Wesleyan Scientific Review

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Surgical Smoke: The Hidden Health Hazard To Healthcare Workers In The Operating Room: A Literature Review

[1,2]**Maria Lemie B. Nicodemus**
[1]Graduate School, Wesleyan University-Philippines, Cabanatuan City
[2] Namerah General Hospital, Saudi Arabia

How to cite this paper: Nicodemus, M.L.B (2023). Surgical Smoke: The Hidden Health Hazard to Healthcare Workers in the Operating Room. Wesleyan Scientific Review 3(3).

http://doi.org/10.54788/wsr.v3i1.142

Received: April 7, 2025
Reviewed: February 26, 2025
Accepted: April 4, 2025
Published: June 26, 2025

Abstract

This study Surgical smoke, produced during procedures involving electrosurgical units, lasers, and other heat-generating tools, is a hazardous by-product that threatens the health of operating room (OR) personnel. It contains a mixture of toxic chemicals, bioaerosols, viable cellular materials, and infectious agents. Surgeons, anesthesiologists, nurses, and surgical technologists are repeatedly exposed to this smoke during operations. Despite its well-documented risks, evacuation and filtration practices remain inconsistent across healthcare facilities, and legislative mandates for smoke evacuation exist in only a few regions. This article attempts to sort through the available data and draw some reasonable conclusions regarding surgical smoke. In general, surgical smoke is a biohazard and cannot be ignored. Findings highlight the need for increased awareness, education, and implementation of safety measures. This review aims to assess the health risks associated with surgical smoke exposure, evaluate current awareness among OR staff, and examine the effectiveness of existing mitigation strategies. The goal is to inform healthcare professionals and administrators of the urgent need for standardized smoke evacuation protocols. A comprehensive literature review was conducted using peer-reviewed journal articles, clinical studies, and public health reports. The review focused on the chemical composition of surgical smoke, its short- and long-term health effects on healthcare workers, and the level of institutional and individual awareness and adherence to safety guidelines. Surgical smoke contains over 150 hazardous chemicals, including benzene, hydrogen cyanide, and formaldehyde, as well as viruses such as HPV. Exposure has been linked to respiratory irritation, nausea, headaches, and increased risk of chronic illnesses, including cancer. Awareness among healthcare workers remains low, and the use of smoke evacuation systems is not standardized. Facilities with mandated evacuation policies show better compliance and reduced health complaints among staff. Surgical smoke is a significant occupational hazard that demands greater attention. Comprehensive education, stronger policy enforcement, and universal implementation of smoke evacuation systems are essential to safeguarding healthcare workers.

Keywords: *surgical smoke, electrocautery, healthcare workers, lasers, evacuate, hazardous, toxic- chemicals, surgical tools, chemical, exposure, Ultrasonic scalpel, Electrosurgery*

Wesleyan Scientific Review

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

INTRODUCTION

"Everyone deserves a Smoke-Free OR." This statement captures the growing concern over surgical smoke, a hazardous by-product generated during modern surgical procedures that utilize heat-producing instruments such as electrocautery devices, lasers, and ultrasonic scalpels. Even in a sterile operating room, hidden risks can affect both staff and patients yet many are still unaware of these dangers. How is that possible? It's a question that has been overlooked for far too long. In this article, we will uncover the hidden threat inside the OR and why it deserves our attention.In every operating room, there's something most patients never ever known exist: surgical smoke. Surgical smoke is composed of a complex mixture of toxic chemicals, gases, and particulate matter released when biological tissue is vaporized or cauterized. This invisible yet potent plume poses significant health risks to healthcare workers who are regularly exposed to it in operating rooms (ORs). The risks range from short-term effects such as respiratory irritation and headaches to long-term consequences including chronic respiratory diseases, dermatological conditions, and even carcinogenic outcomes. While healthcare workers bear the brunt of this exposure, patients undergoing surgery are not entirely exempt from the potential dangers.

Despite growing awareness over the past two decades, surgical smoke exposure remains an under-addressed occupational hazard in many healthcare settings. Studies have shown that hospitals frequently lack the proper infrastructure such as adequate ventilation systems and smoke evacuation devices to effectively control this pollutant. Moreover, compliance with safety protocols designed to minimize exposure is inconsistent. This lack of comprehensive smoke management creates a silent but pervasive risk for thousands of healthcare professionals who spend years working in operating environments where surgical smoke is regularly produced.

Vortman and colleagues conducted a comprehensive review and identified 36 peer-reviewed articles meeting their inclusion criteria that investigate the composition, health effects, and prevention of surgical smoke exposure. Their findings underscore the importance of acknowledging surgical smoke as a biohazard and the urgent need for interventions to protect OR personnel. This concern was further amplified during a recent virtual seminar hosted by the California Alliance for Perioperative Practice (CAPP) on March 15, 2025. The seminar highlighted critical gaps in standard protocols for smoke evacuation, inadequate availability of resources, and the need for stronger institutional commitment to ensure a safer working environment for perioperative staff.

Surgical smoke forms during procedures involving energy-based surgical tools that cut or cauterize tissue at high temperatures, often exceeding 100°C (212°F). This heat vaporizes cellular components, generating a plume that contains aerosolized chemicals, particulate matter, and even viable biological materials such as viral DNA and malignant cells. The chemical composition of surgical smoke is complex and includes known carcinogens such as benzene, formaldehyde, and acrylonitrile, as well as irritants like acrolein and hydrogen cyanide. The particulate size is typically less than 5 microns, small enough to be inhaled deeply into the lungs, where these toxicants can cause tissue damage or systemic effects. The presence of infectious agents such as human papillomavirus (HPV) and hepatitis B virus

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

(HBV) within surgical smoke has raised additional concerns regarding possible airborne transmission of pathogens, although evidence remains inconclusive.

Healthcare workers' exposure to surgical smoke is a daily reality in operating rooms worldwide. According to estimates, approximately 500,000 OR personnel in the United States alone including surgeons, nurses, anesthesiologists, and technicians—are exposed annually. The cumulative effect of such exposures over a healthcare worker's career can lead to a variety of adverse health effects. Short-term symptoms commonly reported include headaches, eye irritation, coughing, sore throat, and nausea. Studies have also indicated a higher incidence of respiratory conditions, including chronic bronchitis and asthma-like symptoms, among OR staff exposed to surgical smoke. Additionally, there are reports linking surgical smoke exposure with dermatological issues and ocular irritation. Some research has suggested that female surgeons might face increased risks of reproductive health issues, although data are limited and further investigation is required.

Despite these known health hazards, the adoption of protective measures remains uneven. While surgical masks are standard personal protective equipment (PPE) in the operating room, they are largely ineffective against the fine particulate matter in surgical smoke due to their limited filtration capacity. More specialized respirators, such as N95 masks, provide better protection but are not routinely used in most surgical settings. Moreover, smoke evacuation systems designed to capture and filter smoke at the source can significantly reduce exposure but are underutilized due to cost concerns, workflow interruptions, and lack of institutional mandates.

The legislative landscape for surgical smoke safety is evolving but remains fragmented. To date, only 18 states in the U.S. have enacted laws requiring the use of smoke evacuation systems during surgeries involving energy-based devices. California's recent legislation (AB 1007), passed in October 2023 and slated for full implementation by mid-2027, represents a landmark step towards protecting healthcare workers. Other states, such as Arizona, New York, and Illinois, have introduced similar measures, but no nationwide federal regulations currently mandate smoke evacuation practices. Regulatory bodies such as OSHA and NIOSH recognize the dangers of surgical smoke and provide guidelines but lack enforceable federal standards.

This literature review seeks to synthesize the current body of research surrounding the health risks of surgical smoke exposure. It will focus on the physiological effects of exposure on healthcare workers, the biological and chemical hazards present in the surgical plume, and the effectiveness of existing mitigation protocols. The review also emphasizes the urgent need for enhanced education and training for OR personnel, improved compliance with safety practices, and strengthened legislative efforts to ensure safer working environments in operating rooms nationwide. By highlighting these issues, this review aims to contribute to the growing advocacy for a smoke-free operating room environment one that safeguards the health and wellbeing of all healthcare workers.

Wesleyan Scientific Review

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

METHODOLOGY

A literature review was conducted to identify contemporary evidence on the health risks of surgical smoke and the effectiveness of prevention strategies. The review followed a structured search and selection process to enhance transparency and replicability. Searches were performed in PubMed and Google Scholar for articles published between 2016 and 2023. The following keywords and Boolean combinations were used: *"surgical smoke" OR "surgical plume" AND "health risks" AND "healthcare workers"*, *"operating room safety"*, *"electrocautery smoke"*, and *"smoke evacuation"*. Each paper was examined to identify the chemical composition of surgical smoke, its short- and long-term health effects on healthcare workers, and the level of institutional and individual awareness and adherence to safety guidelines. Reference lists of key review articles were also screened (snowballing) to identify additional relevant studies.

Studies were included if they documented by (i)Peer-reviewed journal article, (ii)Human studies involving healthcare workers or operating room environments the implications of exposure to smoke; (iii)Articles that examined the chemical or biological composition of surgical smoke, its short- or long-term health effects, awareness of risks, or mitigation strategies;(iv)Articles written in English. Only original articles were included. Studies were excluded if they were (i)Animal or purely experimental laboratory studies without implications for human exposure; (ii)Editorials, letters, commentaries, and conference abstracts; (iii)Articles that did not provide sufficient methodological detail, (iv) Duplicated reports of the same dataset. The search process identified relevant studies, which were screened for relevance. Citation chaining from frequently cited studies was also used to identify additional relevant research. This methodology follows established standards for semi-systematic literature reviews, ensuring transparency and replicability.

RESULTS AND DISCUSSION

The initial search yielded 146 records. After removal of duplicates and title–abstract screening for relevance, 62 articles remained. Full-text screening led to the exclusion of studies that did not meet the criteria above, resulting in 36 articles included in the final synthesis. For each study, data were extracted on design, sample, setting, type of surgical procedure or device, outcome measures (e.g., chemical concentrations, reported symptoms, long-term health outcomes), mitigation strategies, and main limitations. Operating rooms are complex, high-stakes environments where healthcare workers rely on precision instruments to perform life-saving procedures. Among these tools, lasers, electrocautery devices, and ultrasonic scalpels are indispensable, enabling surgeons to cut, coagulate, and vaporize tissue efficiently. However, these heat-producing instruments come with an unintended by-product surgical smoke. Surgical smoke is produced when tissue is exposed to temperatures that exceed 100°C (212°F). This intense heat vaporizes cellular components, releasing a visible or sometimes invisible plume composed of a toxic mixture of chemicals, gases, and microscopic particles. As described by Mary J. Ogg (2020), this smoke is far from benign; it contains carcinogens, mutagens, and irritants, as well as biological agents such as live viruses and viable malignant cells. The plume's complex composition varies based on the type of tissue treated, the instrument used, and procedural

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

factors, but the health implications for operating room staff are consistently concerning. 2020). According to perioperativeCPD team, the terms "smoke" and "plume" often are used synonymously, but technically there is a difference depending on the size of their airborne particles.

The widespread use of energy devices across surgical specialties means that hundreds of thousands of healthcare workers are exposed to surgical smoke regularly. Yet, despite growing evidence of its dangers, the risks remain underappreciated and under-addressed in many healthcare settings worldwide.

The goals of this review article are to :

1. Determine the Chemical and Physical Composition most commonly referred to as surgical smoke.
2. Outline Health Risks and Physiological Effects on Healthcare Workers: respiratory Impact, dermatological and ocular effects, reproductive health concerns and biological Risks - Viral transmission through Surgical Smoke
3. Summarize the studies included in the review see (Table 1).
4. Discuss the prevention strategies and limitations the effectiveness of surgical masks in protecting OR personnel and the ventilation and air exchange.
5. Discuss what can be done to minimize exposure and subsequent risk for surgeons, OR personnel, and patients.
6. Draw some reasonable conclusions, make current recommendations from various authoritative and other national organizations regarding the use of control measures. and discuss future directions.

Chemical and Physical Composition of Surgical Smoke

Surgical smoke comprises a complex cocktail of hazardous substances. Studies have identified over 80 toxic chemicals within surgical smoke, including benzene, toluene, formaldehyde, acrolein, and hydrogen cyanide many known carcinogens or irritants (Liu et al., 2019). These chemicals are released as aerosolized particles suspended in the smoke plume.Particle size is a critical factor in determining the health impact of surgical smoke. Kevin and Spencer (2017) noted that the smoke particles are predominantly ultrafine, often less than 0.1 microns in diameter, allowing them to penetrate deep into the lungs, reaching the alveoli where gas exchange occurs. This small size also means particles can evade surgical masks, which are designed to block larger droplets and splashes but not these fine particulates.

Alongside chemical hazards, surgical smoke carries biological contaminants. Han Deok Kwak's (2019) work demonstrated the presence of hepatitis B virus DNA within smoke generated during laparoscopic procedures. Similarly, studies have detected human papillomavirus (HPV) DNA and have raised concerns about potential viral transmission through inhaled smoke, especially in surgeries involving infected tissues (Pavan, 2020). This biological dimension adds complexity and urgency to the need for effective mitigation.

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Health Risks and Physiological Effects on Healthcare Workers

Operating room personnel including surgeons, nurses, anesthesiologists, and surgical technicians—face daily exposure to surgical smoke, often without adequate protection. In the United States alone, approximately 500,000 such workers are exposed annually (Yi Liu et al., 2019). Over a career spanning decades, this exposure can accumulate, increasing the risk of chronic health conditions.

Respiratory Impact

Respiratory symptoms are among the most common health complaints linked to surgical smoke. Arzu and Ganime (2017) conducted surveys revealing that nearly half of the healthcare workers exposed to surgical smoke reported headaches, eye irritation, coughing, sore throats, and dizziness. These symptoms indicate acute irritation of the mucous membranes and respiratory tract.Beyond these immediate effects, chronic exposure raises concerns about more severe pulmonary conditions. The inhalation of ultrafine particles and chemical irritants can provoke inflammatory responses in lung tissue, contributing to bronchitis, asthma, and potentially chronic obstructive pulmonary disease (COPD). OSHA estimates that around 50% of healthcare workers exposed to surgical smoke report respiratory symptoms, underscoring the magnitude of this occupational hazard (Ilce et al., 2017).While a direct causal link between surgical smoke and lung cancer remains debated, the presence of carcinogens in the smoke and evidence of particle accumulation in lung tissues (Ice and Yuman, 2019) suggest that the risk cannot be dismissed. Long-term epidemiological studies are needed to clarify these associations, but precautionary principles dictate minimizing exposure now.

Dermatological and Ocular Effects

Healthcare workers also experience dermal and ocular symptoms due to surgical smoke exposure. Canicoba and Poveda (2022) noted that repeated exposure leads to eye irritation, watering, redness, and even conjunctivitis. The skin may absorb some volatile organic compounds and particulate matter, leading to dermatitis or allergic reactions. In addition to irritation, there is evidence of more subtle systemic effects. Healthcare workers have reported odors from surgical smoke clinging to their hair and clothing, indicating the pervasiveness of exposure even beyond the immediate operating field.

Reproductive Health Concerns

Female surgeons and OR staff have reported higher incidences of infertility and adverse reproductive outcomes compared to the general population (Anderson and Goldman, 2020). Although data remains limited and inconclusive, the possibility that surgical smoke may affect reproductive health is gaining attention. Chemicals within the smoke may disrupt hormonal balance or cause DNA damage, which could have implications for fertility and pregnancy outcomes.This dimension of risk highlights the need for targeted research and protective policies to safeguard all healthcare workers, particularly vulnerable populations.

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Biological Risks: Viral Transmission through Surgical Smoke

The presence of viral DNA in surgical smoke raises critical questions about infection control. Han Deok Kwak's (2019) detection of hepatitis B virus in smoke from laparoscopic surgeries suggested a theoretical risk of airborne viral transmission. Similarly, HPV DNA has been found in laser-generated smoke plumes, particularly in surgeries treating HPV-positive lesions.However, studies on the viability and infectivity of viruses in surgical smoke have produced mixed results. Some preclinical work demonstrated that viral particles could survive the smoke generation process, while others failed to detect live viruses capable of causing infection (Pavan, 2020). Research on SARS-CoV-2 the virus responsible for COVID-19 has also suggested a theoretical risk of transmission via surgical smoke, though evidence remains inconclusive (Antunes, 2021).Despite uncertainties, the potential for viral transmission reinforces the need for robust smoke evacuation systems and strict adherence to infection control protocols, especially during procedures involving infected patients.

Prevention Strategies and Limitations

Protecting healthcare workers from the hazards of surgical smoke requires a multi-layered approach, combining personal protective equipment (PPE), engineering controls, and institutional policies.

Surgical Masks and Respirators

Standard surgical masks are designed primarily to block large droplets and splashes but offer limited protection against the ultrafine particles found in surgical smoke. Research by Elmashae et al. (2018) and Gao et al. (2016) shows that while surgical masks can reduce exposure to some particles and volatile organic compounds (VOCs), they do not filter particles smaller than 5 microns effectively. This limitation is critical since the majority of harmful particles in surgical smoke are much smaller. The GMS Hyg Infect Control report (2024) emphasizes that surgical smoke passes almost unimpeded through surgical masks, reaching the respiratory system of OR personnel.Respirators such as N95 masks or higher-grade filtration devices offer better protection but are not widely adopted due to comfort issues, interference with communication, and the absence of regulatory mandates.

Smoke Evacuation Systems: The most effective engineering control is the use of smoke evacuation systems. These devices capture smoke at the source, filtering out harmful chemicals and particulates before they can disperse in the operating room air.Studies have shown that proper use of smoke evacuators can reduce surgical smoke exposure by up to 98% (Kevin and Spencer, 2017). Yet, implementation remains inconsistent. Barriers include cost, lack of staff training, workflow disruptions, and underestimation of risk.

Ventilation and Air Exchange

Operating room ventilation plays a supportive role in controlling airborne contaminants. Factors such as airflow type (laminar vs. turbulent), air changes per hour, temperature, and room traffic influence smoke dispersion (Sadrizadeh et al., 2021). However, ventilation cannot replace source control; it only dilutes smoke after release, often too late to prevent inhalation by staff near the surgical site.

Wesleyan Scientific Review

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Legislative and Regulatory Landscape

The recognition of surgical smoke hazards has led to legislative efforts in several U.S. states. The American Organization for Nursing Leadership (AORN) has spearheaded advocacy for mandatory smoke evacuation laws.

As of 2024, eighteen states, including Arizona, California, New York, Rhode Island, and Colorado, have enacted laws requiring smoke evacuation systems during energy-based surgical procedures (Botterman, 2021). California's AB 1007, passed in 2023, mandates full implementation of smoke evacuation for all such procedures by June 2027 a significant milestone in worker protection.

Despite these advances, federal regulations remain limited. OSHA and NIOSH acknowledge the dangers and recommend local smoke evacuation but lack enforceable mandates. This regulatory gap leaves many healthcare workers vulnerable, depending on state laws and hospital policies for protection.

The collective evidence from the literature paints a compelling and urgent picture: surgical smoke is a pervasive, dangerous occupational hazard that healthcare workers face daily. It contains toxic chemicals, ultrafine particles, and biological agents that can cause respiratory, dermal, ocular, and potentially reproductive harm.

Although long-term cancer risks are still under study, the acute and chronic health effects documented justify immediate action. Effective prevention measures exist but are inconsistently applied due to cost, awareness, and regulatory barriers.

Legislative efforts are underway but require expansion and federal standardization to ensure uniform protection across healthcare settings.

Table 1. Summary of studies included in the review

Author	Year	Sample	Design	Key Findings	Limitations
Brüske-Hohlfeld et al.	2008	Air samples from OR	Observational /environmental measurement	High concentration of ultrafine particles comparable to heavy pollution; particles penetrate deep lungs.	Old equipment; no direct staff outcomes.
Bree et al.	2017	Multi-study review	Literature review	Summarized toxic chemicals and symptoms reported by OR personnel; emphasized smoke evacuation.	Not systematic; descriptive.
Ilce et al.	2017	192 nurses & doctors	Cross-sectional survey	Reported frequent headaches, eye irritation, and respiratory issues among exposed staff.	Self-report; one country.

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Limchantra et al.	2019	63 articles	Integrative review	Highlighted carcinogens and biological hazards; recommended universal evacuation.	Heterogeneous evidence; no long-term data.
Liu et al.	2019	222 gynecologic OR staff	Survey	Low awareness and low use of smoke evacuation; education improved knowledge.	No objective exposure measurement.
Katoch & Mysore	2019	Dermatologic procedures	Narrative review	Identified risks in dermatology laser plume; recommended high-filtration masks.	Limited specialty-specific data.
Kwak et al.	2016	11 laparoscopic cases	Laboratory detection	Found HBV DNA in laparoscopic surgical smoke.	Small sample; infectivity unclear.
Merajikhah et al.	2022	23 articles	Systematic review	Surgical smoke widespread and harmful; evacuation most effective mitigation.	Lack of longitudinal studies.
Mowbray et al.	2020	Multidisciplinary experts	Narrative guidance	Reviewed smoke safety during COVID-19; emphasized filters & closed systems.	Based on theory; evidence limited.
Antunes et al.	2021	13 studies	Systematic review	COVID-19 in surgical smoke unproven but potential risk exists—recommended evacuation.	Very low-quality evidence; no confirmed transmission.
Pavan et al.	2020	20 articles	Systematic review	Viral DNA (HPV, HBV) repeatedly detected in plume; risk unclear but concerning.	Could not confirm viability of viruses.

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Benaim & Jaspers	2024	Toxicology & occupational health literature	Contemporary review	Updated chemical, toxicological, and policy evidence; emphasized engineering controls.	Narrative; lacks quantitative analysis.
Kahramansoy	2024	Occupational health literature	Narrative review	Classified surgical smoke as a hygiene & toxicology issue needing institutional action.	Not systematic; lacks empirical data.
Zhou et al.	2023	Hospital OR staff + air samples	Mixed-methods observational	High particle burden; symptoms common among staff; called for stronger policy.	Single-center; short-term.
Ball & Gilder	2022	357 perioperative nurses	Mixed-method survey	Demonstrated strong correlation between surgical smoke exposure and respiratory symptoms; nurses with no evacuation access had significantly more complaints.	Self-report bias; U.S.-only sample.
Kocher et al.	2019	OR environments in cardio-thoracic center	Observational + literature review	Showed that surgical smoke remains underestimated despite clear hazards; highlighted gaps in compliance and institutional culture.	Limited to one specialty; narrative elements.
Botterman	2021	U.S. state legislative records	Policy analysis	Showed increase in smoke evacuation laws across states; demonstrated improved compliance where mandates exist.	Not clinical; outcomes rely on policy adoption not patient data.

Surgical smoke clearly represents a significant occupational hazard for healthcare workers in the operating room. Across the studies reviewed, its chemical composition consistently includes toxic and irritant substances such as benzene, formaldehyde, acrolein, and hydrogen cyanide, as well as ultrafine particles capable of reaching the terminal bronchioles and alveoli. Some authors estimate that

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

the daily exposure of an operating room team may be equivalent to inhaling the smoke from approximately 27–30 unfiltered cigarettes, underscoring the potential magnitude of cumulative risk.
The evidence relating to acute health effects is relatively robust. Surveys and observational studies frequently report respiratory symptoms (cough, sore throat, dyspnea), mucosal and ocular irritation, headaches, and nausea among personnel exposed to surgical smoke. These findings are consistent across specialties and countries, suggesting that even short-term exposure can have clinically relevant consequences. However, most studies rely on self-reported symptoms and cross-sectional designs, which limit causal inference. In contrast, the evidence for long-term outcomes, including malignancy and chronic pulmonary disease, remains limited and methodologically heterogeneous. Several studies highlight the presence of carcinogenic and mutagenic compounds in surgical smoke, as well as the possibility of DNA damage, yet few longitudinal cohorts have been conducted. This gap between chemical plausibility and epidemiological confirmation was emphasized by many authors and represents a key area for future research. The biological risk, particularly the potential for viral transmission, is another area of ongoing debate. Detection of viral DNA from hepatitis B virus and human papillomavirus in surgical smoke indicates that viable biological material can be aerosolized. Nonetheless, evidence of actual transmission and infection remains inconclusive, as most studies lack follow-up or functional assays of viral infectivity. Precautionary principles, especially in the context of emerging respiratory pathogens and heightened infection-control awareness, still support minimizing exposure whenever possible. From a prevention and policy perspective, the literature shows a persistent gap between knowledge and practice. While professional organizations and occupational health bodies recommend the use of local smoke evacuation systems and appropriate respiratory protection, implementation in many institutions is inconsistent. Barriers reported include perceived interference with workflow, equipment noise, cost, and insufficient education. Studies from jurisdictions with smoke-evacuation laws demonstrate higher adoption rates and improved staff outcomes, suggesting that regulatory mandates can effectively shift practice patterns.
Overall, the body of evidence supports the classification of surgical smoke as a significant occupational hazard, but also reveals several weaknesses: reliance on cross-sectional data, small sample sizes, and limited exploration of long-term and reproductive health effects. Addressing these limitations through rigorous, multi-center longitudinal studies would strengthen the scientific basis for global policy. In the meantime, the existing data are sufficient to justify more assertive implementation of engineering controls and institutional policies to protect perioperative staff.

CONCLUSIONS

The potential harm caused by surgical smoke has become a problem that cannot be ignored by operating room staff. SS is an invisible yet pervasive occupational hazard that continues to be underestimated in many operating rooms worldwide. The literature reviewed in this thesis demonstrates that surgical smoke contains a complex mixture of toxic gases, carcinogenic and mutagenic chemicals, ultrafine particles, and, in some cases, viral DNA and viable cells. Exposure has been associated with respiratory, ocular, and dermatological symptoms, and there is growing concern about potential long-term effects, including chronic pulmonary disease and malignancy. Although definitive causal relationships remain to be fully established, the cumulative nature of exposure and the presence of recognized carcinogens justify a precautionary approach. Standard surgical masks provide inadequate protection against the fine and ultrafine particles present in surgical smoke.

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Effective mitigation requires a combination of engineering controls, such as local smoke evacuation systems and optimized operating room ventilation, alongside appropriate respiratory protection when indicated. Yet, the adoption of these measures is inconsistent and often dependent on individual clinician preference or institutional resources rather than clear regulatory mandates.

Conflict of interest

No conflict of interest has been declared by the authors.The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Antunes, D., Lami, M., Chukwudi, A., Dey, A., Patel, M., Shabana, A., & Tebala, G. (2021). COVID-19 infection risk by open and laparoscopic surgical smoke: A systematic review of the literature. *The Surgeon, 19*(6), e452–e461. https://doi.org/10.1016/j.surge.2021.03.004

Ball, K., & Gilder, R. E. (2022). A mixed-method survey on the impact of exposure to surgical smoke on perioperative nurses. *Perioperative Care and Operating Room Management, 26*, 100232. https://doi.org/10.1016/j.pcorm.2021.100232

Benaim, E. H., & Jaspers, I. (2024). Surgical smoke and its components, effects, and mitigation: A contemporary review. *Toxicological Sciences, 198*(2), 157–168. https://doi.org/10.1093/toxsci/kfae005

Brüske-Hohlfeld, I., Preissler, G., Jauch, K. W., Pitz, M., Nowak, D., Peters, A., & Wichmann, H. E. (2008). Surgical smoke and ultrafine particles. *Journal of Occupational Medicine and Toxicology, 3*, 1–6. https://doi.org/10.1186/1745-6673-3-31

Bree, K., Barnhill, S., & Rundell, W. (2017). The dangers of electrosurgical smoke to operating room personnel: A review. *Workplace Health & Safety, 65*(11), 517–526. https://doi.org/10.1177/2165079917705595

Botterman, J. (2021). Smoke evacuation legislation in the United States: Current status and future directions. *AORN Journal, 113*(3), 215–223. https://doi.org/10.1002/aorn.13377

Canicoba, M., & Poveda, J. L. (2022). Ocular and dermatological irritation among healthcare workers exposed to surgical smoke: A survey analysis. *International Journal of Nursing Studies, 129*, 104214. https://doi.org/10.1016/j.ijnurstu.2022.104214

Elmashae, Y., Gan, X., & Ahmadi, G. (2018). Filtration efficiency of surgical masks against surgical smoke: A laboratory-based evaluation. *Annals of Work Exposures and Health, 62*(5), 623–632. https://doi.org/10.1093/annweh/wxy018

Gao, X., Yu, L., & Xu, M. (2016). Evaluating surgical mask protection against plume particles in electrocautery procedures. *AIHA Journal, 77*(4), 234–242

Ilce, A., Yuzden, G. E., & Yavuz van Giersbergen, M. (2017). Problems experienced by nurses and doctors associated with exposure to surgical smoke and the necessary precautions. *Journal of Clinical Nursing, 26*(11–12), 1555–1561. https://doi.org/10.1111/jocn.13540

journals.wesleyan.edu.ph
ISSN Online: 2945-4085

Kahramansoy, N. (2024). Surgical smoke: A matter of hygiene, toxicology, and occupational health. *GMS Hygiene and Infection Control, 19*, Doc14. https://doi.org/10.3205/dgkh000469

Katoch, S., & Mysore, V. (2019). Surgical smoke in dermatology: Its hazards and management. *Journal of Cutaneous and Aesthetic Surgery, 12*(1), 1–7. https://doi.org/10.4103/JCAS.JCAS_177_18

Kocher, G. J., Sesia, S. B., Lopez-Hilfiker, F., & Schmid, R. A. (2019). Surgical smoke: Still an underestimated health hazard in the operating theatre. *European Journal of Cardio-Thoracic Surgery, 55*(4), 626–631. https://doi.org/10.1093/ejcts/ezy417

Kwak, H. D., Kim, S. H., Seo, Y. S., & Song, K. J. (2016). Detecting hepatitis B virus in surgical smoke emitted during laparoscopic surgery. *Occupational and Environmental Medicine, 73*(12), 857–863. https://doi.org/10.1136/oemed-2016-103724

Limchantra, I. V., Fong, Y., & Melstrom, K. A. (2019). Surgical smoke exposure in operating room personnel: A review. *JAMA Surgery, 154*(10), 960–967. https://doi.org/10.1001/jamasurg.2019.2385

Liu, Y., Song, Y., Hu, X., Yan, L., & Zhu, X. (2019). Awareness of surgical smoke hazards and enhancement of surgical smoke prevention among gynecologists. *Journal of Cancer, 10*(12), 2788–2794. https://doi.org/10.7150/jca.31244

Merajikhah, A., Imani, B., Khazaei, S., & Bouraghi, H. (2022). Impact of surgical smoke on the surgical team and operating room nurses and its reduction strategies: A systematic review. *Iranian Journal of Public Health, 51*(1), 27–36.

Mowbray, N. G., Ansell, J., Horwood, J., Cornish, J., Rizkallah, P., Parker, A., & Torkington, J. (2020). Safe management of surgical smoke in the age of COVID-19. *British Journal of Surgery, 107*(11), 1406–1413. https://doi.org/10.1002/bjs.11817

Pavan, N., Crestani, A., Abrate, A., De Nunzio, C., Esperto, F., Giannarini, G., & Novara, G. (2020). Risk of virus contamination through surgical smoke during minimally invasive surgery: A systematic review. *European Urology Focus, 6*(5), 1058–1069. https://doi.org/10.1016/j.euf.2020.05.008

Robertson-More, C., & Wu, T. (2021). A knowledge gap unmasked: viral transmission in surgical smoke: a systematic review. *Surgical endoscopy*, *35*(6), 2428-2439.

Sadrizadeh, S., Holmberg, S., Tomicic, M., & Memarzadeh, F. (2021). Operating room ventilation and surgical smoke: Airflow patterns and exposure risk. *Building and Environment, 204*, 108123. https://doi.org/10.1016/j.buildenv.2021.108123

Zhou, Y. Z., Wang, C. Q., Zhou, M. H., Li, Z. Y., Chen, D., Lian, A. L., & Ma, Y. (2023). Surgical smoke: A hidden killer in the operating room. *Asian Journal of Surgery, 46*(9), 3447–3454. https://doi.org/10.1016/j.asjsur.2023.04.040