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SCOPING REVIEW ON MEASURES USED IN CURBING THE IMPACT OF EXPOSURE TO SURGICAL PLUMES ON THE RESPIRATORY HEALTH OF OPERATING THEATRE PERSONNEL

BY

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ABSTRACT

Surgical plumes, comprising gases, vapors, and particles generated during surgeries, pose a significant occupational hazard to healthcare workers in operating rooms. These plumes can contain carcinogens, pathogens, and other harmful elements, potentially leading to immediate irritations and long-term health risks. Therefore, effective preventive measures and management strategies are crucial to safeguard the well-being of operating theatre personnel.

This review followed the scoping review methodology using Joanna Briggs Institute's (JBI) method. Literature searches were conducted on the following databases: PubMed, CINAHL, and Google Scholar. Four hundred and thirty-seven articles were retrieved. After removing the duplicate and screening only 47 which met the inclusion criteria were analyzed.

The reviewed studies spanning from 2018 to 2023 highlight a growing global concern regarding the health risks posed by surgical smoke exposure for operating theatre personnel. These studies underscore a range of adverse effects, from headaches to potential virus transmission, and emphasize the need for preventive measures. While challenges such as knowledge-practice gaps and equipment limitations persist, innovative solutions like smoke evacuation systems, local exhaust ventilation, and advanced technologies offer promising ways to mitigate the impacts of surgical smoke. Nurse executives and legislative changes also play a vital role in enhancing safety protocols.

In conclusion, these findings stress the multifaceted nature of the issue and the significance of adopting a comprehensive approach to protect the health and well-being of those working in operating rooms.

Keywords: *Surgical plumes, Occupational hazard, Health risks, Preventive measures, surgical smoke exposure*

1 Introduction

Surgical plumes, sometimes known as surgical smoke, are gaseous byproducts generated during a variety of surgical procedures, particularly when ultrasonic, laser, and electrosurgical devices are used [1]. Viral DNA fragments, viable and non-viable cellular material, poisonous gasses, and other biological, chemical, and particle materials are all present in these plumes [2]. The possible risk risks connected with surgical plumes have been acknowledged by the World Health Organization (WHO) and other health agencies. These hazards have been linked to health difficulties such as respiratory problems, ocular irritations, and the spread of infectious infections among workers in operating rooms[3]. Given the possibility of viral transmission by aerosols and droplets in enclosed spaces, including operating rooms, the COVID-19 pandemic's onset increased these worries[4].

Contemporary measures to reduce the impact of surgical plumes have been suggested and put into practice in a variety of healthcare settings in response to the growing body of evidence and concerns. To protect the health and safety of theater employees, these remedies include the use of HEPA (high-efficiency particulate air) filters, localized smoke evacuators, and better room ventilation methods [5]. Furthermore, awareness-raising and best practice-promoting educational efforts have gained popularity within surgical teams. These programs' main objective is to make operating rooms safer by shielding patients and medical staff from potential risks related to surgical plumes [6, 7].

Therefore, a scoping review of the literature was conducted to described the current available data on curbing impacts of surgical plumes on operating theatre personnel.

2 Methodology

A scoping review framework was adopted for this research to collate and assess the prevailing literature on mitigating the effects of surgical plumes on operative theater personnel. This scoping review will be guided by the methodologies outlined by the Joanna Briggs Institute (JBI) and the Preferred Reporting Items for Systematic Review and Meta-analysis Scoping Review extension (PRISMA-ScR). The JBI methodology for scoping reviews encompasses nine stages:

(1) establishment and clarification of objectives and questions; (2) formulation of inclusion criteria; (3) outlining the systematic approach for literature search, selection, data extraction, and evidence presentation; (4) literature search; (5) evidence selection; (6) data extraction; (7) evidence analysis; (8) results presentation; and (9) comprehensive evidence summary [8].

Table 1: Joanna Briggs Institute's approach for scoping review 2020

Steps	Description
Title	Clearly defined title with a focus on the review question.
Background	Contextualize the problem, its significance, and the rationale for the review.
Review Objective/Question	Clearly define what the review intends to address, specifying the populations, interventions, comparators, outcomes, and types of studies if applicable.
Inclusion Criteria	Identify the criteria for the types of participants, interventions, comparators, outcomes, and types of studies to be included.
Search Strategy	Specify databases and other sources, search terms, and strategy to identify relevant studies.
Study Selection	Outline the process for selecting studies, including screening and selection processes.
Assessment of Methodological Quality	Describe the method for assessing the quality of studies, including the tool to be used and the criteria for inclusion or exclusion based on quality.
Data Extraction	Detail the process for extracting data from the studies, including the use of a standardized form.
Data Synthesis	Describe the process for synthesizing the data, be it quantitative (meta-analysis) or qualitative (narrative synthesis or meta-synthesis).
Interpreting the Results	Provide interpretations of the data, looking at patterns, similarities, or differences.
Drawing Conclusions and Making Recommendations	Formulate conclusions based on the data and interpretations, and provide recommendations for practice, policy, or further research.

Author's Compilation (2023)

PRISMA provides a foundational guideline detailing the essentials for presenting results in systematic reviews and meta-analyses. This guideline comprises a checklist of 27 items coupled with a 4-step flowchart to support researchers in detailing their findings accurately. The PRISMA-ScR version enhances readers' understanding of vital terminologies, foundational ideas, and principal components necessary for a scoping review. Furthermore, it serves as a tool for researchers to rigorously assess previously published systematic reviews.

2.1.1 Review Objective and Questions

The purpose of this review is to compile and summarize the research on surgical plumes' effects on operating room staff. The goal is to gain a deeper understanding of the main exposure hazards, the variables that affect these risks, the sources of information regarding surgical plumes, and possible countermeasures or solutions. This knowledge is important because it can lead to safer operating procedures, which will improve theater staff health outcomes and improve surgical procedures.

The researchers embarked on a scoping review of studies present in the literature pertaining to the effects and management of surgical plumes in the context of operating theaters. Grounded in the population, concept, and context (PCC) framework [8], the central inquiry revolves around the question: What does existing literature reveal about the implications of surgical plumes for operative theater personnel and the strategies employed to curb their impact?

An initial search was conducted to ascertain the presence of any prior or ongoing scoping reviews on this topic, with several previous reviews being identified.

2.1.2 Selection Criteria

The process for filtering the identified publications will comprise two phases:

- Preliminary review of titles and abstracts
- Comprehensive assessment of entire articles.

A scoping methodology will be used in this review to methodically find and filter publications. First, titles and abstracts will be evaluated in order to exclude any results from the search that are repeated. Finding publications that address the mitigating effects of surgical plumes on operating room staff will be the main goal of this phase. Publications not pertinent to this main subject will not be accepted.

The next step is a detailed full text study of the articles that made the short list. Only publications released between 2018 and 2023 will be considered for this review; publications released before will be disregarded. If there are any questions or concerns about whether a certain item should be included, a consensus will be reached through debate. If an article's relevance cannot be determined from its abstract alone, the full text will be obtained for a more thorough analysis. After this thorough screening, articles that do not meet the specified inclusion and exclusion criteria will not be reviewed.

2.1.2.1 Eligibility and Exclusion Criteria.

In order to mitigate the effects of surgical plumes on operational theater workers in clinical or hospital settings, research that carefully examined this topic were sought for this review. Articles from peer-reviewed journals that directly addressed the problems and solutions related to surgical plumes and used a quantitative, qualitative, or mixed-method study methodology were required in order for them to be taken into consideration. To ensure relevance to the matter at hand, the major target of these research had to be operating theater personnel.

Only articles published between January 2018 and September 2023 were included to maintain the recency and relevance of findings. Furthermore, the language criterion stipulated that articles be written in or translated to English. However, the review explicitly excluded any articles that were mere review pieces, those not drafted in English, or those which, despite their focus, ventured outside the confines of operative theaters or clinical settings.

2.1.3 Search Strategies

Finding previously published papers relevant to the topic of surgical plumes and their effects on operating room staff is the aim of the search strategy. Extensive database searches were conducted on CINAHL, PubMed, and Google Scholar. The search technique was created by looking up terms that appeared in

pivotal publications' abstracts and titles, as well as index keywords that were used to characterize those papers. Table 2 lists the variety of search terms and keywords that were used.

Additionally, reference lists within these articles were scrutinized for potential relevance. Included studies were restricted to those published in English and within the timeframe from January 2018 and September 2023, ensuring current insights into the mitigation of surgical plume effects.

Table 2: Search terms used for the review

Keyword	**Synonymous term**
Surgical plumes	Surgical smoke OR electrosurgical emissions
Operative theater	Operating room OR surgery suite
Personnel	Staff OR surgical team OR healthcare workers
Impact	Exposure OR harm OR effect

During the search on Google Scholar, approximately 4,070 results were retrieved, with other essential databases including PubMed and CINAHL. The search was restricted to articles available in English. Table 2 above provides a breakdown of the search terms, databases, and the number of articles procured from each source. The search terms were devised based on the primary research questions of this review.

2.1.4 Article Selection

The PRISMA flow diagram presented in Figure 1 illustrates the process used for the selection and extraction of studies. 437 articles were found in the first literature search: 203 from PubMed, 42 from CINAHL, and 192 from Google Scholar. There were 217 unique items left after 220 duplicates were eliminated. 131 of them were eliminated after their abstracts and titles were evaluated. After reviewing the remaining 86 articles in their entirety, 39 more were excluded. Consequently, the final collection of 47 research underwent thorough data extraction.

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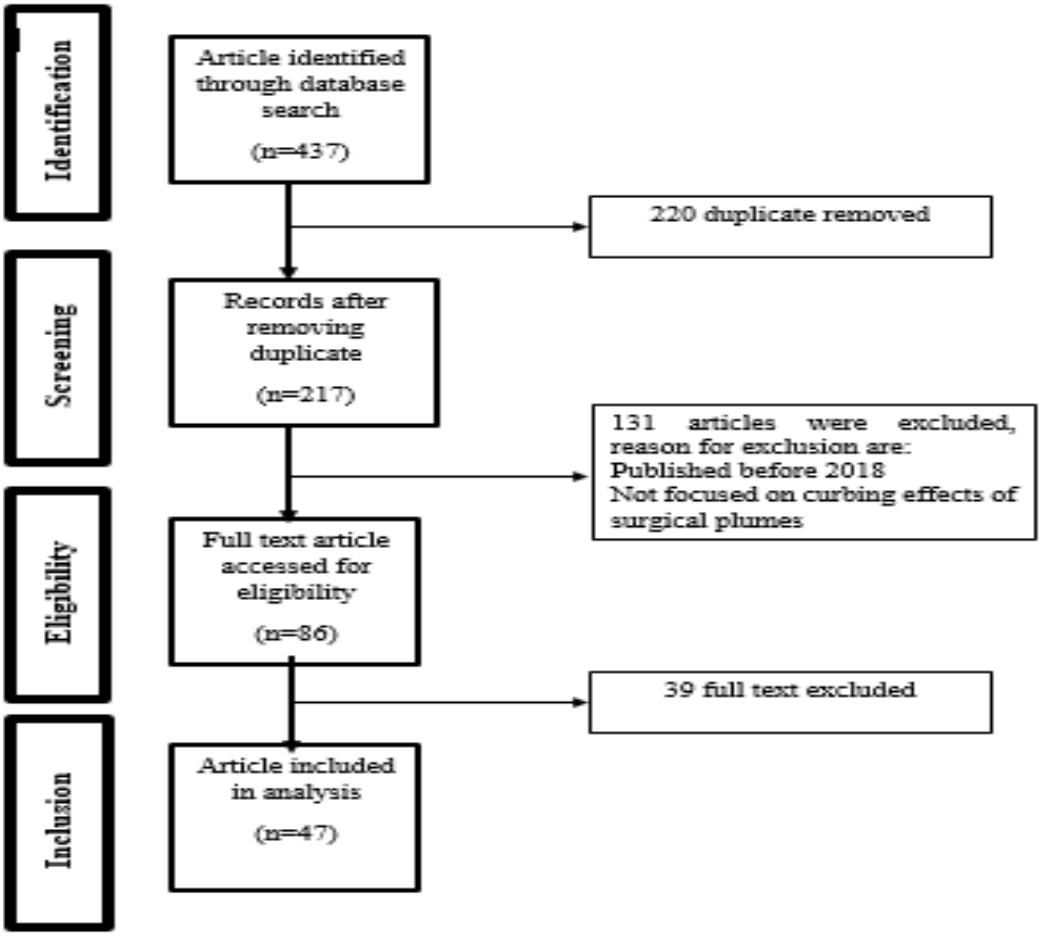

Figure 1: Flow chart showing the selection process of studies included in the scoping review.

2.1.5 Data Extraction

After irrelevant and non-specific results were eliminated, pertinent abstracts were located and initially evaluated in accordance with the review's inclusion and exclusion criteria. When the information in the abstract was not adequate to make a definitive judgment, the complete document was retrieved for additional review. Based on their abstracts, 437 studies from the initial evaluation were shortlisted. Articles that have nothing to do with reducing the effects surgical plumes have on operating room staff were disregarded. After a second assessment, 47 papers that met the review's goals were chosen for further examination.

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3.1 Presentation of Result and Analysis of the selected studies

Table 3: Analysis and presentation of result on curbing impacts of surgical plumes on operating theatre personnel

S/N	Title of the Article		Journal	Goal & Objective	Participant	Concept	Context	Methods	Key Findings
1	Recommended practices for the management of surgical smoke and bioaerosols for perioperative nurses in Thailand[9]		Journal of perioperative nursing	Assess health problems from surgical smoke exposure & evaluate current practices	377 OR nurses in Thailand	Surgical smoke exposure	Thailand	Survey	High percentage of OR nurses reported little or no use of smoke evacuation tools. Most nurses suffered from headaches and/or sore throats.
2	Investigation of surgical smoke symptoms and preventive measures in Turkish operating rooms[10]		International journal of health sciences and research	Investigate surgical smoke symptoms & preventive measures in Turkish ORs	672 OR nurses in Turkey	Surgical smoke symptoms & preventive measures	Turkey	Descriptive study & survey	73.2% of nurses had at least one symptom related to surgical smoke. Only 8.2% had institutional protocols for surgical smoke.
3	Occupational hazards of surgical smoke and achieving a smoke-free operating room environment: Asia-Pacific consensus statement on practice recommendation[11]		Frontiers in public health	Present recommendations for OR personnel on surgical smoke	Experts from the APAC region	Surgical smoke hazards & safety management	Asia-Pacific region	Review & consensus method	17 out of 21 statements achieved consensus, addressing need for policies, training, and preventive controls.
4	Surgically generated aerosol and mitigation strategies: combined use of irrigation, respirator and suction massively reduces particulate matter aerosol[12]		Neurosurgery general	Quantify aerosol reductions using mitigation strategies	N/A (Lab study)	Particulate matter aerosol concentrations & mitigation	United Kingdom	Laboratory study with optical particle counter	Aerosol concentrations significantly reduced through combined use of filtration, suction, and irrigation.

5	Surgical smoke-hazard perceptions and protective measures in German operating rooms[13]		International journal of environmental research and public health	Examine perceptions and protective measures in German ORs post-TRGS 525	7089 surgeons & 219 technical assistants in Germany	Surgical smoke hazards & preventive measures	Germany	Online survey	Majority lack awareness or interest. Only 52% of hospitals and 65% of outpatient facilities had special suction systems.
6	Surgical smoke evacuation compliance: barriers and strategies used among perioperative nurses[14]		Grace Peterson nursing research colloquium	Determine barriers & strategies for surgical smoke evacuation compliance	N/A (Literature review)	Compliance to surgical smoke evacuation		Integrative literature review	Barriers include surgeon refusal, distractibility of equipment, and lack of equipment. Strategies include education and management support.
7	Surgical smoke: still an underestimated health hazard in the operating theatre[15]		European journal of cardio-thoracic surgery	Investigate mobile SES's effectiveness in protecting surgical personnel	N/A (Experiment on porcine tissue)	Surgical smoke & health hazards	Switzerland	Standardized cuts on porcine tissue & smoke analysis	SES reduced concentrations of detected volatile organic compounds. Butadiene & benzene remained high above exposure limits. Surgical masks were ineffective.
8	Safe management of surgical smoke in the age of COVID-19[16]		Journal of British Surgery	Understand hazards of the novel coronavirus in surgical smoke and potential risk mitigation for healthcare staff	-	Surgical smoke		Using existing knowledge of surgical smoke	A theoretical risk of virus transmission exists, with best practice recommendations for operating room setup, energy device choice, and surgical smoke removal devices.
9	Awareness of surgical smoke hazards and enhancement of surgical smoke prevention[17]		Journal of Cancer	Describe components of surgical smoke and highlight its effects on carcinogenesis, mutagenesis, and	Gynecologists	Surgical smoke		Review of components and effects of surgical smoke	Surgical smoke contains potential risks due to the presence of chemicals, particles, bacteria, and viruses. Preventative

				infection among gynecologists					measures include using high-filtration masks, smoke evacuation systems, and legal guidelines.
10	Surgical smoke: risk assessment and mitigation strategies[18]		Journal of the American Academy of Dermatology	Identify risks of surgical smoke in dermatologic procedures and suggest hazard reduction strategies	-	Surgical smoke		Systematic review following PRISMA protocols	Many dermatologists are unaware of surgical smoke risks. Hazard reduction strategies, like smoke evacuators and surgical masks, are underutilized.
11	Clearing the air on surgical plume[19]		ANZ Journal of Surgery	Review potential risks associated with surgical smoke, including risks related to COVID-19, and discuss mitigation options	-	Surgical smoke/plume		Narrative review	Surgical smoke contains toxic chemicals and potentially live viruses. Modern operating rooms rapidly remove smoke, but it's still inhaled by the team. Mitigation should include evacuators and considerations for visibility and communication.
12	Surgical smoke control with local exhaust ventilation: Experimental study[20]		Journal of occupational and environmental hygiene	Evaluate airborne particulates and VOCs from surgical smoke with a Local Exhaust Ventilation (LEV) system	-	Surgical smoke	United States	Experimental study with surgical smoke generated using various control settings	LEVs can significantly reduce airborne particles and VOCs from surgical smoke, but they don't completely eliminate them.
13	Surgical smoke in dermatology: its hazards and management[21]		Journal of Cutaneous and Aesthetic Surgery	Outline the health hazards of surgical smoke in electrosurgery and lasers and provide	Dermatologists	Surgical smoke	India	Review of hazards and management strategies	Confirmed risks include physical injury, infection transmission, and mutagenesis in animals. Smoke evacuators are

				details about safety measures and smoke evacuation systems					vital for dermatosurgical clinics. Awareness and strategies should be part of the training curriculum.
14	Prevalence of HPV infections in surgical smoke exposed gynecologists[22]		International Archives of Occupational and Environmental Health	Investigate if gynecologists performing electrosurgery are at risk of acquiring HPV DNA through surgical smoke	700 gynecologists, China	HPV infection	China	Collection of nasal swab samples from gynecologists and detection of HPV DNA using the flow fluorescence hybridization technique	Gynecologists performing electrosurgery are at risk of acquiring HPV. Surgical masks, especially the N95 mask, significantly reduce the risk of HPV transmission from surgical smoke.
15	The utility of local smoke evacuation in reducing surgical smoke exposure in spine surgery[23]		The Spine Journal	Examine the utility of smoke evacuators in spine surgery	51 consecutive spine surgeries	Surgical smoke exposure	United States	Prospective self-controlled study with two smoke evacuators	Local smoke evacuation significantly reduced surgical smoke exposure.
16	Effect of electrocautery settings on particulate concentrations in surgical plume during tonsillectomy[24]		Otolaryngology–Head and Neck Surgery	Effect of electrocautery settings on surgical plume during tonsillectomy	36 children	Electrocautery & surgical plume	United States	Cross-sectional study with varied EC settings & smoke evacuation conditions	Lower EC settings with smoke evacuation significantly reduces exposure.
17	Applying negative ions to reduce surgical smoke in operation room[25]		Atmospheric Environment: X	Evaluate the efficiency of an ionizer added to an electrosurgical pencil	Not specified	Smoke removal efficiency	Vietnam	Ionizer addition to an electrosurgical pencil vs. smoke evacuation pencil	Newly developed surgical smoke removal devices reduced particle concentrations effectively.

18	Factors Associated with Surgical Smoke Self-Protection Behavior of Operating Room Nurses[26]		Healthcare	Determine factors associated with surgical smoke self-protection behavior	Operating room nurses from a medical center	Surgical smoke self-protection behavior	Taiwan	Descriptive correlational study	In-service education, attitude, and barriers are significant factors
19	Guidelines in Practice: Surgical Smoke Safety[27]		AORN journal	Discuss surgical smoke safety	-	Surgical smoke safety	-	-	Emphasis on protective measures and development of new smoke evacuation devices
20	Awareness of hazard, risk and prevention of surgical smoke among Orthopedic Surgery Residents in South East Nigeria (6)		Journal of the West African College of Surgeons	Determine the level of awareness among orthopaedic surgical residents about hazards and risks and views on prevention.	Orthopaedic surgery residents in South East Nigeria	Awareness of hazard risks and prevention	Nigeria	Cross-sectional survey using a structured questionnaire via Google Form distributed electronically.	Significant level of awareness of surgical hazard risks. 90% agreed to major risks. 95.9% agreed sharp devices reduce needlestick injuries. 65.3% knew about risks during undergraduate education. 30.6% were aware of guidelines.
22	*Risks faced by Nurses and mitigation strategies for the daytime operating room: a review (29)*		*Alternative Therapies in Health and Medicine*	*Overview of the risks and safety concerns of operating room nurses and countermeasures.*	*Operating room nurses*	*Risks faced by nurses and mitigation strategies*		*Review*	*Needle and sharps injuries, radiation, surgical smoke exposure, and more are significant concerns. Precautions, training, protocols, and adequate rest can mitigate these risks. Policies should prioritize nurse welfare.*
23	Electrocautery smoke exposure and efficacy of smoke evacuation system in minimal invasive and open surgery: a prospective randomized study(31)		Scientific reports	Determine composition and concentrations of electrocautery smoke in the OR.	122 surgical procedures	Electrocautery smoke exposure and efficacy of smoke	Switzerland	Prospective observational study involving mass spectrometry.	Harmful VOCs observed in OR air. Some exceeded permissible limits. SES reduced exposure to specific VOCs during open surgery.

						evacuation systems		1:1 computer randomized between smoke evacuation system (SES) vs. no SES.	
24	Applying an air condition to reduce surgical smoke concentration (32)		Air Quality, Atmosphere & Health	Build a cost-effective air curtain device to remove surgical smoke.	Porcine samples.	Reduction of surgical smoke concentration using air curtain	Vietnam	Experiments in an operating room cutting porcine samples with electrosurgical units. Tested scenarios: no control, commercial smoke evacuation pencil, low-velocity air curtain, and high-velocity air curtain.	Air curtain reduces particulate matter and produces less noise than commercial smoke evacuation pencils.
25	Attitude, prevention and perceived barriers among perioperative and anaesthesia nurses towards surgical smoke hazards during COVID-19 outbreak.		Perioperative Care and Operating Room Management	Determine the attitude, preventive practice, and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards.	262 perioperative and anesthesia nurses	Attitude, preventive practice, and perceived barriers related to surgical	Iran	Cross-sectional descriptive study. Data collection with a demographic questionnaire and an SS	Moderate attitude and weak preventive practice levels. Barriers include management and equipment.

						smoke hazards		questionnaire.	
26	Factors associated with surgical smoke self-protection behaviour of operating room Nurses		Nursing & Health Sciences	Determining factors associated with surgical smoke self-protection behaviour of operating room Nurses.	Operating room nurses	Perceptions of the impact of surgical smoke and countermeasures	Northern Taiwan	Mixed-methods study involving focus groups and a descriptive survey.	Nurses believed harmful substances in body are proportional to years worked. Emphasized need for self-protection, rule recognition, and collaboration. Education on surgical smoke hazards and proper PPE wearing identified as essential coping methods.
27	Measurement and Control of Surgical Smoke to Enhance Surgical Team Safety[35]		Journal of Korean Medical Science	Explore the perceptions of surgical smoke and it's long exposure among operating room Nurses.	Operating room nurses	Surgical smoke control	Republic of Korea	Implemented Simple Ventilation Improvement Methods (SVIMs) and measured particulate matter (PM1.0) concentrations in the operating room	SVIMs effectively controlled surgical smoke. Concentration decreased significantly in various locations of the OR after SVIMs application.

Author's Compilation (2023)

4.1 Discussion of the findings according to themes

4.1.1 Characteristics of selected studies

The context and publication year of the examined papers can be used to extract their features. Four investigations were carried out in 2018, with a dispersion throughout Thailand, the US, and more general contexts that were not made clear. As of 2019, there had been seven research conducted in various regions including Turkey, Switzerland, India, the Republic of Korea, and other unnamed ones. When the year 2021 rolls around, 10 studies are noted, most of which are from the UK, China, Taiwan, Thailand, Republic of Korea, and Nigeria. Thirteen research conducted in 2022 throughout various locations including Asia-Pacific, the United Kingdom, the United States, Switzerland, Germany, Vietnam, Republic of Korea, and China demonstrated the growing interest in the subject. Three studies from China and Vietnam by 2023 demonstrate the Asian region's ongoing interest in this subject.

Upon deeper inspection, the studies' common topic relates to surgical smoke's risks, impacts, and preventive methods, highlighting the widespread concern over the health risks this group poses to medical professionals. These research show how interest in the effects of surgical smoke has grown over time, as has knowledge of the dangers it poses to workers. Furthermore, the research' geographic distribution shows a wide range of worldwide interest, with Asian nations dominating in recent years.

4.1.2 Risk hazard of surgical flumes to operating theatre personnel

Numerous studies have shown that surgical smoke is a serious risk to the health of theater operator personnel. highlighting the negative effects of surgical smoke exposure on health [6], such as headaches and sore throats, because protective precautions are not being followed in Thailand. Turkey [10] also repeated this concern of insufficient adherence to safety requirements.

Furthermore, in spite of experiencing symptoms including nausea and changes in breathing, the majority of OR nurses claimed that there were no institutional policies regarding surgical smoke. pointing to some uncertainty [11] in the agreement on surgical smoke control. detecting notable aerosol concentrations following surgical procedures [12], which techniques such as irrigation and filtration might lessen but not completely eliminate. highlighting the gaps in knowledge and actual practice [13, 14], with obstacles to compliance including surgeon resistance and equipment shortages. Sadly, [15] showed that even with mitigating techniques, surgical smoke still included hazardous compounds.

Highlighting the necessity for smoke management and bringing up concerns about the spread of viruses through surgical smoke [16]. This is especially important in light of airborne infections like COVID-19. concentrating on particular professionals [17,18], such as dermatologists and gynecologists, and exposing plausible connections between surgical smoke and infections, mutagenesis, and cancer, as well as

insufficient implementation of mitigating measures, respectively. highlighting the inhalation danger to the surgical team while indicating that there is little evidence [19] of direct viral transmission from the surgical "plume".

4.1.3 Curbing impacts of surgical flumes on operating theatre personnel

Optimising ventilation systems, with a particular emphasis on unidirectional displacement flow systems, is one way to prevent the negative effects of surgical fumes on operating theatre personnel. Comprehensive training programmes should be implemented to address education and attitudes, as described in reference [26], and novel devices such as electrostatic precipitators should be investigated. Encouraging [25] the installation of smoke extraction equipment as a means of minimizing exposure to dangerous volatile organic chemicals. As suggested [28], nurse executives have the power to influence legislative changes that enhance safety procedures. stressing [29] how crucial it is to follow safety regulations. Promising solutions are provided by technological advances such as the Swin transformer [30] and air curtain systems [32]. demonstrating [35] the value of straightforward ventilation upgrades, while Liu et al. (2020) stress the potential of neighborhood smoke extraction systems. Minimizing risks can be achieved by optimizing electrocautery settings, as recommended [24]. Ultimately, reducing the dangers associated with surgical smoke requires an all-encompassing strategy that incorporates behavioral interventions, education, and technical improvements.

4.1.4 Innovative solutions for surgical flumes evacuation

In order to protect the health and safety of operating room staff, creative approaches to surgical fume evacuation have become an important field of study. A variety of strategies to reduce the dangers related to surgical smoke exposure have been investigated in recent studies. proving the utility of surgical smoke-related airborne dangers can be mitigated by local exhaust ventilation (LEV) systems [20], providing a workable engineering solution. emphasized [21] the necessity of smoke evacuators in dermatosurgical clinics and included awareness and management techniques in training programs, emphasizing the significance of tools and instruction.

Demonstrating the usefulness of local smoke evacuation devices in spine procedures [23] and providing a workable way to lower exposure. highlighting [24] how crucial it is to use smoke evacuation systems and optimize electrocautery settings in order to reduce surgical smoke exposure as much as possible. presenting [25] an improved electrosurgical pencil with an ionizer, demonstrating its ability to reduce particle concentrations. Using the MARS-GAN model, artificial intelligence is brought to light [36], demonstrating its potential for surgical smoke removal. By combining a variety of technical, instructional, and engineering

techniques, these creative solutions provide a comprehensive response to the complex problem of surgical smoke evacuation, improving safety in operating rooms.

Out of the 27 studies that were reviewed (table 4), none of them were found to have a critical risk of bias, and most had a low risk of bias. This suggests that the overall quality of the included studies is quite high. This is a positive indicator, as it implies that the research in the field is generally reliable and credible, hence, the quality of the evidence collected in this study can be relied on.

Table 4, Evaluation of Reviewed Studies.

Refs	Confounding Bias	Selection Bias	Classification of Intervention Bias	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall risk of bias
Risk hazards of surgical flumes to operating theatre personnel								
Asdornwised et al. (2018)	Low	Low	Low	Low	Low	Low	Low	Low
Van Giersbergen et al. (2019)	Moderate	Moderate	No Information	Low	Low	Low	Low	Low
Heroor et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Schramm et al. (2021)	Low	Low	Low	Low	Low	Low	Low	Low
Michealis et al. (2020)	Low	**Moderate**	Low	Low	Low	Low	Low	Low
Cretens (2019)	Low	Low	Low	Low	Low	Low	Low	Low
Kocher (2019)	Low	Moderate	Low	Low	Low	Low	Low	Low
Mowbray et al. (2020)	Low	Low	Low	Low	Low	Low	Low	Low
Liu et al. (2019)	Low	Low	Low	Low	Low	Low	Low	Low
Georgesen & Lipner (2018)	Low	Low	Low	Low	Low	Low	Low	Low

Watters et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Curbing impacts of surgical flumes on operating theatre personnel								
Carr et al. (2020)	Low	Low	Low	Low	Low	Low	Low	Low
Seipp et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Yu et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Williams (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Vortman & Thorlton (2021)	Low	Low	Low	Low	Low	Low	Low	Low
Imediegwu et al. (2022)	Low	Moderate	Low	Low	Low	Low	Low	Low
Kocher et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Ninh et al. (2023)	Low	Low	Low	Low	Low	Low	Low	Low
Lotfi et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Moon et al. (2021)	Low	Low	Low	Low	Low	Low	Low	Low
Wang et al. (2023)		Low	Low	Low	Low	Low	Low	Low
Innovative solutions for surgical flumes evacuation								
Lee et al. (2018)	Low	Low	Low	Low	Low	Low	Low	Low
Katoch & Mysore (2019)	Low	Low	Low	Low	Low	Low	Low	Low
Liu et al. (2020)	Low	Low	Low	Low	Low	Low	Low	Low
Carr et al. (2020)	Low	Moderate	Low	Low	Low	Low	Low	Low
Ninh et al. (2022)	Low	Low	Low	Low	Low	Low	Low	Low
Hu et al. (2021)	Low	Low	Low	Low	Low	Low	Low	Low

5.1 Gap identified, Implication and Conclusion

5.1.1 Gap in knowledge

Despite the fact that the reviewed study provides useful information regarding the risks, effects, and preventative methods related to surgical smoke exposure, there are a number of glaring knowledge gaps.

Above all, further study is needed to properly comprehend the long-term health effects of surgical smoke exposure, especially in relation to the risk of developing cancer and persistent respiratory issues among operating room personnel.

Furthermore, the opinions and worries of patients regarding surgical smoke exposure have not received much attention; instead, research has primarily concentrated on the experiences and perspectives of healthcare professionals.

Moreover, it is difficult to compare results and reach firm conclusions since surgical smoke exposure is not consistently measured and reported across research.

Finally, the effectiveness of certain preventive measures, such as the use of specific smoke evacuation devices, needs further investigation to determine their practicality and real-world impact.

5.1.2 Implication

Nursing Practice

Nursing practice is significantly impacted by the current gaps in information regarding surgical smoke exposure. In addition to following current safety procedures, operating room nurses should emphasize their own safety by pushing for more extensive safeguards. This involves minimizing exposure by using personal protective equipment and efficient smoke evacuation systems. In order to support the creation of evidence-based standards and best practices, nurses should also actively participate in research and data collection about surgical smoke exposure. In addition, it is critical that nurses foster a culture of safety in the healthcare setting by educating themselves and their peers about the possible dangers of surgical smoke and the value of preventive measures.

Nursing Education

Comprehensive instruction on the dangers of surgical smoke exposure and its preventative strategies ought to be included in nursing school programs. Beyond only raising awareness, this education should include comprehensive understanding of the different risks linked to surgical smoke as well as actionable solutions to reduce those risks. Furthermore, it is imperative that nursing courses underscore the significance of keeping abreast of the most recent research in this domain to guarantee that nursing practitioners and students are cognizant of novel technology and approaches for surgical smoke control. Additionally, in order to close the information gaps that currently exist and support the creation of evidence-based surgical smoke management procedures, nursing educators should promote critical thinking and

research abilities in their students. This would enable aspiring nurses to actively participate in safeguarding their health and the well-being of patients and colleagues in the operating room.

5.1.3 Conclusion

The global concern over the health risks that operating room workers face from surgical smoke exposure is highlighted by this scoping review, which runs from 2018 to 2023. Together, the research highlight the complexity of this problem and the dangers, impacts, and safety precautions related to surgical smoke. Despite the fact that surgical smoke presents serious health hazards, such as the possibility of cancer and disease transmission, there is still a knowledge vacuum that makes it difficult to put preventive measures into place. A multimodal strategy that includes improved ventilation systems, thorough education, cutting-edge technologies, and legislative advocacy is required to reduce these hazards. The long-term health impacts of exposure and the standardization of measurement and reporting are two areas where there are still many unanswered questions. In order to effectively manage this changing healthcare dilemma, it is vital to prioritize safety, advocate for comprehensive protection, and encourage research and critical thinking abilities. These findings have important implications for nursing practice and education.

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