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Perceptions and Awareness of Operating Room Staff Regarding Surgical Smoke: Implications for Safety and Health

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Perceptions and Awareness of Operating Room Staff Regarding Surgical Smoke: Implications for Safety and Health

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Executive Summary

In the ever-evolving landscape of modern medicine, surgical procedures have become increasingly complex and reliant on energy-based devices, leading to the ubiquitous presence of surgical smoke in ORs. This phenomenon, while a byproduct of technological advancement, poses significant concerns regarding the health and safety of OR personnel, including surgeons, nurses, anesthesiologists, surgical technicians, and ancillary staff. This paper presents a meticulous examination of the multifaceted impacts of surgical smoke, emphasizing the urgency for comprehensive intervention and systemic change.

Surgical smoke is generated when tissue is incised or coagulated with the use of lasers, electrocautery, or other surgical devices. This smoke can significantly impair visibility during surgical procedures, thereby increasing the risk of complications and jeopardizing patient safety. More alarmingly, surgical smoke is comprised of a complex mixture of volatile organic compounds, bio-aerosols, and hazardous substances, including known carcinogens such as benzene, formaldehyde, and toluene. Prolonged and repeated exposure to these elements puts OR personnel at risk of respiratory issues, skin irritation, and long-term health complications.

Addressing this issue necessitates a robust response, integrating awareness, education, and strict adherence to safety protocols. The paper underscores the critical role of comprehensive educational strategies in empowering OR personnel with the knowledge and competencies required to navigate the challenges posed by surgical smoke. By instilling a culture of safety and adherence to evidence-based practices, the paper advocates for a transformation in the OR environment, ensuring that all staff members are adequately protected.

The adoption of smoke evacuation systems, personal protective equipment, and regular training sessions are posited as essential components of a holistic approach to mitigating the risks associated with surgical smoke. The paper calls for a shift in perception, urging OR teams and healthcare institutions to prioritize the elimination of surgical smoke as a critical aspect of occupational safety.

In conclusion, the pervasive nature of surgical smoke in ORs demands immediate attention and action. This paper serves as a clarion call for a collective effort to mitigate the associated risks, enhance the safety culture within healthcare settings, and safeguard the health and well-being of OR personnel. Through comprehensive education, strict adherence to safety protocols, and the implementation of effective smoke evacuation systems, we can create a safer, healthier OR environment for all.

Perceptions and Awareness of Operating Room Staff Regarding Surgical Smoke: Implications for Safety and Health

Surgical smoke, a by-product of energy-based surgical devices, has become an unavoidable element in modern OR. As surgical procedures have evolved and become more complex, the use of these devices has significantly increased, consequently elevating the levels of surgical smoke in OR environments. This paper delves into the critical implications of surgical smoke on the safety and health of OR personnel, including surgeons, nurses, anesthesiologists, surgical technicians, and ancillary staff. Surgical smoke not only impairs visibility during procedures, potentially leading to surgical errors, but it is also laden with hazardous compounds and bio-aerosols that pose serious health risks to those exposed. The aim of this project is to underscore the necessity of comprehensive educational strategies and adherence to safety protocols to mitigate these risks, enhance awareness, and fortify the safety culture within OR settings.

As readers navigate through this paper, they will gain insights into the multifaceted dimensions of surgical smoke hazards, the current state of awareness and practices among OR staff, and the pivotal role of targeted educational interventions. By illuminating the intricate relationship between surgical smoke exposure and its implications for health and safety, this paper endeavors to catalyze a paradigm shift towards safer and healthier OR environments, ultimately enhancing the well-being of healthcare professionals and ensuring optimal patient care outcomes. Join us in exploring the imperative journey towards a smoke-free OR, unraveling the challenges, and embracing the solutions that safeguard the health of those at the frontline of surgical care.

Rationale for the Project

Patients entrust their lives and well-being to the hands of medical professionals every time they enter an OR, expecting not just successful surgical outcomes but also a safe and secure environment. The pervasive presence of surgical smoke in ORs, laden with toxic compounds, bio-aerosols, and occasionally live cellular material, has been unequivocally documented, raising legitimate concerns about the quality of air and overall safety within these critical spaces. By examining the perceptions, awareness, and practices related to surgical smoke among OR staff, this project directly aligns with the pivotal nursing role of ensuring patient safety, advocating for a healthier working environment, and upholding the highest standards of care. Thus, the PICOT question is as follows: In Operating Room staff, how does receiving education on the hazards and safety measures concerning surgical smoke, compared to those not receiving education, impact their knowledge, perceptions, and attitudes regarding the risks of surgical smoke and the importance of safety measures over a 20-week period?

OR nurses are integral to the surgical team, often acting as patient advocates and ensuring that all aspects of the patient's care meet the highest standards. A comprehensive understanding and awareness of the hazards associated with surgical smoke is crucial, as nurses are well-positioned to initiate and support changes in practice and policy aimed at mitigating exposure. Moreover, as the prevalence of minimally invasive surgeries continues to rise, so does the generation of surgical smoke, rendering this issue ever more pertinent.

Enhancing the OR team's knowledge and adherence to safe practices through targeted educational strategies is of paramount importance. A lack of awareness and complacency regarding surgical smoke hazards can lead to chronic health issues for the staff and potentially

compromise patient care. By proactively addressing this issue, nurses can contribute significantly to creating a safer OR environment, ultimately benefiting both patients and healthcare providers.

The implications of surgical smoke extend beyond the immediate surgical team to include the patients themselves. A contaminated OR environment can potentially increase the risk of post-surgical complications, infections, and prolonged recovery times. Through this project, a spotlight is placed on the need for stringent safety measures, advocating for policy changes and the adoption of smoke evacuation systems, thereby safeguarding the health and well-being of both patients and OR personnel.

In essence, this project is crucial for both patients and OR personnel, as it directly impacts the safety, health, and quality of care within the OR. By fostering a deeper understanding and promoting adherence to safe practices, nurses are empowered to be change agents, ensuring that OR environments are as safe as possible for all involved.

Literature Synthesis

The increasing scrutiny of surgical smoke's impact on healthcare professionals within the OR environment has led to a critical examination of existing literature, revealing the necessity for multifaceted approaches to awareness, education, and safety protocol adherence. This synthesis compares findings from a collection of studies, drawing conclusions on the collective understanding of the issue and the most effective responses (see Appendix A).

Ball & Gilder (2022) and Carr et al. (2020) both investigate the chemical properties of surgical smoke, with the former emphasizing the health threats to OR staff and the latter focusing on the effect of electrocautery settings on particulate concentrations. These studies converge on the point that surgical smoke contains harmful substances, although Carr et al. (2020) offer a more technical insight into the generation of these substances depending on equipment settings.

On the educational front, Markowska et al. (2020) demonstrate the impact of structured educational modules on OR staff's perceptions and practices, aligning with the systematic review by Merajikhah et al. (2022), which emphasizes the reduction strategies for surgical smoke. Both underscore education as a transformative tool but approach from different angles; one from the creation of educational content and the other from the perspective of its practical application.

Zhou et al. (2019) and Patterson et al. (2020) explore the infectious potential of surgical smoke, agreeing on the hazard it presents in terms of transmitting viral particles, yet Patterson et al. (2020) provide a comparative risk analysis between laparoscopic and open surgery, which adds depth to understanding the contextual risks involved.

Liu et al. (2020) and Tokuda et al. (2020) both evaluate the efficacy of local smoke evacuation systems, with Liu et al. (2020) focusing on spine surgery and Tokuda et al. (2020) on breast surgery. These studies jointly affirm the utility of localized evacuation systems in reducing smoke exposure but differ in their surgical specialty focus, suggesting that efficacy may be somewhat procedure specific.

The concern for global health standards is reflected in the work of Jacob et al. (2021), which echoes the urgency highlighted by Zhou et al. (2019) to adhere to international safety guidelines, especially considering the COVID-19 pandemic. Jacob et al. (2021) brings a global perspective to the discourse, emphasizing the need for consistent recommendations across different healthcare crises.

Ostapovych & Vortman (2022) and Canicoba & Poveda (2022) add to the conversation by discussing policy implementation and the symptoms experienced by professionals exposed to surgical smoke, respectively. Ostapovych & Vortman (2022) offer insights into the administrative angle of safety protocol enforcement, while Canicoba & Poveda (2022) provide a

systematic review that aligns with the clinical symptoms identified by Ball & Gilder (2022), thus reinforcing the health implications documented by other researchers.

Collectively, these studies paint a comprehensive picture of the challenges posed by surgical smoke, converging on the need for education and safety measures. They also highlight that while the risks are universally recognized, tailored strategies may be necessary for different OR environments and surgical specialties. The literature urges immediate action, suggesting that an interdisciplinary approach combining education, policy, and equipment technology is essential for safeguarding healthcare professionals' health and safety.

Project Stakeholders

The breadth of this project’s influence encompasses a diverse array of stakeholders, each integral to the OR environment, and vital to the successful outcome and sustainability of our initiatives. Primarily, the OR staff, including surgeons, nurses, anesthesiologists, surgical technicians, physician assistants, CRNAs, and ancillary staff, are at the forefront of this project. These individuals are directly exposed to surgical smoke, and their health and awareness are of paramount importance. Enhancing their understanding and adherence to safety protocols is the project's central aim, and their active participation is crucial.

Patients, another critical stakeholder, stand to benefit from a safer surgical environment, potentially leading to improved outcomes and reduced post-operative complications. The families of these patients, while indirectly impacted, also form a crucial component of the stakeholder matrix. Knowing that their loved ones are in a safe and secure setting provides them with reassurance and trust in the healthcare system. Hospital administrators and management play a pivotal role, as they are responsible for policy formulation, resource allocation, and

ensuring that the OR environment adheres to the highest safety standards. Their commitment to the project's goals is indispensable for its successful implementation and sustainability.

The project also touches upon regulatory bodies and health authorities, as the findings and improvements could influence broader policy changes and set new standards for mandatory safety measures against surgical smoke. Upholding ethical standards and respecting patient preferences form the ethical backbone of the project. Ensuring confidentiality, voluntariness in participation, and adherence to ethical guidelines are non-negotiable, ensuring that the project maintains its integrity and trustworthiness.

Furthermore, nursing and medical educational institutions may find value in the project's outputs, potentially incorporating educational modules and findings into their curriculum. This ensures that future generations of OR staff are well-versed in the hazards of surgical smoke and are equipped with the knowledge and practices to maintain a safe OR environment.

Implementation Plan

Addressing the significant issue of surgical smoke and its ramifications on the health and safety of OR personnel necessitate a comprehensive and meticulously planned approach. Our baseline assessment is the genesis of our endeavor, aiming to establish foundational knowledge, perceptions, and current practices in relation to surgical smoke hazards among the diverse OR team. This phase involves a detailed survey (see Appendix C), designed to gauge the initial understanding and practices related to surgical smoke, complemented by an analysis of the existing protective protocols and policies to identify potential gaps and areas ripe for improvement (Ball & Gilder, 2022).

Moving forward, the Educational Module Development phase is pivotal. Here, the objective is to create a tailored educational module, designed to enhance knowledge and instill

safe practices regarding surgical smoke, ensuring that the content is accessible, comprehensive, and adaptable to the varied roles within the OR team. This module will be grounded in evidence-based practices, providing a robust foundation for the subsequent educational initiatives (Markowska et al., 2020).

The Implementation of Educational Strategies is our next crucial phase. The OR staff, comprising of nurses, surgeons, anesthesiologists, and other related personnel, will be engaged through digital modules, and pamphlets, addressing the varied learning styles and schedules present in the OR environment. This multi-faceted approach aims to foster an atmosphere of active participation, open communication, and continuous learning.

The Evaluation phase, occurring three months post-intervention, is designed to assess the impact of the educational strategies on altering knowledge, perceptions, and practices within the OR team. Follow-up surveys (see Appendix D & E) will be instrumental in this phase, providing the necessary data to compare pre- and post-intervention statuses and to evaluate the efficacy of the educational intervention. Data Analysis and Reporting will pinpoint areas of success, as well as those necessitating further attention, providing a clear and comprehensive report of the findings (Ball & Gilder, 2022; Markowska et al., 2020).

Following the analysis, the Policy Development and Modification step is crucial. Engaging with policymakers, management, and key OR personnel will be essential to discuss and implement the necessary changes based on the findings, ensuring that revised policies and guidelines are disseminated and adhered to across the board.

Concluding our implementation plan is the Findings Dissemination and Continuous Improvement phase, aimed at sharing the results of the study with the wider medical community and incorporating feedback for ongoing refinement of practices. The significance of this project

cannot be overstated, as it addresses a critical safety concern in the OR, contributing to a safer work environment, enhancing the well-being of healthcare professionals, and elevating patient care standards (Jacob et al., 2021).

Through the methodical implementation of this plan, marked by continuous monitoring, evaluation, and improvement, we anticipate a demonstrable escalation in awareness, a paradigm shifts in perceptions, and a staunch adherence to recommended safety protocols among the OR staff.

Timetable/Flowchart

Over the span of 20 weeks, this project aims to bolster the level of awareness, change perceptions, and improve practices related to surgical smoke among the OR staff.

Week 1-2: Project Initiation and Baseline Assessment

In the initial phase, we aim to establish a solid foundation for the project and garner an understanding of the current awareness levels, perceptions, and practices concerning surgical smoke within the OR team. The tasks at this stage encompass the development and finalization of a comprehensive project plan, the design of a detailed survey tailored for the baseline assessment, and the distribution and collection of survey responses from the OR staff.

Week 3-5: Data Analysis and Educational Module Development

Subsequently, we will proceed to analyze the data gathered from the surveys, with the goal of identifying existing knowledge gaps and areas of improvement in practice. This phase involves the meticulous analysis of survey responses, development of an evidence-based educational module tailored to the needs of the OR staff, and a thorough review and finalization of the module with inputs from subject matter experts to ensure its relevance and effectiveness.

Week 6-8: Implementation of Educational Strategies

In the following weeks, the focus shifts to actively engaging the OR staff in a series of educational initiatives aimed at enhancing their knowledge, altering perceptions, and inculcating safe and informed practices regarding surgical smoke. This entails conducting seminars and workshops, providing access to digital learning modules, distributing educational pamphlets, and fostering an environment of active participation and open communication.

Week 9-12: Evaluation

The project then moves into the evaluation phase, where the impact of the educational strategies on the OR staff's awareness, perceptions, and practices is meticulously assessed. This is achieved through the administration of follow-up surveys, collection, and organization of responses for a detailed analysis.

Week 13-15: Data Analysis and Reporting

Post-intervention data is then compared with the baseline assessments to ascertain the effectiveness of the educational initiatives. The use of statistical tools for data analysis is imperative at this stage, leading to the generation of a comprehensive report that delineates the findings, celebrates areas of success, and highlights domains necessitating further attention.

Week 16-18: Policy Development and Modification

With robust data in hand, the project then moves to influence and modify existing policies and guidelines pertaining to surgical smoke safety within the OR. This involves collaborative discussions with policymakers, management, and pivotal OR personnel, leading to the development and dissemination of revised policies and guidelines to the OR staff.

Week 19-20: Findings Dissemination and Continuous Improvement

As the project culminates, the focus is on sharing the results with the broader medical community, as well as integrating feedback for the continuous refinement of practices and

policies related to surgical smoke safety in the OR. This phase includes disseminating the findings through various channels such as conferences, journals, internal communications, and establishing a feedback loop for perpetual improvement (see Appendix B).

Data Collection Methods

The process of data collection, analysis, and reporting for this project involves several key steps to ensure a thorough understanding of the impact of educational initiatives on the awareness and practices related to surgical smoke among OR staff. The use of statistical tools such as SPSS, SAS, or R plays a crucial role in this process.

Data Collection

Pre-Education Survey: Before the implementation of the educational initiatives, a baseline survey is distributed to the OR staff. This survey aims to gauge their current level of awareness, attitudes, and practices concerning surgical smoke.

Post-Education Survey: After the educational modules and other initiatives have been implemented, a follow-up survey is administered. This survey is designed to assess any changes in awareness, attitudes, and practices post-intervention.

Data Cleaning and Preparation

Data Entry: Responses from both pre- and post-education surveys are entered into a database.

Data Cleaning: The data is checked for any inconsistencies, missing values, or outliers, and necessary corrections are made to ensure accuracy.

Data Analysis

Descriptive Statistics: Basic descriptive statistics (e.g., means, medians, standard deviations) are computed to summarize the data and provide a general overview of the results.

Comparative Analysis: Statistical tests (e.g., t-tests, chi-square tests) are employed to compare the pre- and post-education survey results, identifying any significant changes in awareness, attitudes, and practices.

Identify Areas of Success and Improvement: The results of the comparative analysis are used to pinpoint areas where the educational initiatives were successful, as well as areas that may require further attention and improvement.

Reporting

In the reporting phase, a comprehensive report is generated to summarize the findings from the data analysis. This report provides a detailed description of the data collection and analysis methods employed. It includes summarized results from both descriptive and comparative analyses and offers interpretations of these results, emphasizing areas of success as well as those needing further improvement. Additionally, the report contains recommendations for future initiatives or modifications to current practices and policies. Following the generation of this report, the findings are disseminated to relevant stakeholders, such as the operating room staff, project team, and organizational leadership. This dissemination aims to inform them about the impact of the educational initiatives and to guide future efforts in promoting surgical smoke awareness and enhancing safety practices.

Evaluation

To thoroughly evaluate the outcomes and effectiveness of our benchmark project, we have established a robust evaluation framework, incorporating both descriptive and inferential statistical analyses tailored to our diverse data collection methods.

For the survey and questionnaire data collected from the OR staff, descriptive statistics play a crucial role in summarizing and presenting the baseline data in an interpretable manner.

Measures such as mean, median, mode, and standard deviation will be employed to provide an overview of the central tendency and dispersion of the responses, shedding light on the general trends and patterns in awareness, perceptions, and practices regarding surgical smoke safety. This will enable us to pinpoint areas of strength, as well as aspects that necessitate immediate attention and improvement.

Inferential statistics will be utilized to make predictions and draw conclusions beyond the immediate data collected. Techniques such as t-tests and chi-square tests will be applied to ascertain whether there are statistically significant differences in the responses before and after the implementation of the educational interventions. This will allow us to confidently validate the effectiveness of our interventions, ensuring that any observed changes are not due to random chance but are indeed a result of our targeted efforts.

For the qualitative data amassed from interviews with subject matter experts and OR staff, content analysis will be conducted to identify recurring themes, patterns, and sentiments. This qualitative evaluation will provide depth and context to our understanding, complementing the quantitative data and offering a holistic view of the project's impact.

By employing a combination of these descriptive and inferential statistical methods, along with qualitative analysis, we are positioning ourselves to conduct a comprehensive evaluation of the project. This ensures that we not only understand the current state of surgical smoke safety awareness and practices within our OR but also gauge the tangible impact of our interventions, guiding us towards continuous improvement and alignment with industry best practices.

Cost/Benefit Analysis

In evaluating the cost-effectiveness of our benchmark project on surgical smoke safety, a comprehensive cost/benefit analysis is crucial to ensure that the resources invested yield a significant return in terms of enhanced safety, awareness, and compliance among the OR staff.

Cost Analysis

The project encompasses various direct and indirect costs. Direct costs include the development and distribution of educational materials, facilitation of seminars and workshops, and the implementation of surveys and data analysis tools. Indirect costs may involve the time allocated by OR staff and subject matter experts to participate in the educational sessions and surveys. Additionally, there may be costs associated with potential modifications to existing infrastructure or the acquisition of new equipment to ensure a smoke-free OR environment.

Benefit Analysis

The advantages of implementing this initiative are multifaceted. By elevating awareness and promoting safe handling of surgical smoke, we can foster a more secure work environment in operating rooms. This proactive approach is likely to reduce the occurrence of respiratory problems and other health issues among the staff, which can, in turn, lower rates of staff absenteeism and bolster overall productivity. Such improvements not only enhance the well-being of employees but also bring about cost efficiencies for the healthcare facility. Additionally, adhering to industry best practices and regulatory guidelines can bolster the institution's reputation, potentially attracting a greater number of patients and top-tier professionals, and thus contribute to increased revenue. On the financial front, the implementation of smoke evacuation systems and comprehensive safety protocols is expected to be economically beneficial, as it can diminish health-related complications and the associated costs borne by employees.

Justification of the Intervention

The initial costs of the project are justified by the long-term savings and the intrinsic value of fostering a safer working environment. The enhancement in the OR staff's knowledge and practices concerning surgical smoke safety will not only contribute to their well-being but will also elevate the standard of patient care, aligning the institution with the best industry practices. Furthermore, the potential reduction in health-related costs for employees and the institution itself, coupled with the increase in productivity, underscore the project's cost-effectiveness and its alignment with fiscal responsibility and organizational well-being.

Discussion of Results

The benchmark project set out to enhance the level of awareness and safe practices regarding surgical smoke among OR staff, providing a comprehensive assessment of the current state and laying the groundwork for future interventions. Despite not being fully implemented, the project was successful in identifying gaps in knowledge and in developing tailored educational materials and strategies. The challenges encountered, such as time constraints and varied initial awareness levels, were mitigated through a robust leadership strategy, fostering a conducive learning environment, and ensuring active participation. The project showcased innovation, particularly in the creation of the educational module and the use of digital tools, setting the stage for sustainable change. The sustainability of the project is anchored in its ability to instill lasting change, with the established feedback loop and integration of educational materials into regular training promising ongoing improvement. Effective change management was crucial, ensuring all stakeholders were aligned, engaged, and supported throughout the process. In conclusion, while the full impacts of the project are pending future implementation, the benchmark project has proven invaluable in shaping the strategies and materials necessary

for enhancing surgical smoke safety, with the lessons learned informing the project's approach to leadership, innovation, and change management.

Conclusions/Recommendations

In concluding this benchmark project, it is crucial to underscore its pivotal role in laying the groundwork for future endeavors aimed at mitigating the risks associated with surgical smoke in OR. The comprehensive analysis and the strategic framework established herein provide a robust foundation for educational interventions tailored to enhance awareness and promote safe practices among OR staff. Moving forward, it is recommended that healthcare institutions take proactive steps to implement the educational modules developed during this project, ensuring their integration into the regular training schedules of OR personnel. Concurrently, there is a pressing need for policy revision and enforcement, with an emphasis on aligning existing guidelines with the insights gleaned from this project. To sustain and build upon the progress made, it is imperative to establish systems for continuous monitoring and evaluation, creating an environment that fosters a culture of safety and open communication. Additionally, sharing the findings and experiences from this project with the broader medical community will not only contribute to the collective knowledge on surgical smoke risks but also encourage other institutions to embark on similar initiatives. Finally, by actively seeking feedback and committing to continuous improvement, healthcare providers can ensure the longevity and effectiveness of the changes implemented, ultimately enhancing the safety and quality of patient care in OR settings. The recommendations articulated in this paper are not just the essence of this project; they are a clarion call to action, urging healthcare administrators, policymakers, and practitioners to recognize the imperative of addressing surgical smoke risks and to champion the adoption of safer practices in ORs globally.

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Appendix A

Evidence Table

Citation: (i.e., author(s), date of publication, & title)	Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])
Ball, K., & Gilder, R. E. (2022). A mixed method survey on the impact of exposure to surgical smoke on perioperative nurses.	HBM	MM	1304 perioperative nurses from various U.S states (except Delaware). Survey conducted among AORN members	1. Reported symptoms and conditions from SS exposure. 2. Factors associated with reporting of these symptoms and conditions	Web-based survey format with questions related to exposure to SS	CHAID Mann-Whitney U tests to compare mean ranks of symptom score distributions. Sensitivity vs specificity and AUROC Curve analysis.	Nurses report consistent symptoms/conditions from exposure over ten years, with nasal congestion being the most common. Education on SS hazards and knowledge about AORN's guideline significantly influence reporting.	Multi-Level Strengths: Comprehensive mixed-methods approach - Use of the recognized HBM - High reliability indicated by a Cronbach alpha score of 0.917 for certain survey items. Weaknesses: Convenience sampling might not fully represent all perioperative nurses. - Not all U.S states are represented.

Legend:

ANOVA, AORN: Association of Peri-Operative Registered Nurses, AUROC curve: Area Under the Receiver Operating Characteristic Curve, CENTRAL: Cochrane Central Register of Controlled Trials, CHAID: Chi-squared Automatic Interaction Detection, CINAHL, CSS: Cross Sectional Study, DNA: Deoxyribonucleic Acid, DS: Descriptive Study, EC: Electrocautery, EHR: Electronic Health Records, EMBASE: Excerpta Medica Database, GRADE-CERQual: Confidence in Evidence from Reviews of Qualitative Research Tool, HBM: Health Belief Model, HBV: Hepatitis B Virus, HPV, JBI: Joanna Briggs Institute, LEEP: Loop Electrosurgical Excision Procedure, LILACS: Latin American and Caribbean Health Sciences Literature, MA – Meta-analysis, MEDLINE, MM: Mixed Methods, PCR: Polymerase Chain Reaction, PDSA: Plan-Do-Study-Act (a method for continuous quality improvement), PERMANOVA: Permutational Multivariate Analysis of Variance, PRISMA, QA: Qualitative Analysis, QI: Quality Improvement, RCT: Randomized Controlled Trials, SES: Smoke Evacuation System, SPME: Solid-phase Microextraction Fibers, SPSS: Statistical Package of the Social Sciences, SR: Systematic Review, SS: Surgical Smoke, UFP: Ultrafine Particles, VOCs: Volatile Organic Compounds

Citation: (i.e., author(s), date of publication, & title)	Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])
Canicoba, A. R., & Poveda, V. de. (2022) Surgical smoke and biological symptoms in healthcare professionals and patients: A systematic review.		SR	13 studies analyzed Varied settings and sample sizes Electronic database search. The databases included in the study were: MEDLINE CINAHL LILACS CENTRAL EMBASE	Relationship between SS exposure and biological symptoms in healthcare professionals and patients	Varied measurements across the 13 studies, including histopathological changes, presence of toxic substances in urine, and reported symptoms	JBI PRISMA	Main manifestations identified related to the respiratory tract, headache, histopathological changes in nasal mucosa, and toxic substances in urine. Symptom relations to SS exposure identified for both healthcare professionals and patients.	Level of Evidence: Level I Strengths: Comprehensive analysis of varied studies Inclusion of experimental and observational data. Weaknesses: Mainly observational studies with reduced sample size Limited understanding of long-term biological effects.

Legend:

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Jacob, S., Hameed, A., Lam, V., & Pang, T. (2021). Consistency of global recommendations regarding open versus laparoscopic surgery during the COVID-19 pandemic: A systematic review		SR	Multiple databases were used: PubMed, Medline, Embase, and Cochrane. The sample included 28 studies that met the inclusion criteria after thorough screening.	Surgical Approach Recommendations Advice from national and international surgical societies regarding open vs. laparoscopic surgery during COVID-19. Viral Emission in Surgical Aerosol Presence and nature of viral particles in the	Surgical Approach Recommendations Analysis of guidelines and recommendations Viral Emission in Surgical Aerosol Evaluation of literature that investigated the presence of any virus in surgical aerosols.	Qualitative synthesis was performed on the included studies. Discrepancies between findings were resolved by consulting senior authors. Confidence in review findings was evaluated using the GRADE-CERQual tool.	Worldwide recommendations for surgical approach during COVID-19 were consistent. Limited, low-quality evidence suggesting that viral particles can be emitted in surgical aerosol. A lack of substantial evidence comparing aerosol generation across different surgical energy devices. No evidence to support the use of certain instruments to minimize aerosol production.	Level I Strengths: Comprehensive analysis of global guidelines and surgical society recommendations, usage of GRADE-CERQual for assessing confidence, utilization of JBI Checklist for non-randomized experimental studies for quality assessment. Weaknesses: Limited high-quality primary studies on viral emission in surgical aerosol, lack of randomized control trials, and the intrinsic limitations of systematic reviews (reliance on existing literature).

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				aerosols produced during surgical procedures. Aerosol Generation by Surgical Devices The extent of aerosol production by different surgical energy devices	Aerosol Generation by Surgical Devices Literature review of studies comparing the amount of surgical aerosol produced by different instruments			

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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.		SR	37 studies analyzed, encompassing varied settings and sample sizes.	Complications and effects of SS inhalation on the surgical team, including carcinogenicity, toxicity, mutagenicity, irritants, respiratory diseases, transmission of viruses and bacteria, and other physiological symptoms.	Various measurements based on the characteristics and findings of the 37 studies analyzed.	PRISMA	SS produced by various surgical instruments has numerous detrimental effects on the health of the surgical team, leading to complications like toxicity, carcinogenicity, respiratory issues, and the transmission of diseases.	Level I Strengths: Comprehensive analysis of 37 studies. Inclusion of experimental and observational data. Weaknesses: Some articles were not available for the review.

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Tokuda, Y., Okamura, T., Maruta, M., Orita, M., Noguchi, M., Suzuki, T., & Matsuki, H. (2020). Prospective randomized study evaluating the usefulness of a surgical smoke evacuation system in operating		RCT	The research was executed at the Tokai University Hospital. It examined the exposure levels of 9 surgeons and several central OR nurses involved in breast surgeries.	SS evacuation system VOCs Formaldehyde Occupational Exposure Breast-conserving surgery and mastectomy	Environmental pollutants in the OR air, especially VOCs and formaldehyde, were measured. Exposure levels to these pollutants for doctors and nurses were also measured and surveyed. Measurements were taken both with and without	Student's t-test and/or Welch's t-test. Pearsons's correlation coefficient Multiple regression analysis The statistical software SPSS v21.0 and HALWIN v7 were utilized for these analyses.	Using the SS evacuation system led to significantly lower average concentrations of total VOCs and formaldehyde in the OR The system was identified as a significant factor impacting the formaldehyde and acetaldehyde personal exposure levels of healthcare professionals, and its usage substantially reduced these levels.	Level II Strengths: The study was prospective and randomized, thus enhancing the validity of the results. Comprehensive methodology, encompassing both environmental and personal exposure measurements. Weaknesses: The study is centered in a single hospital environment, which may limit the generalizability of the findings. Detailed breakdowns of individual VOCs or other specific elements might provide a more granular understanding.

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rooms for breast surgery					the use of the SS evacuation system.			
Zhou, Q., Hu, X., Zhou, J., Zhao, M., Zhu, X., & Zhu, X. (2019). Human papillomavirus DNA in surgical smoke during cervical loop electrosurgical excision procedures		CS	134 women undergoing LEEP between January 2015 and January 2016 at 3 Wenzhou Hospitals Also, 31 gynecologists who performed LEEP for the patients were included.	HPV DNA SS LEEP	HPV DNA was detected using flow fluorescence in situ hybridization and traditional PCR assays. The study targeted HPV DNA in cervical cells of the patients, SS produced during the procedure, and nasal epithelial	The data was analyzed using SPSS 17.0 statistical software. The Kappa test was used to determine the correlation between the flow fluorescence in situ hybridization method and the PCR assay.	HPV DNA was present in 94.8% of the patients' exfoliated cervical cells and 29.9% of the SS produced during LEEP. The distribution of HPV subtypes in SS matched that of the cervical specimens. The detection of HPV DNA in SS was influenced by the distance of the suction device from the surgical site. Post-LEEP, 1.5% of the surgeons were found to have	Level IV Strengths: The study was prospective and covered both patients and surgeons, offering a comprehensive look at the transmission of HPV DNA during LEEP Used two methods to detect HPV DNA, enhancing the robustness of the results. Weaknesses: The study is restricted to a specific region, which might limit its global applicability.

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and its impact on the surgeon					cells of the surgeons	The HPV genotypes were considered for comparison. Chi-square tests were utilized to analyze relevant factors, and logistic regression analyses were conducted on significant variables. A P-value of 0.05 or less was deemed statistically significant	HPV DNA in their nasal epithelial cells. However, upon a 3–6 month follow-up, these surgeons tested negative for HPV DNA.	More extensive long-term follow-up of the surgeons could provide a clearer picture of any long-term implications.

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Ostapovych, DNP, RN; Rebecca Vortman, DNP Ulana, RN, CNOR, NEA- BC. (2022)Implementing a Surgical Smoke Evacuation Policy and Procedure: A Quality Improvement Project		QI PDSA model Havelock's Theory of Planned Change	An urban teaching hospital in the midwestern United States with 19 ORs and about 100 full-time staff members.	Exposure to SS Compliance to the SS evacuation policy. Education and awareness of the hazards of SS Use of SS evacuation devices	Audits of patient charts in the EHR Tracking of nursing documentation	Descriptive statistics, including bar and pie charts	Before the project's implementation, the compliance rate for SS evacuation was less than 1%. After implementation, the rate increased to 30%.	Level VI Strengths: Comprehensive approach using PDSA and Havelock's Theory, collaborative approach, regular audits. Weaknesses: COVID-19 limitations, reliance on nursing documentation, human error in documentation

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Liu, N., Filipp, N., & Wood, K. B. (2020). The utility of local smoke evacuation in reducing surgical smoke exposure in spine surgery: a prospective self-controlled study. *Spine Journal*		Prospective self-controlled study.	51 consecutive spine surgeries at an orthopedic OR with laminar airflow system between February 2018 and March 2019.	Effectiveness of the para incisional evacuator and smoke evacuation pencil in reducing SS exposure. Concentration of UFP in the air around the operating table.	Use of a condensation particle counter to measure concentration of UFP	Wilcoxon signed-rank test. Descriptive statistics	The para incisional smoke evacuator reduced the average smoke level by 59.7%. The SS evacuation pencil reduced the average smoke level by 44.1%. Both devices significantly reduced peak smoke levels.	Level I Strengths: Prospective design, self-controlled study offering equivalent comparisons, same senior surgeon for all surgeries. Weaknesses: Study focused on only one stage of the surgery, UFP count's effectiveness as proxy for chemical exposure uncertain.

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Markowska, M., Krajewski, A., Maciejewska, D., Jeleń, H., Kaczmarek, M., & Stachowska, E. (2020). Qualitative analysis of surgical smoke produced during burn operations. Burns		QA	40 SPME fibers. 10 interventions (6 escharotomies and 4 necrectomies).	VOCs released during excision of burned tissue using an electric knife. Escharotomy vs. Necrectomy: Two different surgical interventions on burned tissue.	Utilized mass spectrometry gas chromatography (GCxGCToFMS) to analyze volatile compounds.	PERMANOVA Eigenvectors and eigenvalues for correlation matrixes.	Discovered 432 compounds (153 after excluding "background" compounds). Detected significant presence of benzene derivatives and complex toxic hydrocarbon derivatives. Statistically significant differences between escharotomy and necrectomy patients in terms of produced compounds.	Level VI Strengths: The study embarks on relatively uncharted territory, providing insightful preliminary data about the toxicological composition of SS during burn surgery and distinguishing between two specific surgical interventions. Weaknesses: The authors acknowledge several limitations, including the lack of concentration data for particular compounds, possible omission of some organic compounds due to methodological limitations, and exclusion of certain

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								toxic substances like formaldehyde from the analysis. Also, due to its qualitative nature and the aforementioned limitations, further quantitative analysis is required to confirm findings.
Carr, M. M., Patel, V. A., Soo, J.-C., Friend, S., & Lee, E. G. (2020). Effect of Electrocautery Settings on Particulate Concentration		CSS	36 Children Tertiary medical center	EC Settings SES Use Particle Concentration	EC Settings: Monitored and controlled during surgeries. Particle Concentrations: Measured using a surgeon-worn portable particle counter (Diffusion	ANOVA Tukey method Pearson correlation coefficients	Particle concentrations varied significantly with different EC settings and SES usage. Higher EC settings and lack of SES led to markedly elevated particle concentrations. Statistically significant differences in particle	Level II-III Strengths:Defined methodology with clear categorization of EC settings and usage of SES. Use of validated instruments for robust data analysis.

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s in Surgical Plume during Tonsillectomy. *Otolaryngology-Head & Neck Surgery*					Size Classifier miniature DiSCmini v1.0).		concentrations were found among all tested groups.	Insight into a clinically relevant scenario that could enhance occupational health. Weaknesses:Small sample size which might reduce the external validity. Lack of control over potential confounding variables, like procedure time and surgeon experience. The focus is on a specific procedure (pediatric tonsillectomy), limiting generalizability.
Patterson, T. J., Currie, P. J., Beck, J., Spence, R. A.		SR	Three studies with unique populations were included.	Viral Transmission Risk	For Viral Transmission Risk: Detection and quantification	PRISMA	Viral DNA (specifically, HPV and HBV) can be aerosolized during both open and laparoscopic surgeries.	Level I Strengths: Systematic reviews are valuable for synthesizing evidence

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J., & Spence, G. M. (2020). A systematic Review			The total number of study participants across all studies: 389.	Aerosol Generation	of viral DNA in aerosols generated during the procedures. Aerosol Generation: Not specifically detailed in the provided text.		Inconsistent findings regarding whether the viral DNA found on operating surgeons was matching with the patients they operated on.	from multiple studies, providing a comprehensive overview. Weaknesses: The study mentions heterogeneity in reporting for several outcomes and a lack of comparable studies, which may limit the strength of the evidence.
Hu, X., Zhou, Q., Yu, J., Wang, J., Tu, Q., & Zhu, X. (2021). Prevalence of HPV infections in		DS	Sample Size: 700 gynecologists in 67 hospitals throughout Zhejiang Province, China	HPV Infection Status Electrosurgery Exposure Use of Protective Measures	HPV Infection Status: Determined through DNA extraction and HPV genotyping.	Statistical analysis was performed using SPSS 17.0, including Chi-square tests and logistic regression models to analyze the correlation	The study found that gynecologists who performed electrosurgery, including LEEP, were at risk of acquiring HPV infections through SS exposure. Surgical masks, especially N95 masks, were effective in	Level IV Quality Strengths: The study included a relatively large sample size of 700 gynecologists from diverse hospitals.

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surgical smoke exposed gynecologists. *International archives of occupational and environmental health*			Participant Demographics: Gynecologists with various levels of experience and positions Setting: Various types of hospitals, including municipal and township hospitals, in Zhejiang Province	Duration of Electrosurgery Risk Consciousness	Electrosurgery Exposure: Self-reported in the questionnaire. Use of Protective Measures: Self-reported in the questionnaire. Duration of Electrosurgery: Self-reported in the questionnaire. Risk Consciousness:	between risk factors and HPV infection among gynecologists who performed electrosurgery.	reducing the risk of HPV transmission from SS The prevalence of HPV infections was higher in gynecologists who had longer durations of electrosurgery.	It investigated a pertinent and previously underexplored issue related to HPV transmission in surgical settings. Weaknesses: The study relied on self-reported data, which may introduce reporting bias. The cross-sectional design limits the establishment of causal relationships, and there may be confounding factors not accounted for in the analysis. Additionally, the study focused on nasal swab samples and did not assess potential HPV transmission to other body areas.

Legend:

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					Self-reported in the questionnaire			

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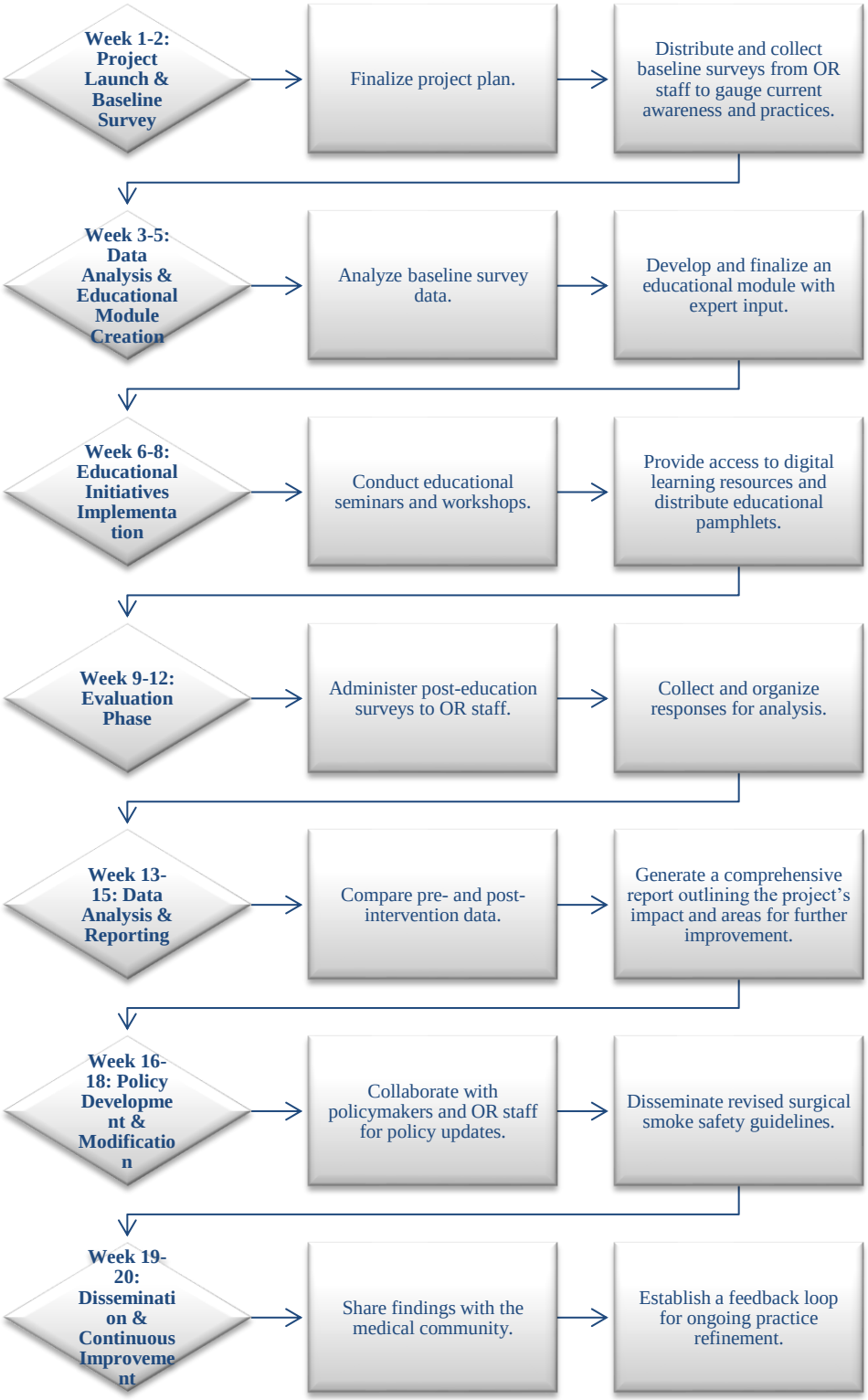
Appendix B

Flowchart



Appendix C

Pre-Education Survey: Understanding Surgical Smoke

Purpose: To assess the current level of awareness, knowledge, and attitudes of OR staff regarding surgical smoke.

1. Demographic Information

- Position/Role in the OR: _____

- Years of Experience: _____

- Have you received any prior training on surgical smoke hazards? (Yes/No)

2. Awareness and Knowledge

- On a scale from 1 (Not Aware) to 5 (Very Aware), how would you rate your awareness of the risks associated with surgical smoke?

- List three potential health risks that you associate with exposure to surgical smoke.

    1._____

    2._____

    3._____

- Are you aware of any safety guidelines or protocols related to surgical smoke in your workplace? (Yes/No)

- What protective measures, if any, do you currently take to minimize exposure to surgical smoke?

_____

_____

3. Attitudes and Perceptions

- How concerned are you about the potential health impacts of exposure to surgical smoke on a scale from 1 (Not Concerned) to 5 (Very Concerned)?

- Do you believe that addressing surgical smoke should be a priority in the OR? Why or why not?

_____

_____

4. Open-Ended Reflection

- What additional information or resources would you find helpful in understanding and mitigating the risks associated with surgical smoke?

_____

_____

_____

Appendix D

Post-Education Survey 1: Impact of Educational Intervention

Purpose: To evaluate the immediate impact of the educational intervention on OR staff's knowledge, attitudes, and intended practices related to surgical smoke.

1. Knowledge and Awareness

- How would you rate your current awareness of the risks associated with surgical smoke post-education on a scale from 1 (Not Aware) to 5 (Very Aware)?

- List any new health risks associated with surgical smoke that you learned about during the educational session.

1.

2.

3.

2. Change in Attitudes and Perceptions

- Has your level of concern about the health impacts of surgical smoke changed after the educational intervention? If so, how?

_____

_____

- Do you feel more equipped to take protective measures against surgical smoke exposure? Please explain.

_____

_____

3. Intended Practices

- What specific protective measures, if any, do you intend to adopt or advocate for in your workplace as a result of this education?

_____

_____

_____

4. Open-Ended Reflection

- What part of the educational intervention did you find most impactful or informative?

_____

_____

- Is there any additional information or support you feel you need to effectively mitigate risks associated with surgical smoke?

_____

_____

Appendix E

Post-Education Survey 2: Sustained Impact and Reflection

Purpose: To assess the long-term impact of educational intervention on knowledge retention, behavior change, and integration of safety practices related to surgical smoke.

1. Knowledge and Awareness (Long-Term)

- Reflecting on the past few months, how has your awareness and knowledge about surgical smoke risks sustained or changed?

_____

_____

_____

- Can you recall and list the protective measures against surgical smoke exposure that were emphasized during the educational intervention?

_____

_____

2. Behavioral Changes and Adoption of Practices

- Have you integrated any new safety practices related to surgical smoke in your daily work? Please provide examples.

_____

_____

_____

- What challenges, if any, have you encountered in adopting these practices?

_____

_____

3. Perceived Efficacy and Support

- On a scale from 1 (Not Effective) to 5 (Very Effective), how would you rate the long-term efficacy of the educational intervention in changing attitudes and practices related to surgical smoke?

- What additional support or resources do you think are needed to enhance safety practices related to surgical smoke in the OR?

_____

_____

_____

_____

4. Open-Ended Reflection

- Reflecting on the educational intervention and its long-term impact, what are your key takeaways or learning moments?

_____

_____

_____

_____

- How do you see the role of education in addressing surgical smoke hazards moving forward?

_____

_____

_____

_____