating theatre personnel and mediate between various hospital departments, surgeons, and other health care staff (Woodhead & Wicker, 2005).

At the same time, intraoperative nurses are expected to remain familiar with the entire operating theatre environment, to continually assess the safety and health of patients in the operating theatre, to anticipate potential risk factors that may affect the health of patients, and to promote confidentiality and protect the dignity of patients during anaesthesia (Fairchild, 1993, 6). Their tasks also include the care given during surgical interventions, as well as the management of nursing activities related to specific ongoing surgical procedures (Fairchild, 1993, 7).

Nurses work in operation theatre are nurse anaesthetists, scrub nurses, circulating nurses. The nurse anaesthetist is a registered nurse. Prior to the start of surgery, the nurse anaesthetist performs a pre-anaesthetic screening which includes a physical assessment and interview of the patient and records the results, develops an anaesthetic care plan, assesses the patient's medical history to predict the response to anaesthesia and obtains the patient's informed consent to the anaesthetic procedure. When the patient arrives in the operating theatre, the nurse anaesthetist assists the anaesthetist in the assessment of the patient's physical condition, the use of tracheal intubation, mechanical ventilation, and pharmacological support (Smeltzer & Bare, 2000, 311).

During the procedure, the nurse anaesthetist assists the anaesthetist in administering anaesthesia, keeps the patient asleep or pain-free during the procedure, monitors the patient's vital signs and every biological function, is responsible for all questions regarding the administration of medication during the procedure and supervises the patient's recovery from anaesthesia (Smeltzer & Pare, 2000, 311). At the end of the procedure, the nurse anaesthetist is required to assess the patient's post-operative or post-anaesthetic response to ensure that the patient's condition is stable, and finally to send the patient and the documented documentation to the post-anaesthetic care unit and inform the patient of the anaesthetic and surgical procedure, transferring responsibilities to the local nursing staff (Smit-Fun et al., 2020).

Additionally, the scrub nurse is also a registered nurse. Scrub nurses are responsible for patients and equipment. Their main activities include scrubbing surgery, setting up sterile tables, and

assisting surgeons and surgical assistants in predicting the instruments and equipment needed during surgery. The scrub nurse must hand over the equipment to the surgeon as required. They should have a good understanding of each device and should not confuse different devices to be able to respond to the surgeon's request calmly and quickly. The scrub nurse is also responsible for the inventory of all equipment, especially after surgery. When the operation is over, the scrub nurse counts all needles, sponges, and instruments to ensure they are considered. This role is based on anatomical knowledge, rigorous aseptic techniques, and surgical sequencing procedures (Fairchild, 1993; Smeltzer & Bare, 2000, 316).

In addition, the circulating nurse is a registered nurse who works outside the sterile area and manages the activities of the operating theatre. The main responsibilities of the circulating nurse include ensuring that consent forms are signed, coordinating patient care before and after surgery, ensuring that the operating theatre is clean, appropriate temperature, humidity and lighting, safe operation of equipment and the provision of materials and supplies for the sterile team. In the meantime, they are also tasked with overseeing aseptic technique, identifying, and eliminating environmental hazards to the patient or surgical team, documenting all activities during the operation, and ensuring that all sponges, tools, and sharps are counted for wear and tear. They are also responsible for managing the flow of information, the exchange of information between members of the surgical team and the transmission of relevant information to the family (Fairchild, 1993, 724; Smeltzer & Bare, 2000, 316).

2.3 Occupation Protection Intervention in Nursing

Occupational safety is a multidisciplinary field concerned with the safety, health, and welfare of individuals at work. It is also known as occupational health and safety (OHS), occupational health, or occupational safety e.g. in an occupation. Because they also allude to the field's objectives, these terms were initially used as an acronym for occupational safety and health program/department/etc (Alli, 2008). An occupational safety and health program's goal is to promote a safe and healthy work environment. OSH protects all members of the general public who may be affected by the workplace environment (Alli, 2002).

The International Council of Nurses (ICN) believes that every nurse has the right to work in a healthy, safe environment free of work-related injury or illness. Occupational health and safety entails anticipating, identifying, assessing, and controlling hazards that may be harmful to workers' health and well-being in the workplace, while also considering the potential impact on the surrounding community and the environment in general. The potential impact on the surrounding community and the environment in general is considered. (International Council of Nurses, 2009)

The working environment of healthcare workers is regarded as one of the most hazardous, and nurses are frequently exposed to health risks. Occupational injuries and illness increase psychological stress and job dissatisfaction, which frequently leads to increased turnover, exacerbating the nursing shortage and compounding the nursing workforce problem. Safeguarding nurses' health and well-being benefits individual nurses, patients, families, and communities, as well as healthcare institutions and systems. (International Council of Nurses, 2009)

A safe working environment in the health sector is critical for providing quality nursing care and promoting a stronger workforce. Biological; viruses, bacteria; chemical: glutaraldehyde, cyto-toxic drugs; ergonomic: overwork, falls, lifting; physical: radiation, sharps; and psychological: shift work, excessive workload, violence, stress, hazards have all been identified in the healthcare environment. Increased demand for care and health care, as well as poor ergonomics and ineffective staffing and shift patterns, all increase the likelihood of exposure to these hazards. (International Council of Nurses, 2009)

Because of the unique nature of nurses' work, many occupational hazards exist in their day-to-day clinical activities, such as direct contact with patients' blood, body fluids, secretions, and excretions, as well as the presence of numerous health hazards in wards, such as volatile chemical disinfectants, ultraviolet rays, radiation, sharps, and electrical equipment. The occupational hazards that nurses face because of medical care reform and development are rapidly becoming more apparent. To minimize occupational hazards and maximize nurses' own health protection, you should obtain the necessary knowledge and training through various types of study, be fully aware of all risk factors, and improve your own protection while working as a nurse. (International Council of Nurses, 2009)

3 Aim, Purpose and Research Question

Aim: To explore the issue of occupational protection for nursing staff in the operating theatre.

Purpose: To reduce the health risks to nurses working in the operating theatre and to provide the best possible working environment, including the equipment and facilities in the operating theatre, the hospital system and the awareness of the nurses themselves.

Research question: What are the occupational protection interventions for nursing staff in the operating theatre?

4 Method

4.1 Literature review

A systematic literature search is regarded as an essential component of the systematic evaluation process. It entails a systematic search of research and aims to provide a transparent identification of research, making it clear to the reader what steps were taken to identify studies and how the review's findings fit within the relevant evidence. (Cooper et al., 2018)

Literature review is a method that contributes to maximising the pertinence, novelty, universality and influence of article (Maggio et al., 2016). Knopf defines a literature review as *“a systematic method for identifying, evaluating, and interpreting work produced by researchers, scholars, and practitioners”* (Knopf, 2006).

The literature review is a method of essay writing that helps any researcher by providing context, informing methodology, identifying innovations, minimising duplication of research and ensuring professional standards are met. A literature review can take many forms, and depending on the type of article or particular subject, these presentations will vary in approach, rigour, and depth of writing. (Knopf, 2006)

Researchers will use scientific databases and search engines to find most of the information they need. Information that meets the needs of researchers can also be called good information, and researchers can use this information to conduct literature searches. As nursing research covers a wide range of disciplines, researchers should use search tools that include disciplines other than nursing: psychology, education and anthropology; and cover a wide range of publication types: reports, standards, conference abstracts and books. (Maggio et al., 2016)

It is important to use this method not simply to list examples of the information gathered in an article, but to combine the information into a whole that works together and remains well organised. It can help the researcher to give a holistic view of a range of research that is unfamiliar to the reader. It can help the researcher to look for and identify problems or gaps in existing research work. It can reveal what has been done well, avoiding theoretical repetition and saving time. It can provide the researcher with new ideas. It allows the study to be placed in a larger context so that the researcher can illustrate what new conclusions might be drawn from the study. (Knopf, 2006)

4.2 Literature search

Author 1: The studies used in this review were taken from CINAHL and PubMed, two databases. The key words "Occupational Protection Interventions", "Nursing Staff", and "Operating Theatre" were also utilized, together with their acronyms and synonyms, as well as the Boolean operators "AND" and "OR". English language publication between 2013 and 2023, full text accessibility, and relevance to the study subject were all inclusion criteria. Articles published before 2013 that weren't in English, couldn't be read in full, or weren't pertinent to the research were excluded. PICOS was used for an initial search, as indicated in Table 1 below.

P: Population (participants)	Operating theatre nursing staff
I: Phenomena of Interest	Any interventions used to reduce health risks for nurses working in theatre
Co: Context	Worldwide working in a clinical setting OR studying at school
S: Types of studies	Published between 2013 to date, English language, full text available.

Table 1. PICOS Criteria (Author 1)

The papers chosen by the writers for inclusion in the review were given a Hawker score after following a step-by-step procedure. In Figure 1, this is displayed. The PubMed and CINAHL databases yielded a total of 318 studies after the use of keywords and Boolean procedures. 30 studies were eliminated once it was discovered that they were duplicates. 25 studies were chosen from the remaining 288 research articles after they had been reviewed based on their titles, abstracts, and relevance to the study topic. Based on the responses to the research topics, the final 9 studies were chosen. (Appendices 1 and 2).

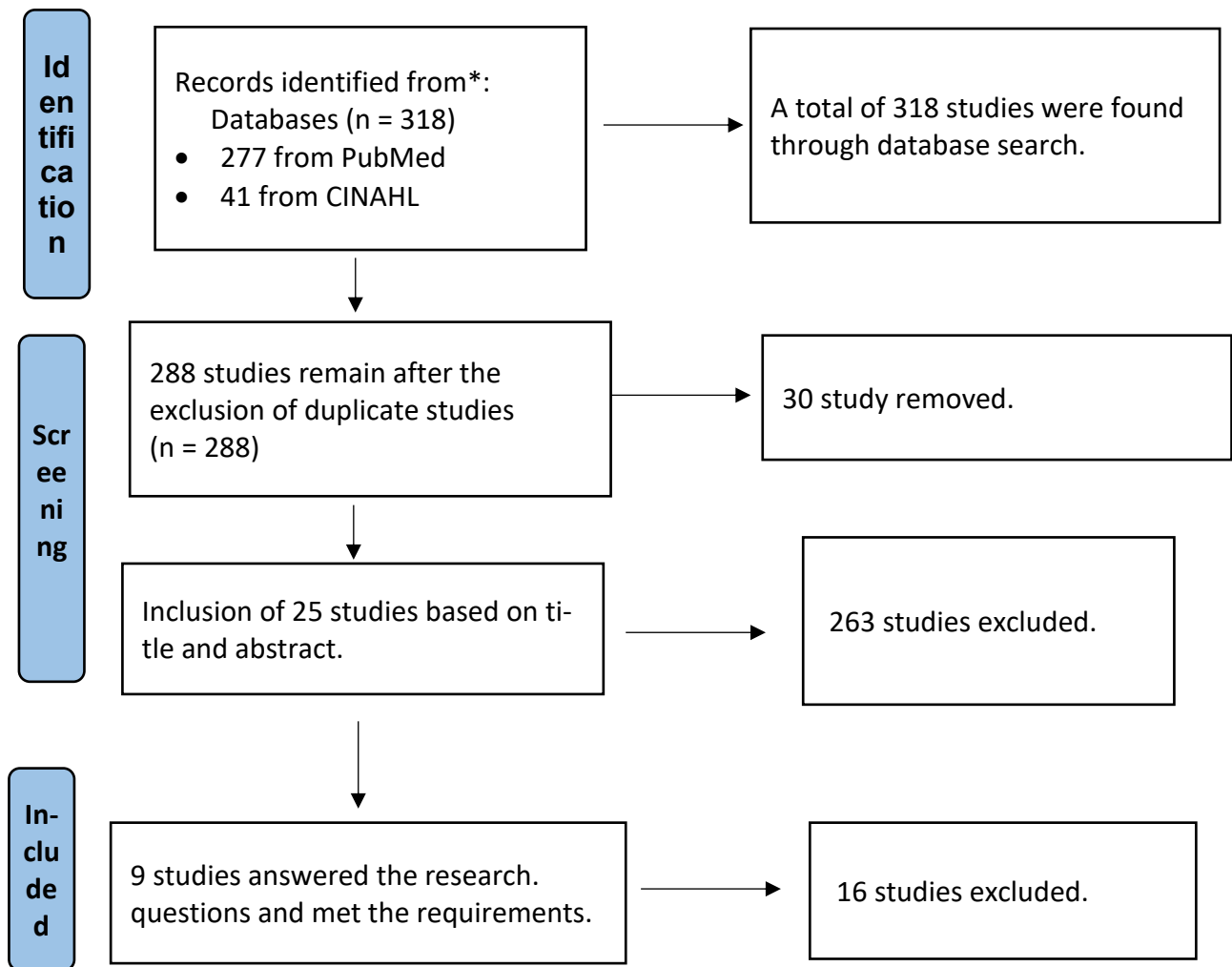


Figure 1: Inclusion and exclusion process. (Author 1)

Author 2: The research in this review comes from PUBMED and CINAHL databases. Use the Boolean operators "and" and "or", as well as the keywords "operating theatre", "nursing staff", "Protective intervention in the operating theatre" and "Occupation Protection in Nursing"; Abbreviations and synonyms of these terms are also used. The selection criteria include the English articles published between 2013 and 2023, the full text available and the answers or contents to the research questions. It does not contain articles that are not in English, have not been completely read or have nothing to do with research before 2013. Preliminary search using PICOS, as shown in Table 2 below.

P: Population (participants)	Nursing staff working in the operating theatre
I: Phenomena of Interest	Current situation OR Protective intervention in the operating theatre OR Occupation Protection in Nursing
Co: Context	Work in operating theatre environments worldwide
S: Types of studies	Published between 2012 to date, English language, full text available

Table 2 PICOS Criteria (Author 2)

The author selects the articles to be viewed through the progressive process and specifies Hawk to evaluate the selected articles. As shown in Figure 1. In the databases of PubMed and CINAHL, 262 studies using keywords and Boolean operators have been found. 12 Repeat the test results and delete them. The remaining 250 studies were selected according to the title and summary, and 26 studies were conducted to prove their relevance and relevance to the research topic. The last ten studies were selected based on the answers to the research questions (Appendix 3 & Appendix 4).

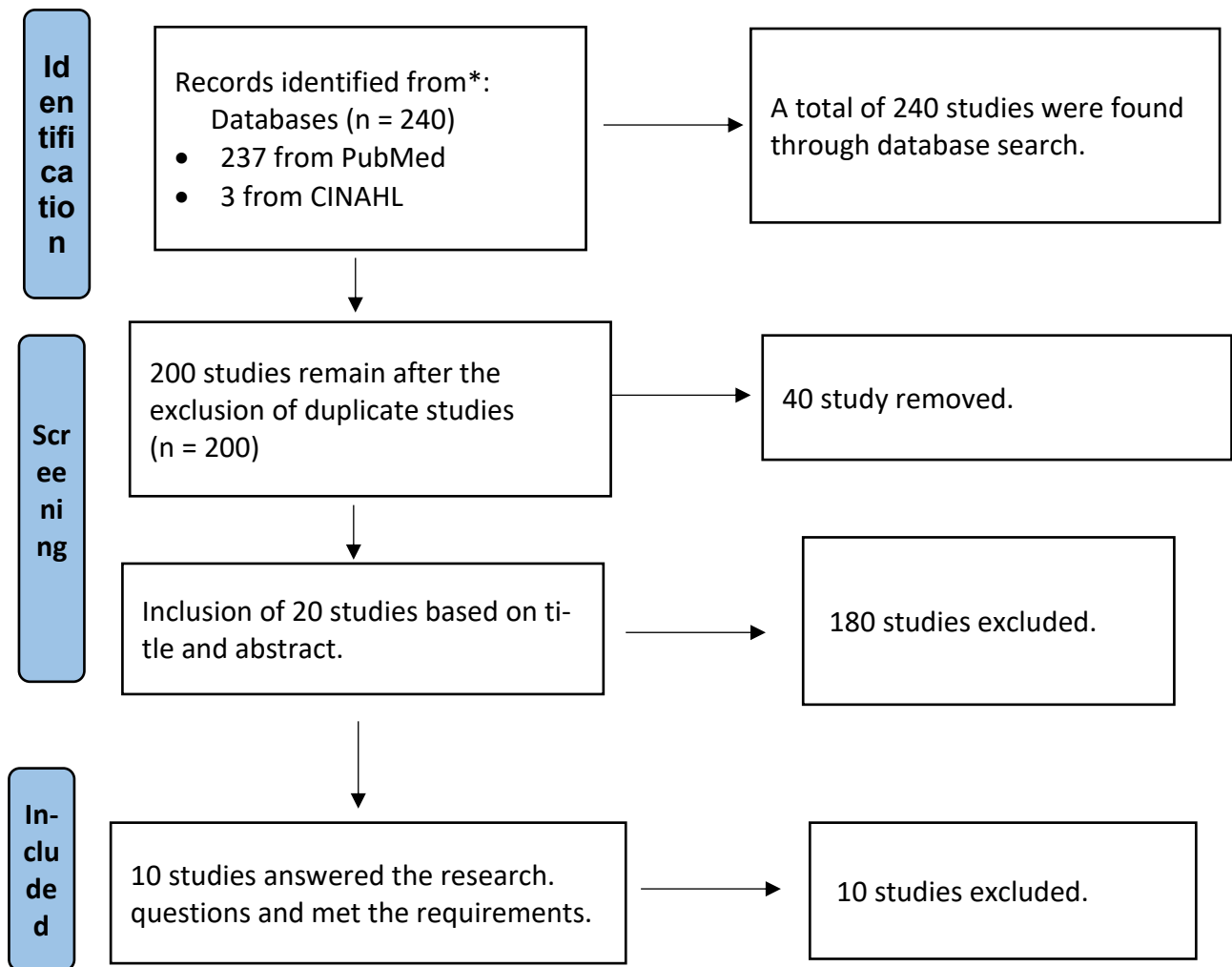


Figure 2: Inclusion and exclusion process. (Author 2)

4.3 Data analysis

According to (Haggarty, 1996), content analysis is a research technique that enables a systematic and trustworthy analysis of the qualitative data gathered during a study so that it can be generalized in accordance with the categories of interest to the researcher. Decontextualization, recontextualization, classification, and compilation are its four primary phases, according to (Bengtsson, 2016). It is ideal for diagnosing complex and sensitive events in nursing work since content analysis methods have the advantage of being able to manage huge volumes of textual material and many documentary sources that may be utilized to corroborate evidence (Elo & Kyngäs, 2008). The author used an inductive content analysis approach, working from the specific to the general, due to the author's lack of prior understanding of the phenomenon and the fragmented nature of the information available on it.

Author 1: After reading the article, the words are refined into fewer content-related categories re-grouped through content analysis and used to describe aspects of the content. These regrouped phrases will be coded into higher level headings. These codes will be categorised into higher level headings. Similar sub-categories are grouped into categories, while categories are grouped into larger categories.

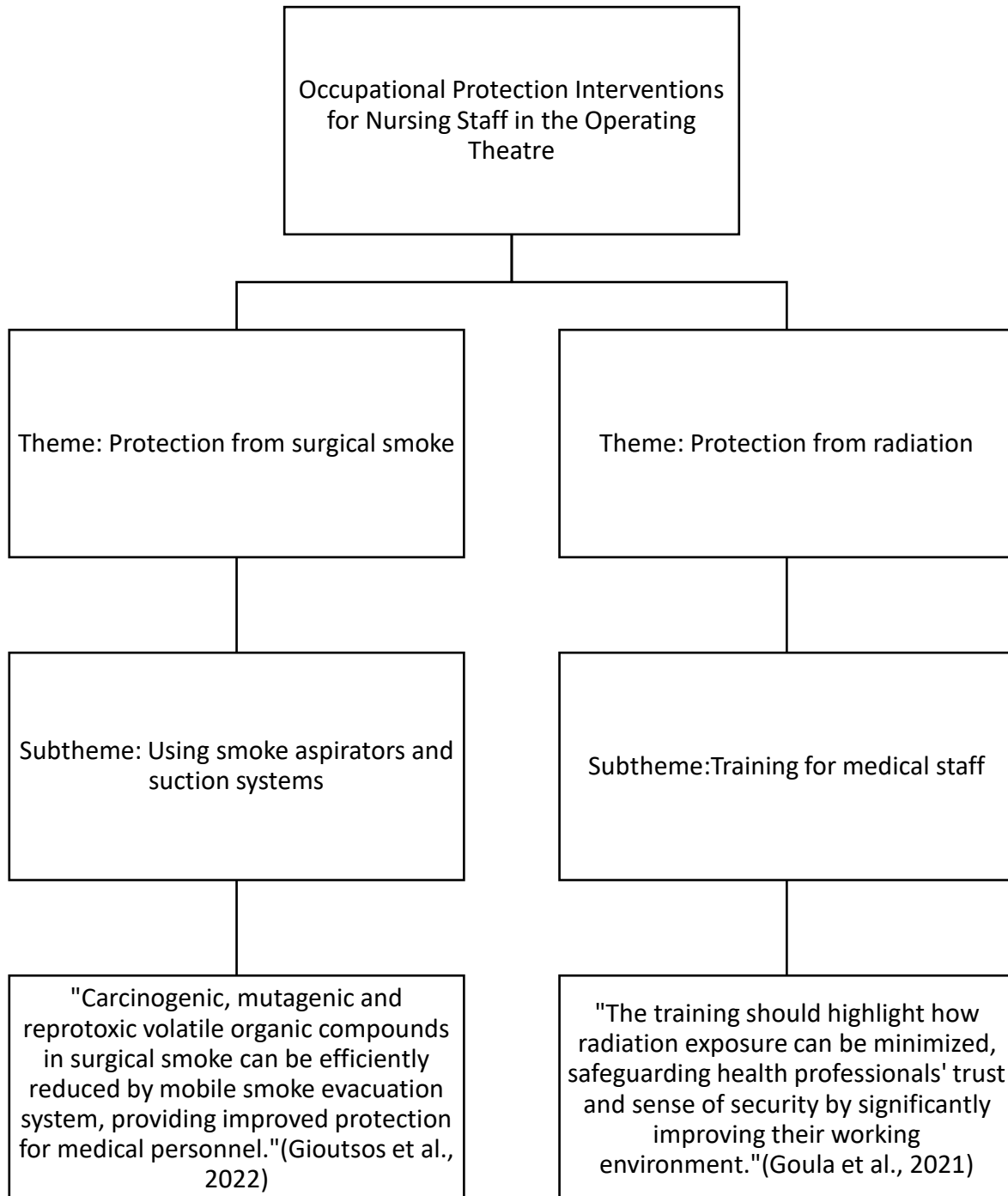


Figure 3: Data analysis process (Author 1)

Author 2: When words, phrases, sentences, etc. They have the same meaning. They can be extracted from fewer content categories through content analysis. To extract data from the article, we need to use different terms to describe different aspects of the content and include a wide range of content in the top title. Then, according to the content hierarchy, place different labels in the following subtitles in turn. Figure 4 illustrates this process.

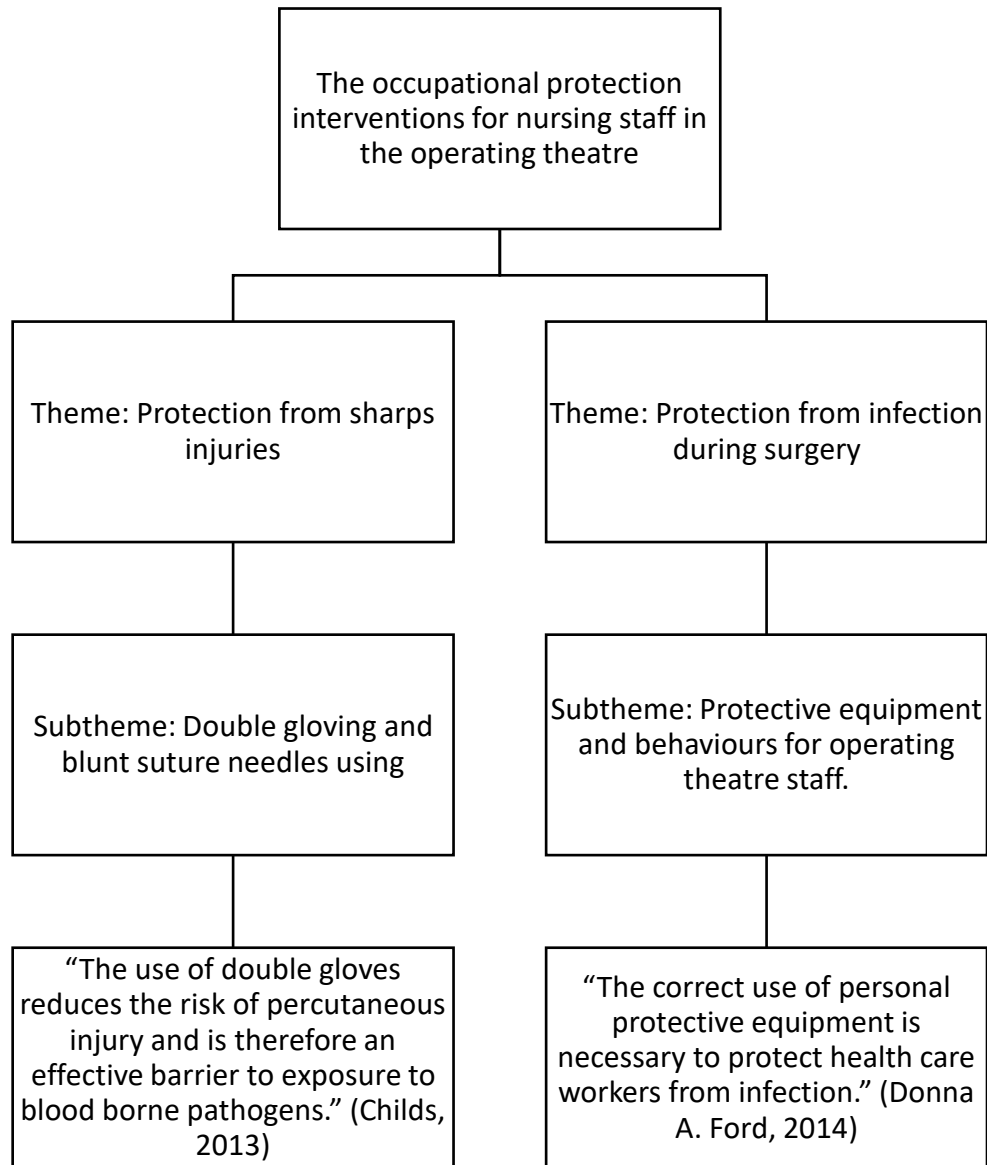


Figure 4 Data analysis process (Author 2)

Author 1 selected 9 articles, Author 2 selected 10 articles, and deleted 1 duplicate item. A total of 18 articles were selected and they were combined in the data analysis.

5 Results

Author 1 selected 9 articles, Author 2 selected 10 articles, and deleted 1 duplicate item. A total of 18 articles were selected and they were combined in the data analysis. The combined analysis resulted in four themes of occupational protection interventions for operating theatre nursing staff: operating theatre smoke protection, radiation protection, protection from sharp injury, protection from infection during surgery. The themes and subthemes are shown in Table 3 below.

Table 3: Occupational Protection Interventions for Nursing Staff in the Operating Theatre

Theme	Subthemes
Protection from surgical smoke	<ul style="list-style-type: none"> • Using smoke aspirators and suction systems • Providing knowledge of surgical smoke • Standardise operating procedures
Protection from radiation	<ul style="list-style-type: none"> • Training for nursing staff • Use appropriate shielding.
Protection from sharps injuries	<ul style="list-style-type: none"> • Using double gloving and blunt suture needles • Use of sharps with safety devices • Reducing scalpel injuries interventions • "Hands-free" technique • Administrative controls • Management and handling of sharps
Protection from infection during surgery	<ul style="list-style-type: none"> • Protective equipment • Appropriate behaviors • An efficient ventilation system

5.1 Protection from surgical smoke

Using smoke aspirators and suction systems

The self-protective behaviour of nursing staff in the operating theatre can be enhanced by the innovative design of easy-to-breathe, protective and low-cost surgical smoke protection devices (Yu et al., 2022). Research has shown that the health risks from mixtures of substances and repeated exposure to surgical smoke can be significantly reduced by the consistent use of additional mobile evacuation systems designed for this purpose. Currently, not every operating theatre is equipped

with a room ventilation system, in which case a mobile evacuation system is a more economical solution (Gioutsos et al., 2022).

By efficiently reducing the carcinogenic, mutagenic, and reproductively hazardous volatile organic chemicals in surgical smoke, mobile smoke evacuation devices provide protection for nursing staff (Rosely & Hamedon, 2019). Positive laminar flow airflow systems are frequently used in operating theatres to help with the exhaust of volatile organic compounds and to decrease surgical site infections. Smoke evacuation devices are the sole way to minimize or lessen exposure to volatile organic compounds (VOCs) if surgery must be done in a space with a negative pressure ventilation system due to infectious conditions (Gioutsos et al., 2022).

The most efficient suction instruments are those made expressly for removing smoke. For operating theatres with laminar airflow systems, smoke evacuation devices are a practical substitute or additional system. By using them regularly, exposure to volatile organic chemicals can be considerably reduced. The level of noise exposure for surgeons is highest when utilizing the other handpieces examined and lowest when using flexible foam funnels. Despite being the most effective equipment with the lowest noise emission rate, the flexible foam suction device is only appropriate for a few surgical wounds. Contrarily, cautery-integrated smoke evacuation devices appear to be the ideal option for bigger incisions since they combine effective smoke evacuation with minimal noise emission. With regard to the latter, it should be mentioned that none of the devices produce dBA levels higher than those that occur in normal conversation (Gioutsos et al., 2022).

Providing knowledge of surgical smoke

Firstly, it is important that operating theatre staff are aware of the sources and components of smoke in the operating theatre so that they can better identify them and take the correct protective intervention. They need to know exactly which surgical procedures produce smoke, what it consists of what chemicals and biological substances are present and how they affect the body. (Yu et al., 2022)

Secondly, operating theatre staff need to know how to use personal protective equipment correctly. This includes wearing appropriate protective equipment such as gloves, masks, goggles, and gowns to protect themselves from fumes and hazardous substances. (Yu et al., 2022)

In addition, operating theatre staff need to know the correct smoke evacuation policy and how to respond in the event of smoke overload. They need to be aware of the operating theatre's ventilation system and air quality monitoring equipment, and how to take emergency intervention in case of an accident. In addition, theatre staff should know how to handle smoke in theatre properly. They need to be aware of the smoke handling equipment in the operating theatre and how to properly dispose of waste surgical materials and smoke. Improving nurses' self-awareness of the hazards of surgical smoke by providing correct knowledge of surgical smoke, self-protection strategies to improve attitudes to surgical smoke, and promoting the health of nurses in the operating theatre is important to increase the surgical team's focus on proper use of self-protective equipment and implementation of surgical smoke evacuation policies. (Yu et al., 2022)

The results of the study showed that "no in-service education on surgical smoke concepts during in-service", "surgical smoke attitude scores" and "surgical smoke Self-protective behaviours were significantly associated with 'in-service education on surgical smoke concepts', 'surgical smoke attitude scores' and 'resistance factor scores on surgical smoke'. (Yu et al., 2022)

Standardising operating procedures

Research has shown that smoke exposure can be reduced, the quality of surgery improved and the health of the surgical team and patients maintained by establishing a smoke-free workplace (Yu et al., 2022). Hospital directors in nursing and hospital administration need to focus on the safety and health of operating theatre staff by establishing smoke removal policies, monitoring surgical smoke self-protective behaviours of operating theatre staff, and providing adequate and sufficient surgical smoke equipment and utilities (Rosely & Hamedon, 2019).

The first step is to establish a clear operating theatre smoke management policy, including sources of smoke production and steps for smoke management, to ensure that every nurse understands how operating theatre smoke should be handled. This should be followed by providing the

necessary training and education to healthcare staff on the hazards, precautions, and treatment of smoke in the operating theatre to increase awareness and skills. Hospitals should develop standard operating procedures (SOPs) that include steps for the management and handling of smoke in the operating theatre. Nurses should perform tasks in accordance with SOPs to ensure consistency and standardisation of practice (Köze et al., 2022).

Next, appropriate protective equipment such as masks, goggles and gloves may be considered to protect healthcare workers from the hazards of operating theatre smoke. After this healthcare professionals should wear protective equipment correctly and ensure that it is properly cleaned and disinfected before and after use. Finally, hospitals should regularly monitor and evaluate the effectiveness and implementation of their operating theatre smoke management policies and take steps to improve and refine policies and procedures to ensure the safety and health of health care workers (Rosely & Hamedon, 2019).

5.2 Protection from radiation

Training for nursing staff

During the work of each individual, the Hemodynamic Services Units (HSU) carries out professional training, firstly to stimulate theoretical knowledge and then supplementary practice with patients. During regular training, supervisors also ask them to be aware of the exposure of patients, even those who have received a minimum dose during the procedure. (Gallo et al., 2013)

Healthcare workers must be aware of the dangers they face and the steps to take to reduce those risks, both for the benefit of the organization and for their own safety (Gallo et al., 2013). The information presented in educational training seminars should be sufficient to cover all pertinent aspects of radiation protection, with a focus on staff exposure to radiation, related radiation risks, the significance of radiation safety equipment, and the application of theoretical safety knowledge in real-world situations.

Training should emphasize how to reduce radiation exposure, maintain confidence and security, and significantly improve the working environment while keeping in mind the three main

principles of radiation protection: justification, protection optimization, and dose limitation application. All of the aforementioned can change the unfavorable views that healthcare personnel may have, which will undoubtedly enhance the services offered (Goula et al., 2021).

There appears to be a lack of compliance and understanding of radiation protection among trauma surgeons and technical assistants. Operating theatre nursing staff may overestimate their level of understanding of radiation protection, which can be dangerous given the increased radiation exposure. We therefore support rapid and effective training for trauma surgeons and other nursing staff to address key precautions (Jentzsch et al., 2015).

Use appropriate shielding

Regarding safety and security intervention, it has been observed that in most cases workers limit the intervention taken in relation to ergonomic and biological risks to the detriment of others, particularly regarding the barrier intervention that must be taken each time protective lead is used and knowledge of the monthly dosimeter reports. No professionals were found to refuse to use personal protective equipment, particularly in relation to radiation protection. Controls for available equipment, such as quality assurance and occupational exposure, were reported in all four services inspected, every two years and every four years, as required by current regulations and the National Commission for Environmental Protection. This helps professionals to have no doubts about their working environment and thus contributes to their occupational health and safety (Gallo et al., 2013). These include using image intensifiers close to the patient and surgeon, wearing dosimetry and protective gear, reducing the X-ray time, and changing the C-arm's preferred anterior and posterior positioning, maximum distance, collimation, and voltage. Additionally, it may be helpful for training purposes to utilize visual feedback for complex and potentially dangerous radiation facts (Jentzsch et al., 2015).

According to the study institution's standard operating procedures, two shields were always placed between the patient and the doctor: a lower lead shield attached to the operating table's side that extended to the floor, and an upper lead shield mounted on the ceiling with a contoured patient incision. Disposable radiation-absorbing pads may be used at the surgeon and staff's discretion. Staff members dress in customary lead attire, such as thyroid collars, aprons, and lead

skirts. The use of auxiliary lead shielding is associated with a reduction in radiation exposure of nurses and scrub technicians of about two thirds during cardiac catheterization, and it is a straightforward and very inexpensive means of providing dedicated auxiliary lead shielding. This effective approach of radiation protection for personnel is nonetheless linked to a considerable drop in E Physician radiation exposure has been successfully reduced in the past by the use of supplementary shields. (Madder et al., 2018)

5.3 Protection from sharps injuries

Double gloving and blunt suture needles using

The study by Tammy Childs (2013) reported that surgical team members, particularly, scrubbers who pass instruments to surgeons have a higher incidence of skin damage and exposure to body fluids, blood and other potentially infectious substances than health care workers in non-surgical areas. Ford's (2014) study further found that the main sources of injury are due to the frequent handling of dangerous equipment and sharp instruments, the breakage of the glove barrier poses a risk of transmission of blood borne pathogens during surgery, as well as skin exposure to large amounts of blood, body fluids and other potentially infectious substances.

Double gloving and double gloving with an indication glove system are both protective against percutaneous injuries and lessen the likelihood of glove perforation, according to Walczak et al. (2020). Wearing two pairs of gloves is a simple and highly efficient technique to lower the risk of bloodborne infections, which is a regular occurrence during surgery. Surgical team members who wear double gloves notice blood stains on their hands less frequently following surgery than those who wear single gloves. Additionally, compared to those wearing just the gloves, those using the recommended glove system changed their gloves a lot more frequently during surgery.

The evidence Tammy Childs (2013) found strongly supports the use of double gloves instead of single glove to reduce the number of perforations in the innermost glove next to the skin of surgical team members, thereby reducing the number of percutaneous injuries among surgical personnel. Km et al. (2013) agree that the deformation of double layer gloves, such as three-layer gloves, knitted gloves, and wearing cloth pads between latex gloves, has also been proven to prevent

perforation of the innermost glove. On the other hand, glove piercings are not normally detected by the user. It is therefore Ford (2014) recommended that personnel wearing gloves use a perforation indication system, as not only are perforations more visible, but they are also detected more frequently. In the event of glove perforation, virus suppressive gloves can be worn to reduce the amount of virus transmission, especially during surgical procedures where the risk of glove perforation is high.

Km et al. (2013) study findings showed that there is a large amount of high-quality evidence that the use of blunt suture needles can markedly reduce the risk of percutaneous injury for surgical personnel, supports the use of blunt-ended sutures to close muscles and fascia. During surgery, using blunt needles can reduce the risk of glove perforation and self-reported injury compared to traditional suture needles. This result has been reported and confirmed in nearly 3000 surgeries, including appendicitis, lymphadenitis, and abdominal surgery.

Use of sharps with safety devices

According to the study by Km et al. (2013), members of the surgical team must employ sharps with safety-engineered devices to isolate or remove the danger of exposure to bloodborne pathogens when sharps cannot be completely eradicated. Sharps with built-in safety features, such as blunt-ended suture needles, safety scalpels, and safety-engineered syringes and needles, help prevent sharps injuries. Fascial closure devices, tissue sutures, tissue adhesives, and adhesive skin closure tapes are further wound closure methods and needle-free techniques for successful per-cutaneous damage avoidance (Km et al., 2013).

Reducing scalpel injuries interventions

The findings by Lakbala et al. (2014) reveal that standard precautions, programmes recommended by professional health organisations, the use of neutral zones and safely designed devices all contributed to a reduction in the incidence of injuries from specific types of sharps. Particularly notable was the impact of precautions such as the use of safety device equipment, protective masks and gowns, and the reduction or complete elimination of needle reloading and removal of needles, which led to a significant reduction in the rate of injuries caused by hollow needles. In

addition, to reduce sharps injuries in the operating theatre, training, and awareness of safety intervention for those at risk is necessary.

The findings of Paterson et al. (2021) found another measure is to replace the scalpel with a surgical instrument, which retains its haemostatic performance advantages, although the conventional electro-surgical unit lacks the inherent sharpness, low precision, deep thermal damage and delayed wound healing of the scalpel. However, there is also a better alternative, a surgical system that uses pulsed radiofrequency energy-induced electro-surgical plasma to cut and coagulate tissue as a precise anatomical method for simultaneous haemostasis, and this surgical system results in less thermal damage and significantly lower inflammatory cell counts and produces stronger healing incision strength compared to conventional electro-surgery. As a result, the risk of accidental cuts or burns to nurses and other members of the surgical team is eliminated when the surgeon completes the incision and sets down the instruments.

"Hands-free" technique

According to Km et al.'s (2013) study, hand-to-hand handling of sharp objects like needles, blades, and other tools is a significant contributor to percutaneous injury. As a result, it is advisable to adopt "hands-free" techniques to reduce manual handling of sharp objects with gloved hands. "Hands-free" approach refers to the use of a neutral zone to pass any sharp instrument, such as a scalpel, needle, etc., rather than moving items from one hand to the other. Therefore, using a neutral zone prevents two members of the surgical team from using a sharp object at the same time. For example, when in the needle holder, the scrubbed team member should place the needle in the suture pack and use the suture pack to position the needle in the needle holder. The scrubbed team member should then reposition the needle using the one-handed technique and place it in the needle box in the sterile field.

Administrative controls

According to (Donna A., 2014) findings, healthcare facilities are required to have a bloodborne pathogen exposure control plan. This plan must include exposure assessments for workers who may be exposed to blood and bodily fluids, a strategy for reducing sharps injuries, including

strategies for prioritizing risk reduction, and a procedure for tracking sharps injury data. The plan must be reviewed and updated at least annually, and it is important to ensure compliance with this control plan and related policies, which demonstrate a commitment to sharps injury prevention. In addition, administrative staff work with the infection prevention department to develop the exposure control plan. Frontline staff, including nurses, surgeons, and members of the surgical team, should be involved in identifying control methods to prevent sharps injuries.

Management and handling of sharp equipment

In Donna A's (2014) study, the author found that when dealing with disposable or reusable sharp devices, work practice control can change the way tasks are performed. To successfully implement work practice control, surgical team members need to understand the potential dangers of current practice and be willing to change their approach and then practice in a new, safer way all the time, so proper education and guidance is important in the process.

The safe handling of sharp objects is important. Injuries to sharp objects can occur if they are left on the floor or table, or if they protrude from rubbish bags or disposal containers. Sharp containers should be able to hold the necessary kind of sharps while also being large enough to prevent leaks and punctures. Containers should be easily recognized, situated close to the point of usage, and be visible. As soon as the level becomes apparent, containers need to be replaced. When placing needles and other sharp objects on sterile locations, nursing staff should use counting devices. To protect the surgical team's members from damage, it is crucial to carefully identify and separate contaminated disposable and reusable sharps. Reusable sharps should be clearly segregated on a box trolley for easy identification (Donna A., 2014).

5.4 Protection from Infection during surgery

Protective equipment

According to the (Wicker & Dalby, 2016) study, the hospital supplies workers with personal protective equipment such gowns, gloves, masks, aprons, goggles, helmets, and disposable fluid-proof shoe covers to protect them from cross-contamination. Wearing protective eyewear during

surgery is crucial to preventing splashes of substances into the eyes, such as blood, tissue, bodily fluids, infectious material, or faces. Therefore, the surgical team is advised to use a mask with a full-face shield, glasses, or goggles. Regular glasses, on the other hand, are not regarded as a safe form of protection since they frequently permit splashes of microorganisms to enter the eyes, potentially posing a cross-contamination issue for members of the surgical team.

According to (Yu et al., 2022b) findings, everyone entering the operating theatre must wear a specialized surgical gown to prevent cross-contamination between patients and practitioners. Before staff exits the operation theatre, all personal protective equipment, such as masks, gowns, and shoe cover, must also be taken off. If shoe covers are not worn, before leaving the operation theatre, shoes that have been saturated in blood, bodily fluids, or pus must be taken off and disinfected.

Appropriate behaviours

Lo Giudice et al. (2019) has similar findings. It is considered inappropriate practice for staff to leave the operating theatre in their normal surgical gowns according to strict hospital regulations. If a surgical gown is soiled, the staff member should also change it, especially if he or she needs to be transferred to another operating theatre. For example, if a nurse attended a tonsillectomy surgery in the morning and then moved to a vascular surgery in the afternoon, he or she would need to change theatre scrubs because of the risk of cross-contamination of microorganisms that would be transferred from the previous operating theatre to the next.

In line with this, Wicker & Dalby (2016) reported that for self-protection, members of the surgical team should follow the following points in the operating theatre. Using a disposable surgical cap that covers the hair. It is important to wear a surgical mask at the start of a sterile procedure. Staff should use a new mask for each new surgical procedure and masks should be disposable after use. In addition, surgical gowns contaminated with blood or body fluids must be changed as soon as possible to prevent infection. Disposable shoe covers are worn in some operating theatres but are not usually worn as removing them can lead to hand infections. However, if they have been torn, they must be replaced when it becomes apparent that they are contaminated and removed before leaving the operating theatre.

An efficient ventilation system

Protecting the health of patients and nursing personnel in the operating theatre environment requires effective microbial infection control. According to a study by (Romano, Milani, Ricci, et al., 2020), effective ventilation systems in healthcare facilities maintain a low level of contamination of airborne particles and microorganisms in the environment, lowering the risk of airborne infections and ensuring healthy and safe working conditions for healthcare personnel.

The study also shows that ventilation systems and air contamination levels are strongly correlated, and efficient ventilation systems can dramatically lower infection rates. Laminar flow ventilation is the most typical type of ventilation utilized in operating theatres, where massive air supply diffusers deliver a uniform flow of clean air through the surgical area to eliminate microbiological pollutants. Numerous studies have demonstrated that, according to the dilution principle, laminar flow ventilation is superior to turbulent mixed airflow ventilation in terms of minimizing airborne microorganisms (Romano, Milani, Ricci, et al., 2020).

The study by Romano, Milani, Ricci, et al. (2020) reported that the most popular ventilation system in operating theatres is unidirectional airflow (UDAF), which creates a low turbulence airflow directed from the high efficiency ceiling filter to the floor. Highly induced air mixing diffusers in mixed airflow ventilation supply clean air to lessen the concentration of airborne pollutants in the surroundings. As a result, operating theatres with unidirectional airflow or hybrid (unidirectional airflow + mix) systems can more effectively and quickly dilution and removal of air contaminants from the site of source generation.

6 Discussion

Through a literature review and summary of literature information, this review has managed to identify four main protective interventions for operating theatre nursing staff. The main protective interventions including protection from surgical smoke, protection from radiation, protection from sharps injuries and protection from infection during surgery. Protection from surgical smoke includes using smoke aspirators and suction systems, providing knowledge of surgical smoke, standardizing operating procedures. Protection from radiation including training for nursing staff, using

appropriate shielding. Prevention of sharps injuries including using double gloving and blunt suture needles, using of sharps with safety devices, reducing scalpel injuries interventions, "hands-free" technique, administrative controls, management, and handling of sharps. Protection from infection during surgery includes protective equipment, appropriate behaviors, an efficient ventilation system.

6.1 Discussion of results

The authors of this literature review have found that identified four protective interventions for operating theatre nursing staff including protection from surgical smoke, protection from radiation, protection from sharps injuries and protection from infection during surgery, and these four interventions have proven to be very effective. In addition, these four main protective interventions are associated with specific content such as using smoke aspirators and suction systems, providing knowledge of surgical smoke, standardizing operating procedures; training for nursing staff, using appropriate shielding; using double gloving and blunt suture needles, using of sharps with safety devices, reducing scalpel injuries interventions, "hands-free" technique, administrative controls, management, and handling of sharps; using personal protective equipment, appropriate behaviours, an efficient ventilation system.

Regarding to smoke protection in the operating theatre, Steege et al. (2016) found similar results in a previous study where standard operating procedures developed by hospital management played a large role. The specifics of these procedures should include the use of local exhaust ventilation (LEV) for all surgical smoke producing procedures - electrosurgery and laser surgery and the formulate of these procedures should be derived from the recommendations of industry and government organisations. Therefore, it be ensured that these health and safety procedures protect all healthcare professionals in the operating theatre/area from the effects of surgical smoke.

In addition, Dehghani et al.(2021) in his previous study found a new finding in addition to the conclusions of this literature review, which is that there are several anaesthetic gases to be aware of in addition to operating theatre smoke. Anaesthetic gases e.g. nitrous oxide, halothane, isoflurane, desflurane, sevoflurane, also known as inhaled anaesthetics, are used as the primary therapy for preoperative sedation and as an adjunct to intravenous anaesthetics e.g., midazolam, isoprotterol in the perioperative anaesthetic maintenance setting. Although relatively benign in terms

of immediate adverse effects, anaesthetic gases have been observed to cause malignant hyperthermia in some individuals, which can seriously affect the health of operating theatre care workers if they inhale anaesthetic gases (Clar et al., 2023). The findings of Dehghani et al. (2021) suggest that although occupational exposure to anaesthetic gases was below acceptable levels for all occupations tested except anaesthetists, prolonged exposure to anaesthetic gases may be hazardous to the health of operating theatre nursing staff. Therefore, it is strongly recommended that administrative and technical controls such as continuous testing of anaesthetic machines for leaks, regular checks of ventilation systems using advanced decontamination techniques and regular training of staff be implemented.

Regarding to radiation protection in the operating theatre, this literature review found that radiation protection is vital for operating theatre nursing staff. The findings of this literature review are further endorsed by a study by (Tok et al., 2015) who found that the application of the ALARA principle – as low as reasonably radiation - in areas where fluoroscopy is used is necessary and that it plays an important role in occupational health. In addition, it is important that operating theatre nursing staff receive education on radiation protection, as inadequate education on relevant safety can result in exposed operating theatre nursing staff not having adequate information on relevant safety self-protection and not knowing how to apply effective precautions. Apart from this, it must be mandatory for operating theatre nursing staffs to wear radiation dosimeters and to limit their radiation exposure, and if the dosimeter detects radiation levels above the limit amount, additional protective devices need to be provided.

Furthermore, a study by (Mohapatra et al., 2013) further supports this study finding, which also mentioned in their research that in operating theatres that exceed the annual limit of the International Commission on radiation protection (ICRP), 30% of the personnel need to receive retraining in the correct use of imaging equipment, the effective training can reduce the radiation value of nurses. In addition, effective placement of protective covers during surgery has been proven to reduce operator radiation dose by up to 80%. In addition, the Fenestrated Endovascular Aortic Repair (FEVAR) operations performed by nurses in the operating theatre within one week should not exceed three times, so that the radiation value received by scrub nurses working in the operating theatre will be controlled below 50mSv per year and 100mSv within five years as specified by the International Commission on radiation protection.

But this does not mean that low levels of radiation are harmless. Nursing staff must be aware that the accumulation of small doses of radiation can form cumulative effects over many years, which will have a negative impact on the lens of the eye. In addition, nursing staff in the operating theatre should be educated about the optimal placement of protective covers, such as rearranging protective covers whenever patients are moved, which will also minimize the risk of radiation hazards to patients. (Mohapatra et al., 2013)

Regarding protection of sharp injuries, the authors of this literature review found that double-layered surgical gloves, blunt needles, “hands-free” technique can effectively reduce the risk to nursing staff during surgical procedures. A study by Zhang et al. (2021) supports the findings of this literature review that in all general surgical procedures, double-layer medical gloves not only reduce the rate of surgical glove perforation, but also reduce the risk of contamination by blood-borne pathogens, chemicals, etc. during surgical procedures, especially for surgical procedures lasting an hour or more. According to Parantainen et al. (2011) findings showed that nurses are extremely vulnerable to glove punctures and needle puncture wounds that expose the skin to blood during surgical procedures, so the use of blunt needles can reduce this potential hazard as they are not only less likely to penetrate the skin, but can also function as it should in human tissue. In addition, the use of blunt needles can significantly reduce the probability of nurses being exposed to blood pathogens and body fluids during sustained and prolonged surgical procedures, and there is a small chance that this conclusion will be changed in future studies (Parantainen et al., 2011).

Also, Study of Stringer et al. (2002) supports this literature review’s finding of using “hands-free” technology. Hands-free technique reduces the probability of skin damage, harmful contamination, and glove breakage due to the handling of sharp instruments. So, surgical team during surgical procedures can effectively reduce the risk of percutaneous injury especially in surgeries with blood loss more than 100ml, i.e. the use of trays or other effective means of avoiding the simultaneous handling of sharp objects (Stringer et al., 2002).

The study by Lakbala et al. (2014) further concur the findings of this literature review that it is effective for local professional health departments to develop a reasonable bloodborne pathogen exposure control plan or protocol for healthcare facilities, and most importantly that the plan improves nursing staff compliance with preventive interventions. The plan or protocol needs to

include clear guidance on safe injection issues, sharps injuries. In addition, the effective safety education and training for nursing staffs can make them aware of the importance of operating theatre work safety guidance and the use of safety devices will result in a reduction in non-suicidal self-injurious behaviour (Lakbala et al., 2014).

Regarding to the handling of sharps, Chen et al. (2008) study presented similar ideas to the authors of this literature review concerning proper handling of sharp instruments is done in such a way that potential percutaneous injuries can be avoided, for example such potential injuries may occur when preparing for hollow needle handling. According to this study, implementing safe sharps disposal procedures will reduce the risk of skin prick injuries. For example, disposable items, such as needles and syringes, should be placed in a special container for sharps immediately after use, and the container should have the required depth and capacity, but should never be overfilled. Additionally, dispose of disposable sharps as medical waste at the end and replace them with new ones promptly. (Chen et al., 2008)

A study by Romano, Milani, Gustén, et al. (2020) supports this literature review's finding, revealing that effective ventilation systems play an important role in controlling air pollution and infection. Infection problems in the surgical area can arise from human contamination and contamination from various instruments and devices, and the use of ventilation improves the efficiency of filtration of harmful particulate matter, thereby improving optimal contamination control and reducing the incidence of infection in the operating theatre. According to Romano, Milani, Gustén, et al. (2020) study, if used properly, personal protective equipment can protect against potential risks such as viruses and body fluids. Personal protection in the operating theatre includes medical surgical gloves, gowns, full face masks, medical masks, and goggles, but although it is important to wear these, personal protective equipment alone cannot prevent stab wounds from sharp instruments.

6.2 Critical evaluation, ethical considerations, and limitations

The authors assessed the quality and dependability of the publications included in this literature review using the evaluation tool created by (Hawker et al., 2002a). The program assigns scores to selected articles based on their introduction and purpose, title and abstract, methodology and

data, ethics and bias, results, transferability or generalizability, sampling, data analysis, impact, and usefulness on a scale of 1 to 4, with a total score of 36, calculated by dividing 4 by 9. For an item to be eligible for the review, it must have a minimum of 30. As a result, when the nine selected papers were critically assessed, Author 1 obtained an average score of 33.6, as shown in Appendix 1. The highest article received a score of 35, and the one with the lowest was given a 32. According to Appendix 3, the essay by Author 2 obtained a total score of 34.6 for the 10 articles picked, with a maximum score of 35 and a minimum score of 34, as shown in Appendix 3.

This assessment and critical criterion led to the development of the final papers, which the authors used to analyse and synthesize the findings. Only publicly accessible public domain articles that were published in English or that were freely available online were considered for inclusion in this review. Since occupational protection of nurses in operating theatres is a topic getting growing attention and numerous discoveries have been produced in numerous research, the sample of publications chosen and included in this study is not exhaustive. Therefore, prejudice is one of the study's potential shortcomings. Even though a thorough literature search was done, certain studies that were deemed appropriate might not have made it into our review. Additionally, some subjectivity and bias may have entered into the selection of the literature sources. This study might have included both positive and negative findings as a result, which would have limited the validity and applicability of the paper's conclusions. Additionally, it's probable that certain relevant studies published before 2013 were excluded from this analysis, which would restrict the validity and dependability of this thesis's results. However, the writers cited this research in the discussion section to back up the thesis's conclusions, which improved its validity and dependability.

Regarding ethical issues, all information in the publications chosen for this review is properly cited from original sources and is fully recognized by the appropriate authors. The citation format is based on the American Psychological Association's seventh edition, which is the most recent specification and has received full support from the pertinent writers (APA, 7th edition).

7 Conclusion and recommendations for further studies

Implement the conclusion of this literature review, which includes four types of intervention: protection from surgical smoke, protection from radiation, protection from sharps injuries, and

Protection from infection during surgery, into clinical applications. Firstly, the hospital management should establish rules and regulations related to protective intervention for operating theatre nursing staff and formulate a nursing staff protection agreement. Based on this, performance rewards for nursing staff following safety regulations should be implemented to motivate nursing staff to follow regulations and improve employee compliance.

In addition, it is also necessary for hospitals to provide financial support. In terms of protection from surgical smoke devices in the operating theatre, smokers should be purchased, and suction systems should be installed, such as additional mobile evacuation systems, mobile smoke exhaust systems, positive airflow systems, and LEV (integrated burning smoke exhaust device); In terms of protection from radiation devices, dosimeters, lead shields, disposable pads for absorbing radiation, lead protective clothing and other equipment should be purchased; in terms of protection from sharps injuries devices, double layer gloves and blunt suture needles should be provided, and a "Hand free" neutral zone should be established in the operating theatre; In terms of protection from infection during surgery devices, one-way air flow or hybrid - one-way air flow+mixed system is used. At the same time, personal protective equipment is provided, such as gowns, gloves, masks, aprons, goggles, hats, and disposable liquid proof shoe covers.

At the same time, on-the-job training for nursing staff is also very important. Hospitals could educate nursing staff how to operate instruments correctly and teach advanced technologies, such as how to use "Hand-free" technology. After training, exams could be conducted to check and accept educational results, and the use process of instruments for operating theatre nursing staff should be standardized. Finally, surveillance teams could be established to supervise whether the hospital's funds and equipment are in place, whether nursing staff use the equipment according to standards, and whether maintenance personnel conduct regular maintenance, to strengthen the supervision of occupational protection.

Further recommendation on future studies includes finding protective intervention for anesthesia gas in the operating theatre which was commonly practiced among the periods.

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M et al. (2022)	3	4	4	4	4	3	4	4	4	34
Madder et al. (2018)	4	4	4	4	4	4	3	3	4	34
Rosely & Hamedon (2019)	4	4	4	4	3	4	4	4	4	35
Yu et al. (2022)	3	3	4	4	4	3	4	4	4	33

Appendix 2. Author 1: Data extraction

Author/s, year, Country and Title of study	Context	Methodology	Key Findings	Hawker score
<p>Gallo, A. M., de Lima, F. A. C., Reis, L. M. dos, & Cremer, E. (2013).</p> <p>Brazil</p> <p>Occupational Exposure to Ionizing Radiation from the Perspective of Nursing Professionals in Hemodynamics</p>	<p>The research question for this article was to assess the occupational exposure of haemodynamic care professionals to ionising radiation.</p>	<p>The research method was qualitative and techniques such as qualitative interviews and focus group discussions were used.</p>	<p>The authors suggest that appropriate radiation safety policies and regulations should be developed, radiation safety training should be strengthened, and better protective equipment and Interventions should be provided to safeguard the occupational health and safety of haemodynamic nursing staff.</p>	33
<p>Gioutsos, K., Nguyen, T.-L., Biber, U., Enderle, M. D., Koss, A., & Kocher, G. J. (2022).</p>	<p>The research question in this article was to assess the impact of modern mobile surgical</p>	<p>The research method was quantitative and techniques such as operating theatre</p>	<p>The study evaluated the impact of mobile surgical smoke emission systems on occupational safety in the operating theatre. It was concluded that modern mobile surgical smoke emission systems are an effective occupational safety measure in the</p>	32

<p>Switzerland</p> <p>Surgical smoke: modern mobile smoke evacuation systems improve occupational safety in the operating theatre</p>	<p>smoke emission systems on occupational safety in the operating theatre.</p>	<p>air quality monitoring and questionnaires were used.</p>	<p>operating theatre and it is recommended that such modern smoke emission systems be adopted in the operating theatre to protect the occupational health and safety of operating theatre staff.</p>	
<p>Goula, A., Chatzis, A., Stamouli, M.-A., Kelesi, M., Kaba, E., & Brilakis, E. (2021).</p> <p>Greece</p> <p>Assessment of Health Professionals' Attitudes on Radiation Protection Measures</p>	<p>The research question in this article was to assess the attitudes of health professionals towards radiation protection Interventions.</p>	<p>The research method was quantitative, and a questionnaire survey was used.</p>	<p>The results of the study show that there are differences in the attitudes and practices of health professionals towards radiation protection Interventions and that targeted training and guidance is needed to improve their awareness and practice of radiation protection.</p>	33
<p>Jentzsch, T., Pietsch, C. M., Stigler, B., Ramseier, L. E.,</p>	<p>The research question in this article</p>	<p>The research method quantitative research, using</p>	<p>The results of the study revealed a general lack of knowledge and training in radiation protection for</p>	35

<p>Seifert, B., & Werner, C. M. L. (2015).</p> <p>Switzerland</p> <p>The compliance with and knowledge about radiation protection in operating room personnel: a cross-sectional study with a questionnaire</p>	<p>was to assess the level of compliance and knowledge of radiation protection among operating theatre personnel.</p>	<p>techniques such as questionnaires and statistical analysis, cross-sectional surveys</p>	<p>operating theatre personnel. The article concludes that better training and education is needed to improve the radiation protection of operating theatre personnel.</p>	
<p>Köze, B. Ş., van GIERBERGEN, M. Y., & Yeniay, L. (2022).</p> <p>Turkey</p>	<p>The research question in this article was to explore the impact of air quality in the operating theatre, specifically surgical smoke, on the air quality in the operating theatre.</p>	<p>The research method was a qualitative study, using observation and sampling.</p>	<p>The results of the study suggest that Interventions are needed to improve the air quality in the operating theatre, in particular the effective treatment of surgical smoke. It is recommended that healthcare facilities install effective surgical smoke purification equipment in order to reduce air pollution in the operating theatre and reduce health risks to healthcare workers.</p>	34

Quality of Air in the Operating Room: Surgical Smoke-A Descriptive Study				
M, K., A, C., A, S., L, C., D, C., S, R., F, B., G, F., S, F., M, C., A, M., & Dm, C. (2022). Italy Occupational Exposure to Halogenated Anaesthetic Gases in Hospitals: A Systematic Review of Methods and Techniques to Assess Air Concentration Levels	The research question in this article is to explore the issue of occupational exposure to anaesthetic gases in hospitals, with particular reference to methods and techniques for assessing air concentration levels.	The research method was quantitative, and a systematic review was used to analyse and summarise relevant studies.	The results of the study indicate the need for a combination of factors and the selection of appropriate methods and techniques when assessing air concentrations of anaesthetic gases. At the same time, it is recommended that hospitals take effective Interventions to reduce the risk of anaesthetic gas release and occupational exposure in order to protect the health of health care workers.	34
Madder, R. D., LaCombe, A., VanOosterhout, S., Mulder, A., Elmore, M., Parker, J. L.,	The research questions in this article were to explore the	The research method was quantitative, using an	The results of the study indicate that the use of an auxiliary lead shield is effective in reducing the radiation exposure levels of hand washers and	34

<p>Jacoby, M. E., & Wohns, D. (2018).</p> <p>USA</p> <p>Radiation Exposure Among Scrub Technologists and Nurse Circulators During Cardiac Catheterization: The Impact of Accessory Lead Shields</p>	<p>radiation exposure of hand washers and nurses during cardiac catheterisation procedures and to assess the effect of an auxiliary lead shield on radiation exposure.</p>	<p>experimental design and data analysis.</p>	<p>nurses and has important applications in cardiac catheterisation procedures. It is also recommended that radiation protection Interventions be strengthened during the procedure to protect the health of nursing staff.</p>	
<p>Rosely, M. F., & Hamedon, T. R. (2019).</p> <p>Malaysia</p> <p>Health Effects of Surgical Smoke and Its Associated Factors Among Perioperative</p>	<p>The main question of this study was to investigate the effects of surgical smoke on the health of perioperative health care workers and to analyse the factors associated</p>	<p>The research method was a quantitative study with a cross-sectional study of three perioperative health care workers from 137 departments at Shaden Hospital, who were sampled</p>	<p>The results of the study showed that more than half of the respondents believed that surgical smoke affected their health and more than a quarter of the respondents had experienced surgical smoke related health problems. There was also a significant correlation between healthcare workers' work experience and use of surgical smoke</p>	<p>35</p>

Healthcare Workers in Hospital Serdang	with these health effects.	using a stratified proportional random sample	extraction equipment and surgical smoke related health effects.	
Yu, C.-L., Hsieh, S.-I., Lin, L.-H., Chi, S.-F., Huang, T.-H., Yeh, S.-L., & Wang, C. (2022). China Factors Associated with Surgical Smoke Self-Protection Behavior of Operating Room Nurses	The research question in this article was to explore the factors associated with operating theatre nurses' self-protective behaviour in relation to surgical smoke.	The research method was quantitative, using a cross-sectional research design with a self-administered questionnaire to collect data from a sample of 213 nurses selected from the operating theatres of selected hospitals.	The results of the study indicated that there was a deficit in surgical smoke self-protective behaviours among operating theatre nurses. It was associated with factors such as gender, education, surgical experience, job satisfaction and knowledge. The article also analyses the influence of relevant factors on surgical smoke self-protective behaviours among operating theatre nurses.	33

Appendix 3. Author 2: Critical Appraisal of the articles (Hawker et al., 2002)

Author	Abstract and title	Introduction and aims	Method and data	Sampling	Data analysis	Ethics and bias	Result	Transferability or generalizability	Implications and usefulness	Total score
Childs, Tammy (2013)	4	4	3	4	4	4	4	4	4	35
Donna A., Ford (2014)	4	4	3	4	4	3	4	4	4	34

Km et al. (2013)	4	4	3	4	4	4	4	4	4	35
Lakbala et al. (2014)	4	4	4	4	4	3	4	4	4	35
Lo Giudice et al. (2019)	4	4	4	3	4	3	4	4	4	34
Paterson et al. (2021)	4	4	4	3	4	4	4	4	4	35

Appendix 4. Author 2: Data extraction

Author/s, year, Country, and Title of study	Context	Methodology	Key Findings	Hawker score
<p>Childs, Tammy. (2013). USA Use of Double Gloving to Reduce Surgical Personnel's Risk of Exposure to Bloodborne Pathogens: An Integrative Review.</p>	<p>This article explores how double gloves can reduce bloodborne pathogen outbreaks and discusses the research evidence supporting the use of double gloves.</p>	<p>The study used a systematic literature review to extract information and analyse research findings.</p>	<p>This article finds evidence to support the use of double gloves and double gloves with an indicated glove system to reduce the risk of percutaneous injury and are therefore an effective barrier to exposure to bloodborne pathogens. They can be used to protect members of the surgical team from percutaneous injury.</p>	<p>35</p>
<p>Donna A, Ford. (2014). USA</p>	<p>This article discusses legislation related to the prevention of blood borne diseases, the causes of percutaneous injuries in the surgical period, the identification of risks related to percutaneous</p>	<p>By extracting information and analysing many articles for the literature review, the authors have also added their own new ideas.</p>	<p>Prevention of sharp injury should be a key concern for members of the surgical team to understand the causes and types of injuries that occur in the surgical environment. Eliminating hazards that can occur and</p>	<p>34</p>

Implementing AORN Recommended Practices for Sharps Safety	injuries, control Interventions and actions to prevent injuries due to sharp instruments.		using safely designed equipment are effective preventive Interventions. The use of neutral areas is recommended when hands are passing sharp instruments, and in addition, double gloves can greatly reduce the risk of percutaneous injury.	
Lakbala, P., Sobhani, G., Lakbala, M., Inaloo, K. D., & Mahmoodi, H. (2014) Japan Sharps injuries in the operating room	This article explores the fact that sharp injuries are common in surgery and carry the risk of transmitting blood-borne viruses. The aim of this study was to determine who suffered such injuries, under what circumstances and what actions were taken to minimise the risk of intraoperative needle and sharp injuries.	A stratified sample of 250 respondents was selected, representing a variety of healthcare professionals. A total of 250 questionnaires were distributed and 215 (86%) were returned for statistical analysis. The reliability of the questionnaire was confirmed by Cronbach's alpha calculation.	The respondents who used double gloves, 13 (12.4%) reduced their patients' risk of infection and 52 (49.5%) reduced their own risk of infection. Plans by professional health organisations, the use of safety design devices and training for staff safety awareness are all necessary.	35

<p>Lo Giudice, D., Trimarchi, G., La Fauci, V., Squeri, R., & Calimeri, S. (2019)</p> <p>Italy</p> <p>Hospital infection control and behaviour of operating room staff</p>	<p>The purpose of this study was to discuss infections occurring in the hospital and to observe the behaviour of health care workers performing surgical procedures to assess compliance with SSI guidelines.</p>	<p>An observational descriptive study was conducted in a university hospital. A specially designed form was used to record the actions of the surgical team during a randomly selected surgical procedure. Observations included the use of surgical gowns, the frequency of opening doors and the number of staff in the operating theatre.</p>	<p>The level of staff compliance with international guidelines is low and it is therefore recommended that training courses be provided to raise staff awareness of the prevention and management of HAIs.</p>	<p>34</p>
<p>Paterson, A., Kumaria, A., Sitaraman, M., Sabbubeh, T., Ingale, H., & Basu, S. (2021)</p> <p>UK</p> <p>Dissection using pulsed radiofrequency energy device (Plasma Blade) is safe and efficient in experimental revision</p>	<p>The Plasma Blade is an innovative electrosurgical device that utilises pulsed radiofrequency energy. Our goal was to assess the risk of damage to the neuromodulation hardware during Plasma Blade dissection.</p>	<p>Simulation setup of chicken breast with different hardware threads and plasma blades used in three configurations. After dissection, the wires were examined with the naked eye and an operating microscope. An oscilloscope was used to simultaneously evaluate the induced currents.</p>	<p>Demonstrates that the Plasma Blade can safely dissect deep brain stimulator (DBS), vague nerve stimulator (VNS) and spinal cord stimulator (SCS) hardware. It is used as a safety device in the operating theatre and can be used to protect members of the surgical team from sharp objects.</p>	<p>35</p>

<p>neuromodulation implant surgery.</p>				
<p>Romano, F., Milani, S., Gustén, J., & Joppolo, C. M. (2020)</p> <p>Switzerland</p> <p>Surgical Smoke and Airborne Microbial Contamination in Operating Theatres: Influence of Ventilation and Surgical Phases</p>	<p>This article discusses that air cleanliness is a key factor in operating theatres, and it is necessary to protect the health of patients and staff by controlling air pollution to prevent microbial infections. Operating theatre pollution is also affected by ventilation systems and the daily work behaviours of staff.</p>	<p>Thirteen real surgical procedures were carried out in two operating theatres equipped with different ventilation systems. Ultra-fine particle measurements were taken throughout the surgery, while microbiological measurements were collected during specific phases of the surgery.</p>	<p>Ventilation systems are a key element in providing a clean and safe environment in the operating theatre. Operating theatres are equipped with UDAF or hybrid (UDAF+mix) systems for better and faster dilution and removal of air contamination at the point of source generation.</p>	<p>34r</p>
<p>Romano, F., Milani, S., Ricci, R., & Joppolo, C. M. (2020)</p> <p>Italy</p> <p>Operating Theatre Ventilation Systems and</p>	<p>This article discusses the important role that ventilation systems play in the operating theatre in controlling air contamination and</p>	<p>This study describes the measurement procedures and results obtained during sample inspections and periodic performance tests during the surgical period of surgical patients. Microbiological contamination data were</p>	<p>The results confirm that the air dispersion solution and the design air volume are key factors. the performance values of the P-UDAF system in controlling airborne particulate and microbial contamination are better</p>	<p>34</p>

<p>Their Performance in Contamination Control: "At Rest" and "In Operation" Particle and Microbial Measurements Made in an Italian Large and Multi-Year Inspection Campaign</p>	<p>reducing the risk of surgical site infection.</p>	<p>analysed and commented on according to four relevant air dispersion protocols and design categories.</p>	<p>than those of the MAF air dispersion solution.</p>	
<p>Wicker, Paul., & Dalby, Sara (2016) UK Operating Theatre Attire and Personal Protective Equipment - Rapid Peri-operative Care</p>	<p>This article discusses the correct personal protective equipment to be worn by staff working in the operating theatre to prevent cross-contamination.</p>	<p>By selecting 7 scientific articles on this topic, a systematic literature review was conducted, and new ideas from the author were added.</p>	<p>Proper staff behaviour and the appropriate use of personal protective equipment within the surgery can significantly reduce microbial cross-contamination.</p>	<p>35</p>
<p>Km, D., Dj, C., Wd, H., A, K., & Ed, S. (2013) Canada</p>	<p>This article explores the occupational risks associated with percutaneous injuries that occur in the operating theatre and encourages</p>	<p>This article uses the method of evidence review described by the International Recovery Liaison Committee and a systematic English search</p>	<p>This article supports risk reduction using double gloves and blunt sutures, as well as the use of neutral zones for sharps</p>	<p>35</p>

<p>Use of safety scalpels and other safety practices to reduce sharps injury in the operating room: what is the evidence?</p>	<p>harm reduction through behavioural change and the use of safely designed surgical sharps.</p>	<p>of Ovid. Two authors assessed all articles and categorised them for analysis based on the level of evidence and the observed impact of the intervention on outcomes.</p>	<p>handling and the use of suture aids.</p>	
<p>Yu, C.-L., Hsieh, S.-I., Lin, L.-H., Chi, S.-F., Huang, T.-H., Yeh, S.-L., & Wang, C. (2022)</p> <p>China</p> <p>Factors Associated with Surgical Smoke Self-Protection Behaviour of Operating Room Nurses</p>	<p>This article discusses the fact that surgical smoke contains blood, chemicals, tissue particles, bacteria, and viruses. Its potential risk of physical, cytotoxic, and genotoxic injury to those in the operating theatre. The purpose of this study was to identify factors associated with surgical smoke self-protective behaviour in operating theatre nurses.</p>	<p>This study is a descriptive correlation study, using a cross-sectional survey method, using a structured questionnaire as part of a large survey study.</p>	<p>This study found that the self-protective behaviour of nursing staff in the operating theatre could be enhanced through the innovative design of easy-to-breathe, protective and low-cost surgical smoke protection devices. It is also important to increase nurses' self-awareness of the hazards of surgical smoke.</p>	<p>35</p>