Title

Conceptualizing the Experience of Surgical Smoke: A Mixed Methods Inquiry

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Conceptualizing the Experience of Surgical Smoke: A Mixed Methods Inquiry

by
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Dedication

I dedicate this dissertation to the perioperative team members who generously shared their experiences of surgical smoke with me in order to move the science of surgical smoke forward.

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I would like to thank my entire dissertation committee for their steadfast and strong support of this incredible journey. Dr. OiSaeng Hong, my dissertation chair, thank you for your guidance and multiple opportunities for enriching my experience that you led me to such as the Targeted Research Training (TRT) at Berkeley and Jonas Scholar experience. Dr. Stella Bialous, for your role as my qualifying exam chair, and then as far back as my master's program, your guidance helped to lead me up to this moment, including highlights such as the internship at the World Health Organization and the teaching residency I enjoyed with you in the doctoral program. Dr. Karen Schumacher, for your course in mixed methods, to accompanying me through this much anticipated mixed methods study with enduring patience, encouragement, and excellence. Dr. Suzaynn Schick, for your role as my research mentor, committee member, and for all the very informative and interesting knowledge you generously shared around smoke.

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Epigraph

Every person on this planet has the right to breathe clean air.

Yet almost every person is having this right violated.

Clean air is a human right, one that is fundamental to our health and prosperity.

—Guterres & Anderson, *International Day of Clean Air for Blue Skies*

Conceptualizing the Experience of Surgical Smoke: A Mixed Methods Inquiry

Merideth Lewis

ABSTRACT

BACKGROUND: In the United States, over 500,000 perioperative team members are exposed to surgical smoke annually. Surgical smoke, a by-product of electrocautery use during operative procedures, contains particulate matter and volatile organic compounds, which are known irritants and carcinogens with mutagenic potential. Surgical smoke adversely impacts the respiratory, cardiovascular, and neurological systems. Despite the exposure to surgical smoke in the operating room, little is known about the *experience* of surgical smoke by perioperative team members.

PURPOSE: Past research has an almost exclusively quantitative approach, with scarce conceptual development beyond descriptions of the smoke's content, mechanism, hazards, and mitigation strategies. The purpose of this dissertation is to use a mixed methods approach to advance the understanding of the experience of surgical smoke.

METHODS: A scoping review with the aims to synthesize the evidence on how perioperative teams experience surgical smoke in operating rooms was conducted. Further, a convergent parallel mixed methods design was used to collect qualitative and quantitative data in parallel, analyze both strands separately, and then merge the results. Qualitative data consisted of semi-structured interviews with 35 multi-disciplinary perioperative team members. Verbatim transcripts were analyzed using constructivist grounded theory methods, including initial and focused coding, and memo-writing. The quantitative data consisted of participants' (N=35) responses to a 22-question validated and modified Air Quality Perception scale and demographics survey. These data were analyzed using descriptive statistics and statistical testing.

RESULTS: There were nine qualitative articles describing the experience of surgical smoke using various conceptually related terminology. The qualitative findings of perioperative team members described multifaceted perspectives on surgical smoke, which were termed their "stance" on the experience of surgical smoke. Each perioperative team member's stance was their way of seeing and thinking about surgical smoke. Stance consisted of 8 dimensions. The quantitative findings revealed that most perioperative team members do not perceive exposure to surgical smoke in terms of poor air quality. The merged findings examined convergence and divergence of the qualitative and quantitative results. Four dimensions of stance were convergent, four were divergent. The convergent dimensions were Awareness, Symptoms, Meaning, and Behavioral Responses. The four divergent dimensions were Knowledge and Beliefs, Personal Impressions, Team Dynamics, and Past Experience.

CONCLUSIONS: This mixed methods dissertation research offers a novel understanding of how perioperative team members experience surgical smoke. The mixed methods findings are compelling, confirming that the experience of surgical smoke is a broader and deeper phenomenon than previously understood. Understanding stance allows for targeted education and informs policy development and implementation to ensure that the hazardous exposure to surgical smoke continues to be mitigated. Describing and measuring the experience of surgical smoke has constructed the conceptual framework of stance and suggested further modification of the Air Quality Perception scale that may be transferred to other environmental settings and hazards.

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Chapter 1: Introduction

Introduction

My curiosity around the experience of surgical smoke began unexpectedly. As a perioperative nurse for more than a decade, I had worked in operating rooms as both a scrub nurse and a circulating nurse. The reasons surgical smoke came into my awareness are two-fold. Firstly, I had chosen to return to graduate school and had to step away from my role on the cardiac team. Secondly, transferring to a less acute hospital and experiencing different surgical cases, combined with a talk I attended about surgical smoke in the operating room at the Association for periOperative Registered Nurses' (AORN) Annual Surgical Conference and Expo in 2017 in Boston, is how it all began.

I would not realize it for about a year, because the combination of hearing the talk, then returning to a smoky operating room, and finally connecting what I had learned with my own experience while working in a particular service, is what brought my full attention to the experience and exposure to surgical smoke in the operating room. I had always smelled it and knew it was just there, a part of surgery. There was very little smoke in the cardiac service, so when I began doing plastics cases like breast revisions, it was a big change. Smoke had entered my awareness, and I was now experiencing it more frequently.

From the outset of my health policy master's program at the University of California, San Francisco, the experience of exposure to surgical smoke has been my main area of interest. As a perioperative nurse, I advocate daily for the safety of my patients and colleagues. I felt compelled to find new ways to advocate on their behalf. So, I began to look upstream for policy solutions. Most of the literature I discovered was similar: measuring and identifying the chemical and physical components in surgical smoke and recommending that it be evacuated from operating rooms. I quickly realized how challenging it would be to commit to smoke evacuation

practices on a systems level. Research on other types of air pollution, such as ambient air and tobacco smoke, has established that air is contaminated with particulate matter and volatile organic compounds, which are harmful to health and should be avoided.

The wildfires in Northern California in 2017 that coincided with my entry into graduate school and that continued during my doctoral coursework and throughout the pandemic impressed upon the general public that breathing air with high levels of known hazardous materials and viral contaminants should be minimized. The aim of my mixed methods research, using grounded theory, is to reduce exposure to surgical smoke and to build a bridge between our knowledge of smoke *in general* and surgical smoke *in particular*. Further, I hope that my research will provide a conceptual foundation for a future theory that advances the science of surgical smoke exposure.

What is Surgical Smoke?

Surgical smoke is the particulate, odiferous aerosol by-product of electrocautery and laser devices used in surgery to maintain hemostasis, decrease surgical time, and provide visibility during operative procedures (Dalal & McLennan, 2016). This means that a heated metal tip makes contact with tissues and vessels to dissect and seal them, allowing for exposure to perform the operation and minimize blood loss. It has been referred to by different names, including smoke, diathermy plume, vapors, bio-aerosols, and air contaminants (Ulmer, 2008). In 2021, Vortman and colleagues wrote the first concept analysis to unify the many names into one term, *surgical smoke*. Since Tomita et al.'s (1981) landmark study, which compared surgical plume to secondhand cigarette smoke, the surgical community has become more aware that exposure to surgical smoke puts perioperative teams and patients at risk. This dissertation contributes to the conceptual development of the *experience* of surgical smoke.

Conceptualizing the Experience of Surgical Smoke: A Mixed Methods Inquiry

Problem Statement

In the United States, more than 500,000 perioperative teams (i.e., anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons) are exposed to surgical smoke each year (Occupational Safety and Health Administration, 2017). Exposure to surgical smoke can damage the respiratory, cardiovascular, and neurological systems (Fencl, 2017; Robertson-More & Wu, 2021; Thangavel et al., 2022). It is a complex mixture of water vapor, particulate matter, and volatile organic compounds. Such particulate matter and volatile organic compounds are known to be toxic to the cardiopulmonary system (Basith et al., 2022), carcinogenic, mutagenic, and irritating (Gatti et al., 1992; Moot et al., 2007; Sarigiannis et al., 2011; Ulmer, 2008). The more than 150 chemical compounds found in surgical smoke have also been identified in second-hand tobacco smoke, compounds such as formaldehyde, toluene, benzene, and hydrogen cyanide (Al Sahaf et al., 2007; Hensman et al., 1998).

In addition, exposure to particulate matter and volatile organic compounds is known to cause upper respiratory symptoms with unknown long-term consequences (Steege et al., 2016). Particulate matter causes inflammation of the alveoli, which renders individuals more susceptible to virus penetration and infection (Robertson-More & Wu, 2021). In the lay and scientific communities, smoke is a known hazard, whatever its source (Comunian et al., 2020; Thangavel et al., 2022). Epidemiological evidence has shown that decreases as small as $10\mu/m^3$ in particulate matter 2.5 micrometers in diameter and smaller ($PM_{2.5}$) are associated with improvements in cardiopulmonary health (Morishita et al., 2015).

Rationale for Dissertation Research

Despite the known health risks associated with breathing smoke, little is known about the experiences of perioperative teams who inhale it. For this dissertation, the experience of surgical smoke is defined as the act of working in an operating room, during a surgical case where electrocautery is used and being exposed to the surgical smoke that is generated. Exposure is through active inhalation and potential dermal uptake of smoke constituents. Experiencing surgical smoke also encompasses verbal and nonverbal communication with team members in the workplace. Experience includes personal reflections on how a smoky operating room manifests itself in one's body, psyche, and intellect. The type, meaning, and impact of experiencing surgical smoke is at once an individual and collective experience, alone with one's thoughts and sensorial effects and at the same time a team member during active cases. Experience also includes reflections of past encounters with surgical smoke. Finally, experience may include listening to or recounting a personal story of a smoky case, taking in and sharing such an experience in the operating room, passive and active experiences. Such levels of the surgical smoke experience have yet to be formally defined, articulated, or deconstructed in the literature.

Within surgical smoke research, the most notable deficiency is the lack of experiential knowledge of perioperative teams as collectives and as individuals. Past research has used an almost exclusively quantitative approach to the phenomenon of surgical smoke. A far more complete understanding is needed by corroborating and synthesizing, in a scientifically rigorous way, qualitative and quantitative data on surgical smoke. Although the symptoms reported are valuable data, more nuanced areas need exploring, such as if and how perioperative team

members experience surgical smoke, if and how their perceptions match observed risk behaviors, and how this novel, merged data can improve safe practice and policy in operating rooms.

The reported adverse health effects and complications from repeated exposure to surgical smoke include, but are not limited to, respiratory symptoms, eye irritation, cough, headache, malaise, lethargy, and worsening of pre-existing conditions such as asthma, chronic bronchitis, and emphysema (Steege et al., 2016). For the most part, these symptoms have been reported by perioperative nurses about perioperative nurses (Ball, 2012). Little to no data has been collected on the experience of entire perioperative teams (i.e., anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons). Some roles may have varied levels of risk and exposure that have not yet been formally considered and studied. More and different types of research are needed to understand more completely the experience of surgical smoke because research to date has been sparse, emphasizing sensorial experience in a secondary/complementary role to quantitative data about the chemical and physical aspects of smoke exposure. Additionally, the research on surgical smoke has not been comprehensive and inclusive of all surgical team members, namely anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons.

Impact of Dissertation Research

This dissertation explored the experience of surgical smoke in the operating room using a mixed methods study design that collected qualitative and quantitative data to create a more comprehensive account of the experiences of perioperative teams. I hope that my research will begin to define and generate concepts and constructs that address the concerns of individuals and entire perioperative teams, from the most basic physical and sensorial experiences to the intellectual and personal values of those who experience exposure to surgical smoke.

Conducting scientifically rigorous, mixed methods research on the experience of surgical smoke will enable policy makers, hospital leaders, and perioperative team members to understand this phenomenon in a more comprehensive way. Clear, comprehensive, and thoughtfully designed research can help policy makers design appropriate new policies. Surgical teams can become empowered change agents. Ideally, this mixed methods research will also advance the field of perioperative nursing and occupational and environmental health nursing.

Purpose and Innovation

This dissertation was designed to better understand the experience of surgical smoke exposure by using a mixed methods analysis of qualitative and quantitative data. Specifically, interviews using constructivist grounded theory coding methods and two surveys were conducted to develop and define themes on the experience of surgical smoke that offer a better understanding of the phenomenon. A convergent parallel mixed methods design was used in which qualitative and quantitative data were collected in parallel, analyzed separately, and then merged (see Figure 1.1). Capitalizing the word *qualitative* signifies that this research had a more extensive focus in the interviews and time than the quantitative portion, and is represented as "QUAL + quan" (Creswell & Plano Clark, 2018). The qualitative data, semi-structured interviews, explored the experience of surgical smoke in the operating room by surgical teams in a county hospital near a major metropolitan area on the west coast of the United States.

The quantitative data comprised responses to a 22-question, validated Air Quality Perception scale (AQP; Deguen et al., 2012), which was modified by the author for the operating room environment. The mAQP scale measured the participants' sensory experiences and perceptions of air quality. Quantitative results were used to describe the participants' self-report of the surgical smoke experience, including their sensorial experiences and perceptions of air

quality, including behavioral avoidance strategies, as measured by the mAQP scale (see Table 1.1).

The reason for collecting qualitative and quantitative data was to bring greater insight to the phenomenon of experiencing surgical smoke, including perceptions of air quality, than could be obtained by either type of data alone. In this dissertation, the experience of surgical smoke is the phenomenon being studied. Included are elements around surgical smoke: what participants say/do not say about the smoke, what they do/do not do around the smoke, and why they think and act around the surgical smoke the way they do. In my experience of surgical smoke, teammates respond to such exposure in verbal and nonverbal ways. Hospitals also communicate with surgical teams by providing, or not providing, the equipment and supplies for surgical smoke evacuation. In this dissertation, I have defined and conceptualized the experience of surgical smoke based on participant responses to two surveys and the analysis of semi-structured interviews, complemented by my informed background and extensive experience in the operating room, as outlined in my Statement of Positionality (see Appendix A).

Research Questions

Qualitative Research Question

How do perioperative team members describe their experience of surgical smoke in the operating room?

Quantitative Research Question

How do perioperative team members describe their sensorial experience and perception of air quality around surgical smoke in the operating room as measured by the modified Air Quality Perception (mAQP) scale?

Mixed Methods Research Question

What are the emergent themes that combine qualitative and quantitative dimensions of the experience of surgical smoke in the operating room by perioperative teams?

Philosophical Foundations

Pragmatism was the overarching philosophical assumption of my mixed methods research and has been used by many mixed methods scholars (Tashakkori & Teddlie, 2003). The emphasis is on experience and how beliefs and actions impact consequences (Schwandt, 2015). Examining and taking action on problems in a pragmatic way, in lieu of using an a priori theory, encompasses the pragmatic philosophy, as is using many sources of data to inform the researcher. The qualitative method of constructivist grounded theory has similar philosophical underpinnings, which will be explored briefly. The quantitative tradition of research is grounded in positivism that relies on logical or mathematical proof (Stevenson, 2010). These philosophical assumptions guided qualitative and quantitative data collection and analysis, and the data integration approach used by the researcher (Creswell & Plano Clark, 2018).

Often, a philosophical or theoretical component is used to inform and guide a researcher. For this research, symbolic interactionism was foundational for the grounded theory inquiry. George Herbert Mead was the "father" of social behaviorism, which Herbert Blumer then expanded into symbolic interactionism. Blumer was interested in how people adjust to their environment (Audi, 1999). In the study of perioperative teams, this applies when observing the phenomenon of surgical smoke. Blumer was especially interested in concrete social clauses that encompass gestures that can be unconscious and communication that includes gestures and language (Audi, 1999). In operating rooms, gestures and language are used in communication, team dynamics, and situational awareness. These patterns of communication vary in every

operating room, with every case. Communication styles and operating room culture are unique to every region, hospital system, and country.

My approach to qualitative data analysis was informed by Strauss and Corbin (1990), Charmaz (2014), and Braun and Clarke (2022), among others. The experience of surgical smoke is conceptually young, with scarce research development beyond basic descriptions of smoke's chemical and physical composition, its mechanism of action, hazards, and mitigation. Little is known about how surgical teams experience this in the operating room beyond reported symptoms. In the past two decades, the number of studies of perioperative team members' (usually perioperative nurses) perceptions of air quality and the risk of surgical smoke exposure has been exceedingly small (Ball, 2012; Chia et al., 2012). Most of the literature has been written by perioperative nurses, surgeons, and entities like corporations that manufacture surgical smoke evacuation devices. In 2024, Rodrigues and Winnington's qualitative study examined attitudes and practices about surgical smoke and mitigation practices using thematic analysis, which added to the body of qualitative research on surgical smoke.

Literature Review

A major gap in the literature is investigation of the experiences of surgical smoke by perioperative teams. A scoping review was performed to synthesize and evaluate the existing body of evidence on perioperative personnel's experience of surgical smoke to uncover knowledge gaps, guide future research, and inform policy (Lewis & Tahir, 2024). Past and current systematic and standard literature reviews reveal an emphasis on surgical smoke risk, mitigation, and exposure levels (Canicoba & Poveda, 2021; Mellor & Hutchinson, 2013; Mowbray et al., 2013; Robertson-More & Wu, 2021), reflecting recurring themes in the

literature, including measurement of elements in surgical smoke. No systematic reviews of the experience of surgical smoke were found, revealing a substantial and important knowledge gap.

Quantitative Research

In most quantitative studies, the contents of surgical smoke are described, health hazards are stated, and the recommendations almost always include the evacuation of surgical smoke and more research. There has also been great variability in how surgical smoke has been measured, reflecting heterogeneity that lacks scientific rigor.

Qualitative Research

Qualitative research on surgical smoke is largely undocumented, and only briefly mentioned in a few studies. Only a handful of studies have examined symptoms experienced and perceptions around concepts such as behaviors related to perceived risk, often as an addendum to a quantitative survey or study.

Mixed Methods Research

Previous research on surgical smoke has only recently included mixed methods as a formal design. There have been two mixed methods studies to date (Ball & Gilder, 2021; Moon et al., 2021). Mixed methods expectations have advanced. A guide for generating and critiquing scientifically rigorous mixed methods studies can be used to establish criteria for relevance, transparency, integration, and rationale (Creswell & Plano Clark, 2018).

The dearth of qualitative information on the experience of surgical smoke has established mostly one-dimensional information about the phenomenon. Using a mixed methods approach has generated a multidimensional and in-depth account of the experience of surgical smoke by perioperative teams (i.e., anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons) and their perceptions of air quality in that environment. A

conceptualization has emerged to inform and guide future studies of the actual and in-depth experience of surgical smoke.

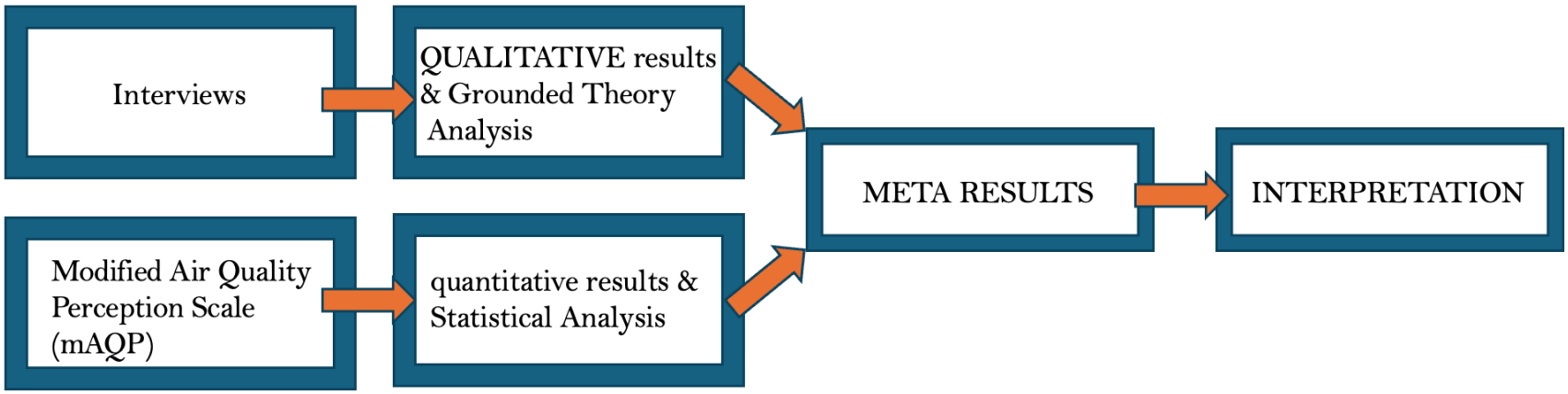

Figure 1.1

Mixed Methods Procedural Diagram

Note. This was adapted from Creswell, J. W., & Plano Clark, V. L. P. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage Publications.

Table 1.1

Air Quality Perception Scales, Original and Modified

Air Quality Perception Scale (AQP)	**Modified Air Quality Perception Scale (mAQP)**
Over the past week, as a result of air pollution, did you	*Over the past week, as a result of surgical smoke, did you*
1. Feel worried about your health	1. Feel worried about your health
2. Have "red" eyes	2. Have "red" eyes
3. Suffer from nose irritation	3. Suffer from nose irritation
4. Sneeze	4. Sneeze
5. Have a dry throat	5. Have a dry throat
6. Cough	6. Cough
7. Have difficulty breathing	7. Have difficulty breathing
8. Suffer from headaches	8. Suffer from headaches
9. Change your leisure activities	9. Think about calling out sick
10. Stay indoors	10. Call out sick
11. Air your home	11. Open the sub-sterile or main operating room door
12. Close the shutters in your home	12. Walk out of the operating room into sub-sterile room
13. Use an air freshener in your home	13. Attempt to air out your operating room suite
14. Avoid opening your windows	14. Change your mask
15. Feel the need to wash your hands or face	15. Feel the need to wash your hands or face
16. Drink more water than usual	16. Drink more water than usual
17. Smell an unpleasant smell outdoors	17. Smell an unpleasant smell in the hallway
18. Smell an unpleasant smell indoors	18. Smell an unpleasant smell in your operating room suite
19. Notice that your curtains were dirty	19. See smoke plume around the sterile field
20. Notice that the sky was cloudy	20. See smoke plume in your operating room suite
21. Think that your quality of life was being degraded	21. Think that your quality of life was being degraded
22. Think about moving home	22. Think about getting a different assignment

Note. This figure illustrates the conceptual modification of the original Air Quality Perception Scale (AQP) by Deguen, S., Ségala, C., Pédrono, G., & Mesbah, M. (2012). A new air quality perception scale for global assessment of air pollution health effects. *Risk Analysis*, *32*(12), 2043-2054. https://doi.org/10.1111/J.1539-6924.2012.01862.x This modified Air Quality Perception Scale (mAQP) by M. Lewis with oversight from J. Chen was in conceptual alignment with the original scale.

Chapter 2: Scoping Review

Scoping Review: Rationale and Purpose

Although exposure to surgical smoke is not a new phenomenon, standard terminology was only defined in a formal concept analysis in 2021 due to the large variety of terms to reference surgical smoke in surgery (Vortman et al., 2021). In keeping with this scholarship, surgical smoke will be the term used in this dissertation, though other references will include various names such as plumes, vapors, etc. when referring to surgical smoke. As described in Chapter 1, surgical smoke is the noxious by-product of energy-generating devices that are used in surgery. Particulate matter in smoke causes inflammation of the alveoli, which then renders individuals more susceptible to virus penetration and infection (Robertson-More & Wu, 2021).

The most commonly recommended practice to mitigate harm is to employ a smoke evacuation system (Chavis et al., 2016; National Institute for Occupational Safety and Health [NIOSH], 2024; OSHA, 2024). Smoke evacuation consists of tubing that collects smoke and passes it through a designated filter (i.e., a high- efficiency particulate air (HEPA) filter and an activated charcoal filter) to remove, respectively, particles and volatile organic compounds in the smoke aerosol. By this method, perioperative team members can avoid inhalation. The cannister, tubing, and filter become biohazardous waste (Fencl, 2017). Several countries have enacted legislation that mandates evacuation of surgical smoke to protect workers from its harms; in the United States, only 17 states, including California, have successfully passed such legislation to ensure mandatory smoke evacuation in operating rooms (Vortman et al., 2021).

During the COVID-19 pandemic, proving causation of viral transmission and harm became a focal point in the surgical smoke literature, leading to an increase in systematic reviews. In 2020, four out of five registered protocols on surgical smoke addressed viral transmission by surgical smoke (Fox-Lewis et al, 2020; Patterson et al., 2020 & Pavan et al.,

2020; Robertson-More & Wu, 2021). Most other studies on viral transmission in surgery are decades old, and the methods are heterogeneous, lacking rigor (Yadav et al., 2020). Yadav and colleagues (2020) discovered that the evidence informing most guidelines on surgical smoke was not well-grounded in hard evidence. Despite widespread use of such guidelines to inform policy, the researchers noted that the guidelines are inequitable because they lack representation from low- and middle-income countries, favoring high-income countries that are more likely to afford smoke evacuation devices.

Knowledge Gaps

The literature does not address the lived experiences of perioperative teams who inhale surgical smoke in the operating room. This is a glaring gap in knowledge. The aims of this scoping review were to synthesize and evaluate the existing body of evidence on the experiences of perioperative teams to surgical smoke to uncover gaps in knowledge, to guide future research, and to inform policy. Systematic and standard literature reviews, past and present, have emphasized the risk of surgical smoke, mitigation, and exposure levels (Canicoba & Poveda, 2022; Mellor & Hutchinson, 2013; Mowbray et al., 2013; Robertson-More & Wu, 2021), reflecting recurring themes such as the measurement of elements in surgical smoke.

Due to climate change, the United Nations adoption of the Sustainable Development Goals in 2015, and a proliferation of wildfires worldwide, professional and lay communities have become increasingly focused on air quality (Gumy & Mudu, 2018; Linou et al., 2018). So much so that widespread use of N95 masks, especially during the COVID-19 pandemic, has become part of our vernacular and practice to protect ourselves from smoke and other exposures. The population at large now knows and understands the implications, sensations, and lived experience of smoke exposure and viral threat.

Objectives

The primary aim of this scoping review was to synthesize the evidence on how perioperative teams experience surgical smoke in operating rooms. A secondary aim was to gain a deeper understanding of the perioperative teams' experiences of surgical smoke. The findings of this scoping review will reveal knowledge gaps and guide researchers in developing policies and practices on preventing exposure to surgical smoke.

Methods

The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR; Tricco, et al., 2018) guided this scoping review. Use of its 22-item checklist contributed to this review's rigor and comprehensiveness. The checklist is also known as the Joanna Briggs Institute Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (Tricco et al., 2018; see Appendix B).

A scoping review was most appropriate because the paucity of studies on this inquiry was anticipated. Few qualitative and mixed methods studies have been published on the experience of surgical smoke. A scoping review was most aligned with this dissertation's purpose to better understand the experience of surgical smoke and allow for a synthesis and evaluation that reflects the qualitative tradition of rich, deep, and broad exploration of such a phenomenon (Flick, 2013). This form of qualitative research enables a multifaceted, comprehensive evaluation (Flick, 2013) that is novel and unique in the body of available literature on the topic of perioperative teams' experience of surgical smoke. A scoping review also creates a roadmap of concepts and definitions within a research field, establishes evidence types and amounts, and provides an opportunity to see what, if any, new evidence is emerging (Lockwood et al., 2019).

Scoping reviews are generally conducted to get a broad overview of a phenomenon of interest. The main goal is to "characterize the quantity and quality of the literature, perhaps by study design and other key features" (Grant & Booth, 2009, p. 95). Searches can sometimes be limited, based on factors such as time available to the researcher, and there is no "formal quality assessment" of the literature (Grant & Booth, 2009, p. 95). Synthesis is usually in table format with an accompanying narrative (Grant & Booth 2009). This scoping review was not registered with a review protocol.

Eligibility Criteria

To be included in this review, studies had to meet the following criteria (see Table 2.1):

1. Samples had to include members of the perioperative team. *Perioperative team* was defined to be those who experience surgical smoke exposure, directly and indirectly, including, but not limited to nurses, surgeons, scrub technicians, anesthesiologists, anesthesia technicians, physician assistants, nurse attendants, anesthesia technicians, and housekeeping staff.
2. Studies had to include information on the perioperative teams' experiences of surgical smoke.
3. Studies using qualitative methods (i.e., interviews; focus groups; descriptive, narrative, surveys; and questionnaires with qualitative components), mixed methods, or quantitative studies with a qualitative component had to gather data on perceptions and experiences of surgical smoke.
4. Studies had to be peer reviewed, with full-text articles in English. Because the phenomenon of surgical smoke has existed since the 1920s with little mitigation, there was no date limit on studies selected (O'Connor & Bloom, 1996).

Information Sources

A systematic search of the CINAHL, Embase, PubMed, and Web of Science databases was conducted using keywords and MeSH/Emtree terms to identify qualitative, peer-reviewed studies of the experience of surgical smoke in operating rooms. Reference lists from previous systematic reviews complemented the search, when needed.

Search Strategy

The SPIDER (Sample, Phenomena of Interest, Design, Evaluation, Research type) tool was used to determine search terms and eligibility criteria (see Table 2.1). Boolean operators were used to construct the search strategy, design, evaluation, and research type. The operator "OR" was used in lieu of "AND" due to the variable nature of how qualitative data findings are indexed (Cooke et al., 2012). All materials were in English. Because surgical smoke has been recognized since introduction of the *Bovie*, an electrosurgical unit for cutting and coagulating tissue with high-frequency electricity) in the early 1900s (O'Connor & Bloom, 1996), studies were accepted without date limits. Sample search strategies from Covidence using search engines are included in Appendix C. All searches were dated, saved, and stored securely to allow for scientific reproducibility and transparency (Morse, 2007).

Initially, broad scoping searches were conducted to ascertain how best to pursue the concept of the experience of surgical smoke (Cooke et al., 2012). The searches were iterative, leading to specific sets of keywords and were then adapted to fit into various database search engines. The concept, *the experience of surgical smoke*, could not be found in a search. As a rule, it, or related terminology, was embedded within a study. Thus, it was critical to conduct searches that were inclusive of terminology related to this phenomenon or experience, terminology such as *symptoms*, *adverse effects*, and *hazards of surgical smoke* (Cooke et al., 2012).

Data Management

Covidence (2024) software, which screens studies for rigor, bias, and duplicates, was used to analyze studies.

Selection Process

The selection process and results are illustrated in a flow diagram of the PRISMA-ScR Checklist guidelines (see Appendix D; Tricco et al., 2018). The author conducted title and abstract screening to make sure that they aligned with inclusion and exclusion criteria. Eligibility was determined from the pool of selected studies.

Data Collection Process and Synthesis

Experiences of surgical smoke were recorded as presented in each study. Covidence (2024) was used to identify overarching themes, theoretical or philosophical framework, methodology (e.g., questionnaires and interviews), and demographics (e.g., type of team member, gender, geographic location) during data extraction. Study details (i.e., year of publication, author(s) name(s), study design, country of origin, and overall study characteristics are presented in Appendix E. Synthesis was created through a narrative based on themes, emerging concepts, and methodologies of the nine selected studies.

Results

Covidence screening revealed that a mixed methods study (Ball & Gilder, 2022), known to the author but not identified in the search, was included. As a final check, a search of Google Scholar was performed using the terms *"surgical smoke"* AND *"mixed methods"* AND *"surgical smoke."* Five articles emerged: the three included in Covidence screening, the Ball and Gilder (2022) study, and a fifth that did not meet the inclusion criteria. The CINAHL, Embase, PubMed, and Web of Science searches yielded 2,089 studies, 2090 including the one from

Google Scholar (see Appendix D). After removing duplicates (n = 395), the remaining 1,695 studies were screened by title and abstract; 1,236 were excluded due to irrelevance. In November 2024, a total of 459 full text articles were screened by title and abstract for inclusion. Studies were excluded for several reasons, leaving nine studies that met the inclusion criteria. Of the 459 screened studies, only 0.87% were qualitative or mixed methods (0.43%) studies that investigated the experience of surgical smoke in the operating room. No systematic reviews on the subject were found, revealing a substantial knowledge gap.

Characteristics of Selected Studies

Methodologies for the nine studies varied (Appendix E). Vortman et al. (2021) used the Delphi technique to establish expert consensus on the mitigation of exposure to surgical smoke and health concerns setting itself apart from other methodological strategies. Two studies explicitly identified their design as mixed methods (Ball & Gilder, 2022; Moon et al., 2021), which is advisable for mixed methods research (Creswell & Plano Clark, 2018), and two used both qualitative and quantitative methods, although this was not formally acknowledged in their titles (Barber et al, 2022; Michaelis et al., 2020).

The nine studies were conducted in six countries: (a) Turkey (Ilce et al., 2017; Soysal et al., 2023); (b) United States (Ball & Gilder, 2022; Golda et al., 2019; Vortman et al., 2021); (c) Germany (Michaelis et al., 2020); (d) the Republic of Korea (Moon et al., 2021); (e) Iran (Lotfi et al., 2022); and (f) New Zealand (Barber et al., 2022). All nine were published within the past 7 years, suggesting that this type of research is emerging as a new conceptual focus of occupational and environmental health.

The aims of the nine studies included exploring knowledge, perceptions, and attitudes toward surgical smoke, indicating conceptual abstraction, while others explored attitudes and

impact of hazard perception, protective measures, problems and barriers to surgical smoke and mitigation strategies. Ball and Gilder (2022) and Barber et al. (2022) discussed how a theory can be used to frame findings; the former used the health belief model, the latter situated surgical smoke within the Planetary Health Education Framework. Participants in the nine studies were heterogeneous and included perioperative nurses, surgeons, and surgical scrub technicians.

Key Findings

Among the key themes emerging from the studies were (a) conceptual elements such as the awareness and presence of surgical smoke in the operating room (Barber et al., 2022; Lotfi et al., 2022; Michaelis et al., 2020; Moon et al., 2021; Vortman, 2021), (b) coping with surgical smoke and perception of risk, for example, lack of knowledge, predictors of protective behaviors, gender differences in valuation/symptom presentation, and role differences (Ball & Gilder, 2022; Golda et al., 2019; Ilce et al., 2017; Lotfi et al., 2022; Michaelis et al., 2020; Moon et al., 2021; Soysal et al., 2023), and (c) barriers and efforts to improve working conditions such as lack of equipment, lack of support for evacuation, and lack of policies (Ball & Gilder, 2022; Michaelis et al., 2020; Lotfi et al., 2022; Soysal et al., 2023; Vortman, 2021).

One of the main barriers to addressing exposure to surgical smoke was lack of nursing leadership in surgical services. Vortman and colleagues (2021) noted that the lack of leadership among surgeons is an important factor; just over 30% of surgeons surveyed use surgical smoke evacuation. In fact, Michaelis et al. (2020) found the response rate to be only 5% among the surgeon group due to “lack of interest” in surgical smoke protective measures.

Michaelis et al. (2020) and the Moon et al. (2021) opted to use the same research question to explore the perceptions, knowledge, and attitudes of perioperative personnel toward surgical smoke and followed it with a second question on the use of protective equipment and

countermeasures, both ways of dealing with smoke. Both studies explored the experience of surgical smoke conceptually, a clear strength. However, comparing the studies' results was all but impossible because the respective samples were so different: Michaelis et al.'s (2020) sample compromised mostly surgeons ($N = 359$) and used a questionnaire; Moon et al.'s (2021) sample compromised only female perioperative nurses ($N = 12$) to understand perceptions and practices around surgical smoke. This makes it difficult to draw scholarly comparisons or assess reproducibility. Barber et al. (2022) used a critical approach, using the Planetary Health Education Framework to glean insight on the experience of surgical smoke, a novel and expansive way to view the phenomenon.

Synthesis

This scoping review identified an emerging shift toward less measurement of surgical smoke's characteristics and more on exploring its impact by examining physical symptoms, perceptions, and general attitudes toward surgical smoke mitigation. This shift occurred at almost the same time as the COVID-19 pandemic, which may have moved the science of surgical smoke exposure from foundational conceptual characteristics of measured smoke components toward examining knowledge, values, and behavior about it.

Overall, the publication of nine papers on this emerging topic in the span of 6 years from countries that are culturally and geographically diverse indicates the increasing importance of the research question. In Turkey, Ilce et al. (2017) explored problems around exposure to surgical smoke and necessary precautions. The remaining eight articles, written between 2019-2023, reflect an evolution toward more focused research questions on perceptions of hazards and protective measures. In 2022, Barber et al. went beyond the confines of these familiar concepts. Amidst and emerging from the COVID-19 pandemic, these researchers used the Planetary Health

Education Framework to pose new questions, such as how surgical smoke can be approached on a systems level to promote health for people and planet, around all the levels of environmental and social responsibility. This was an innovative approach.

One of the most helpful studies, Soysal et al.'s (2023) case control study, combined a sound industrial hygiene standard and used universal language and terminology that aligns with the Environmental Protection Agency (EPA) when it refers to surgical smoke as "indoor air pollution" (p. 444). They correlated the physical symptoms and laboratory test values of 19 healthcare professionals (i.e., lecturers, general surgery assistants, anesthesiologists, anesthesia technicians, nurses, and assistant staff) with a closely matched control group. Soysal et al. validated the link between the physical effects in a rigorous way that could be used to assess the impact of surgical smoke in other settings. This study directly correlated the amounts of exposure to surgical smoke with symptoms and effects such as tearing and burning of the eyes, hair odor, nausea, and cough. The study confirmed that "surgical smoke was [is] an important contaminant for indoor air quality in the operating room" (Soysal et al., 2023, p. 444). The authors used precision, comparison, and thoughtful methodological strategies to create an accurate and valuable contribution to the literature on surgical smoke exposure.

In New Zealand, Barber et al. (2022) used the Planetary Health Education Framework to "discover thoughts about the problem of surgical smoke, idea of a surgical smoke free policy, and to formulate ideas on how the matter could be approached in an environmentally and socially responsible way" (p. 18). The themes that emerged from this qualitative survey focused on "nature, society, and technology" (Barber et al., 2022, p. 18). They found that a systems approach that is ecologically and socially centric, rather than smoke-free policies as a first option, could present new ways of looking at more than just one facet of the solution.

The nine studies selected offer a solid contribution of highlights, perceptions, awareness, coping strategies, and educational/legislative efforts/policies of the latest literature on the experience of surgical smoke in operating rooms. They all speak to the current state of the science with varied awareness levels and methodological approaches. The body of knowledge on surgical smoke is expanding, as shown by the increasing number of publications after the pandemic, the increase in publications from low- and medium-income countries, and the application of theory. Barber et al. (2022) have viewed solutions as interconnected with the environment and surgical teams. From this vantage point, new questions and solutions have emerged, “Is it necessary to use an electrosurgical device for all cases?” Significant shared findings emphasize that more research is needed to identify and quantify the health risks caused by occupational exposure to surgical smoke.

A newer study, published after the scoping review literature search by Rogdrigues & Winnington (2024), explored concepts related to the experience of surgical smoke. Their aim was to understand how attitude influenced practices for mitigation of surgical smoke. In particular, they used semi-structured interviews to explore attitude and perceptions, education, and barriers of surgical smoke mitigation strategies. This study used the research method of Exploratory Descriptive Qualitative Research (Hunter et al., 2019) and reflexive thematic analysis informed by Braun & Clarke (2021). They concluded that education, leadership, and ongoing mitigation strategies be employed at all levels across all roles to decrease the risks of exposure to surgical smoke.

Strengths and Limitations

To my knowledge, my scoping review is the first to examine the lived experiences of perioperative teams to surgical smoke. The growing awareness of the right to breathe clean air

(Linou et al., 2018) empowers this study. The timing is synchronous with the smoky environment in most surgical suites and the experience of outdoor air pollution caused by wildfires worldwide related to climate change. This scoping review's singular strength is that it is one of the first to focus exclusively on qualitative, peer-reviewed research studies on how surgical smoke is experienced. Hopefully, it will awaken the perioperative community, especially perioperative nurses, to become advocates and activists for change. Researcher bias might weaken this study's findings because the researcher is a perioperative nurse herself. However, more rigorously conducted mixed methods studies may accelerate more qualitative and mixed methods reviews of the experience of surgical smoke. Finally, this scoping review only had one reviewer, a limitation acknowledged.

Discussion

As a result of climate change and the COVID-19 Pandemic, citizens worldwide have adopted the terms *particulate matter* and *N95* in everyday conversation. This may stimulate more conscious, robust, and meaningful consideration of why there is still unevacuated smoke in operating rooms when there is evidence that it does harm. Existing research in other disciplines has established the harm of noxious gases and particulate matter that is present in all smoke, including wildfires, cooking, and the combustion residue of car exhaust, industry, and improper disposal of chemical waste around the world (Gumy & Mudu, 2018).

Barber et al.'s (2022) systems approach was timely due to climate change, environmental awareness, and the availability and allocation of healthcare resources. Their study offers novel guidance, a systems level approach that offers a cost-effective way to explore, understand, and mitigate surgical smoke. The team was rigorous in its methodology, with clear aims, appropriate methods for the research questions, and useful statistical analyses. The elements of quality

research were clear, accounted for, and easy to follow in the text. Data visualizations were expansive, and aesthetically pleasing, avoiding visual overload for the reader. There was a meaningful and positive correlation with support for a smoke-free policy and the perceived risk of exposure to electrocautery smoke. Although this qualitative study addressed some of the major themes in my scoping review, including the consensus that surgical smoke mitigation policy is required for safe working environments in operating room, Barber et al.'s purpose was to discover thoughts and ideas on surgical smoke issues and policies. This information was used to formulate ideas for environmentally and socially responsible solutions with application to the Planetary Health Education Framework.

Barber et al.'s (2022) qualitative study on the experience of surgical smoke is the only one thus far to have identified a theoretical framework a priori to guide inquiry. Expanding beyond familiar concepts of surgical smoke such as smoke contents, perceptions of hazards, and protective measures, the researchers used the Planetary Health Education Framework to pose new questions such as how surgical smoke can be approached on a systems level to promote health for people and planet, around all the levels of environmental and social responsibility.

Among this study's strengths are its use of a framework to discover themes that are interconnected, revealing an environmental approach that expands beyond standard smoke free policy, suggesting social responsibility and re-evaluating the need for electrocautery devices. New facets emerged in the literature that were not present until this study articulated them, and the researchers made good use of wider literature in bridging the concepts of environmental impact and surgical smoke. The sample size ($N = 462$) was large for analysis, giving power to the study. Justice, environmental and human, were exposed and acknowledged, moving the issue of surgical smoke to a new and different conceptual level in the literature.

Among this study's limitations is that it is the first study of its kind to modify the Planetary Health Education Framework. The questions posed were written by the five authors, using questions in previous surgical smoke literature. Although innovation and multiple authors are strengths, more research is needed to validate the use of the Planetary Health Education Framework. The response rate was biased, including more surgeons than nurses, and likely included those who feel strongly about the issue. The qualitative data were gleaned from comments on the survey, not from interviews. Although the diagram is helpful, it is still in a nascent and cumbersome state. Verbiage is inconsistent in the description, and the model is two dimensional on paper. It is an excellent beginning that begs more nuance, specifically from more qualitative data.

The application of a theory or framework to a policy issue informs the body of knowledge in new directions, using relational ecological human factors and planetary systems approaches (Barber et al., 2022; Lewis, 2024b). More and different studies are needed as the paradigm shifts from the Holocene Epoch to the Anthropocene Epoch, where climate change, multiple global environmental crises, and threats to biodiversity and planetary health command new research methodologies to solve these universal challenges.

This scoping review inspires and further validates the need to examine the phenomenon of surgical smoke as planned in my dissertation research: a mixed methods parallel convergent study on the experience of surgical smoke. Applying the Planetary Health Education Framework was a novel way to address aspects of the phenomenon conceptually. As I planned how to better understand the lived experiences of surgical smoke among perioperative team members, I critically examined and applied Kingdon's Multiple Streams Framework (1994) and

Bronfenbrenner's ecological systems theory (1975). The former offers overarching insights from a policy perspective; the latter offers insights from a relational level (Lewis, 2024b).

Merging Kingdon's (1994) and Bronfenbrenner's (1975) frameworks shed new light on the macro and micro levels of the surgical smoke phenomenon, with ecological systems theory providing a more personal way of understanding the experience of surgical smoke in a relational way. Discovering Barber et al.'s (2022) application of the Planetary Health Education Framework to surgical smoke indicates that using a framework or theory to explore the issues around surgical smoke was a pathway to a more complete and deeper understanding. Although the application of two frameworks and one theory shed new light and perspective on the phenomenon of surgical smoke, there is still a need to understand more deeply and conceptualize this experience on a personal level.

This scoping review has confirmed the gap of research in the qualitative realm. However, I wanted a methodology that would advance the conceptual understanding of surgical smoke and the field of perioperative nursing. At an earlier point, ethnography appealed to me because no one had examined the subculture of surgery and surgical smoke, as well as surgical smoke over the past 100 years (McCauley, 2010). Interpretive phenomenology also offered novel insight into the lived experience of surgical smoke from the positionality of an "inside outsider" (Appendix A). Despite these qualitative options, there was only one methodology that could advance the knowledge conceptually, *grounded theory*, specifically constructivist grounded theory, which will be explored in Chapter 3, the Methods component of my dissertation research.

My mixed methods dissertation research has contributed rich and novel data that is grounded in personal and unique perspectives and experiences of surgical smoke. As an example of how this data was gathered, the quantitative survey was administered before interviews,

minimizing recall bias. Although an interview guide was developed, questions were arranged in a way that promoted original, open-ended responses. Although Barber et al., (2022) used an inductive approach and collected both quantitative and qualitative data, my dissertation research was designed to use mixed methodology informed by constructivist grounded theory in a rigorously constructed and scientific way. Using formal methodology increased credibility and rigor. Having designed interviews in the tradition of grounded theory also provided an in-depth and novel set of data, with corroborating evidence to further substantiate the complexity, interconnectedness, and dynamic nature of the experience of surgical smoke.

Conclusion

Perioperative registered nurses are uniquely trained and are strong advocates of their patients. For perioperative team members, awareness of the hazards of surgical smoke can be a way of becoming and being strong advocates for themselves and their teams. Building a substantial body of qualitative and mixed methods research will strengthen advocacy for safety in the workplace. By exploring the experience of surgical smoke (indoor air pollution) in the context of outdoor air pollution and its known health risks, remedial action and change is possible. This scoping review validates the need for more research on the experience of surgical smoke in a scientifically sound and methodological way (Bhattacharya, 2017). This will advance how we think, expand how we conduct research, and ultimately cleanse the operating room environment.

Table 2.1
Spider Table of Study Inclusion and Exclusion Criteria

Phenomenon of Interest	Studies about the perioperative team's experience, perceptions, and attitudes of surgical smoke in the operating room	Studies about the patient experience, measurement of surgical smoke; analysis of surgical smoke components, compliance with mitigation policy
Design	Qualitative, Mixed Methods, Quantitative with qualitative component	Quantitative studies without qualitative components, protocols, editorials, opinion pieces, news articles, and dissertations
Evaluation	Qualitative or quantitative analysis of experiences, perceptions, and attitudes on surgical smoke	Analysis of factors not related to the perioperative team experiences of surgical smoke
Research Type	All peer reviewed journal articles qualitatively addressing the experience of surgical smoke by the perioperative team	Non-data-based papers, papers not published in peer reviewed journals
Report Characteristics	Full texts available in English No publication date restrictions	Full text not available, language other than English, protocols, editorials, opinion pieces, news articles, and dissertations

Chapter 3: Methods

Methods

Design

The mixed methods convergent parallel design (see Figure 3.1) comprised four phases: (a) concurrent data collection of separate strands of data, qualitative and quantitative; (b) separate analysis of each strand of data using respective analytic methods; (c) merging the two strands of data, which is depicted in a joint display table for direct comparison and relational points of intersection; and (d) integration of the merged results, an exploration of convergence/divergence/complementarity of data thematically, which generated new understanding and knowledge on the phenomenon of interest. Divergent results required reflective steps including review of original datasets, results, and other issues relating to type and quality of original databases (Creswell & Plano Clark, 2018). This dissertation research investigated the same themes in both strands, sensorial experiences, and perceptions of air quality about the same phenomenon, the experience of surgical smoke.

The primary researcher collected both strands of data to compare and/or combine results that revealed where divergence and/or convergence occurred and when the two types of data complemented each other (Creswell & Plano Clark, 2018). Both strands typically have equal importance but can weigh more heavily in one or the other tradition, qualitative or quantitative. This dissertation research was a "QUAL+ quan," which denotes a mixed method design with a more extensive qualitative focus due to the depth of the interviews and time the primary and secondary researchers spent collecting and co-analyzing the data. Morse (1991) defines the goal of a convergent mixed methods study "to obtain different but complementary data on the same topic" (insert page number). This design is also helpful for researchers who are on a tight timeline with limited funding because both types of data can be gathered efficiently and when

both forms of data (qualitative and quantitative) need to be gathered (Creswell & Plano Clark, 2018). Other mixed methods designs call for sequential collection of qualitative and quantitative data, which can lengthen the study's duration considerably.

This dissertation research used the mixed methods design to better understand the experience of surgical smoke by members of a perioperative team (i.e., anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons) in the operating room. Integrated data, including data that has emerged with integration, allows for a more robust and thorough understanding of the experience of surgical smoke, sensorial qualities, and how air quality is perceived. Overall validity of this mixed methods dissertation research was strengthened by using parallel questions that addressed the same concepts, using the same sample of perioperative team members for each strand to allow for comparisons, and using a convergent data analysis integration strategy (joint display and/or direct comparison in a table) and strategic analysis to understand unexpected results (Creswell & Plano Clark, 2018).

Sample

The same purposive sample, for both the qualitative and quantitative strands of data, was used to facilitate richness and depth of understanding. Potential participants (anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons at a West Coast county hospital operating room) were recruited by email, flyer, and word of mouth. The sample ($N = 35$) comprised 7 anesthesiologists, 10 perioperative nurses, 3 physician assistants, 9 scrub technicians, and 6 surgeons on the surgical team. This size allowed for deep and rich qualitative data and flexibility that enabled a saturated level of meaning and was representative of the whole by not being too large or too small (Sandelowski, 1995). A sample size of 35 for the quantitative

strand slightly exceeded the minimum size needed to calculate descriptive statistics; 30 is generally considered to be the minimum size acceptable (Pett, 2016).

Inclusion Criteria

To be included in this research, participants had to speak English and be consenting adults (18 years of age or more) who were employed in the West Coast county hospital and who were members of the perioperative team. No non-English-speaking members were on the perioperative team. They would have been excluded from participation because the primary modes of data collection (i.e., reading questionnaires and responding in writing and participating in interviews with the primary researcher) required one to be fluent in English.

Setting

Participant interviews were held on Zoom. The intake demographic form and the mAQP scale (see Table 1.1) took place online using the Qualtrics platform. Participant interviews took place on Zoom in a private room. They were transcribed using the Zoom transcription platform; the primary researcher cleaned data in the transcripts immediately following interviews. Both the primary and secondary researchers analyzed interview results and shared data while being securely signed in to the University of California, San Francisco's (UCSF) Ivanti network for security.

Sampling Procedures

Purposive sampling was used in this predominantly leading qualitative convergent parallel mixed methods dissertation research (QUAL+ quan). Participants were recruited and selected for having experienced surgical smoke in the operating room. Because the surgical team comprised anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons, the strategy of maximal variation sampling (Creswell & Plano Clark, 2018) naturally

emerged. Although individuals on any perioperative team have diverse roles, they are all in the same space at the same time during a surgical operation, experiencing surgical smoke together. All of the participants completed a quantitative scale (mAQP), which examined some of the same themes that were embedded in the interview questions, including sensorial qualities and perception of air quality while experiencing surgical smoke. The integration phase exposed new themes in the experience of surgical smoke not previously known. This unique sampling strategy for both strands of data, using the same participants with thematically similar questions, strengthens and corroborates the validity of the final results.

Variables and Measures

In this dissertation research, variables included the roles of anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons. Some perioperative nurses perform the usual role of circulating cases, while roughly one-third also perform in the role of the scrub nurse. Circulating duties include preparing the operating room, being an advocate for patient safety, communicating with all members of the team, and providing direct patient care to prevent injury and promote health and healing. Not every perioperative nurse is trained to perform the role of scrub nurse. In addition to providing anesthesia, the anesthesiologist's role may also include serving as an indirect assistant to the surgeon for brief interventions around hemodynamic status. The physician assistant's role is to directly assist the surgeon during the operation, as instructed by the surgeon. The role of the attending physician is to perform the operation. The role of scrub technicians, at the sterile field, is to practice under the license of the registered perioperative nurse. They assist the surgeon directly and are responsible for setting up the sterile field, inspecting and passing instrumentation to the surgeon, and ensuring that all needed instruments and supplies are available and sterile before incision.

Naturally, the roles of those in surgical services may be more complex than described above. Each case is unique, every patient is different, and the mix of perioperative team members can (and does) change from case to case and within a case due to such circumstances as breaks, permanent relief, and the like. Other physicians such as residents, fellows, and visiting surgeons were not included in the sample due to the hospital structure's as a nonteaching hospital, this study's recruitment strategy, inclusion criteria, and materials that relied on email and word of mouth within the surgical services department in the participating operating room.

Each operating room has a slightly different layout and arrangement based on the case and the room's architecture, although every case has an anesthesiologist at the patient's head, a surgeon or assistant on each side of the patient, a scrub person (perioperative nurse or scrub technician), and a circulating nurse on the periphery of this standard core arrangement (see Appendix F). Each case also contributes to the variables, as does the availability and use of surgical smoke evacuation devices. The types of such equipment vary, as does the preference of each surgeon. Some surgical operations produce copious amounts of smoke such as breast reconstruction and transurethral prostatectomy, while others produce less such as cardiac and ophthalmological operations. The type of tissue being cauterized may produce different particle sizes and various ratios of gaseous content (Karjalainen et al., 2018).

The measures in this study are both qualitative and quantitative; traditional numeric measuring occurred within the quantitative strand using the mAQP scale. Initially, scores were calculated and generated around sensorial qualities and perception of air quality. When the data were merged, quantitative data were compared and contrasted with interview responses in the qualitative interview data and organized in a joint display table. Basic demographic information

was measured and reported using the Qualtrics platform and R, a platform for statistical computing, data analysis, and graphics.

Procedures

Permission and Recruitment

The primary researcher received approval for this study from UCSF's Institutional Review Board (IRB). For the qualitative and quantitative strands of this dissertation research, a purposive sample, a perioperative team, was recruited by email, flyer, and word of mouth at a West Coast county hospital. The flyer and the recruitment email were worded alike for continuity. Recruitment ran from February to October 2025; almost all of the participants were recruited by June 2025. Interviews were conducted between mid-April 2025 and the first week of December 2025.

Eligible participants were composed of anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons. The primary researcher collated the groups in various combinations during data analysis. Eligible participants signed the mandatory, IRB-approved consent form electronically using Docusign before the demographics survey and mAQP scale survey were administered. The signed consent forms were stored on the Docusign platform and UCSF's Ivanti secure network. The risks of engaging in this dissertation research were minimal to none. One potential perceived risk involved the demographics survey in which participants were asked to disclose their age, Veteran/Burn Pit Registry status, pre-existing medical conditions, and if so, their opinion as to whether exposure to surgical smoke exacerbated their condition. Participants voiced no risk or privacy concerns during recruitment, interviews, or post interview phases.

The four principles of informed consent (decision capacity, documentation of the consent, disclosure, and competency) were followed without conflicts. As primary researcher, I had no disclosures, other than being a doctoral candidate at UCSF's School of Nursing, and no conflicts of interest. Likewise, the secondary researcher did not have any conflicts of interest. Morse (2007) notes that one performing research on their own work may constitute a conflict of interest. However, I brought to this dissertation research a depth of insight and understanding of the specialized environment of the operating room. It also afforded me entry to a restricted hospital area. The perioperative team was informed that their participation was voluntary, and one could withdraw consent or withdraw from the study at any time. The primary researcher emphasized this point at every encounter, on all communications.

After signed consent forms appeared on Docusign, the demographics survey and quantitative survey, the mAQP scale, were sent electronically to each participant. The platform securely recorded and stored responses from February 2025 through February 2026; most responses were received by June 2025. Data were transferred to an Excel spreadsheet for cleaning and harmonizing and to allow an expert statistician at UCSF to conduct further descriptive statistical testing on the R platform.

Positionality

In keeping with the standards of rigorous qualitative research, I offer the following commentary on my positionality as primary researcher. I am a nurse scientist and doctoral candidate at UCSF and have worked as a specialty certified and registered perioperative nurse in operating rooms for the past 23 years. Throughout those years, as an AORN member, I have served at local to international levels to advocate for patients and colleagues on safety and excellence in surgical care. Such care is achievable through communication, collaboration, and

commitment to safe practices and timely policies that are embodied and cultivated in the art and science of professional nursing.

As a certified perioperative registered nurse who has experienced surgical smoke, I am aware of the physical effects it can have on one's body and mind. Breathing air that is contaminated with particulate matter and volatile organic compounds is hazardous exposure in the workplace that should be mitigated. Multiple studies have shown that smoke of any kind contains known carcinogens with mutagenic potential. My hope is that this dissertation research and its conceptual framework will provide new insights to advance the field of perioperative nursing and occupational and environmental health in operating rooms.

Data Collection

In this mixed methods study, qualitative and quantitative data were collected separately, and it was essential that each process should be conducted systematically and with rigor (Creswell & Plano Clark, 2018).

After potential participants responded to recruitment material, the primary researcher reviewed their eligibility. If they were deemed eligible for the study, the demographics survey and mAQP scale were made available. The Docusign and Qualtrics platforms allowed participants to complete all materials online. Following completion of the demographic surveys, online interviews were scheduled. However, a 2-week wait period was mandatory before interviews were conducted. This was done to decrease recall bias between responses to the online survey and the interview.

Subsections (i.e., Qualitative Data Collection Methods and Quantitative Data Collection Methods) will address the data collection procedures as they relate to each data strand, research

questions, and recommendations. Because the same participants were involved in both strands, the sampling procedures, recruitment, and consent processes were the same.

Qualitative Data Collection Methods

Qualitative Research Question

How do perioperative team members *describe* their experience of surgical smoke?

Qualitative Data Collection Sources

Data were obtained from the 35 participants by semi structured interviews. Interviews generally averaged 20-30 min; a semi structured interview guide, informed by constructivist grounded theory, was used (see Appendix G). The extent of data collection aligned with the minimum recommended sample size of roughly 30 participants. Such a size allows for deep, rich qualitative data, flexibility, and a saturated level of meaning that is representative of the whole by not being too large or too small (Sandelowski, 1995).

Zoom interviews with each participant were conducted roughly 2 weeks after Qualtrics demographic and mAQP scale data had been gathered. This was an attempt to minimize response bias, disruption, and avoid confusion with my role as a researcher. In conducting this dissertation research, I was an “inside outsider” versus a perioperative nurse in the circulating or scrub role, my typical clinical role.

Data Recording and Data Management

A semi structured interview guide was used. Interview scripts were used for uniformity and comprehensiveness. Interviews were conducted in a private room away from distractions on the Zoom platform using its simultaneous transcription feature. Immediately following interviews, transcripts were copied to Microsoft Word and reviewed with recordings to ensure accuracy. An Excel spreadsheet was used to organize the qualitative data files. The primary

researcher, with the analytical oversight and support of the secondary researcher, used printed copies of transcripts for all hand-coding.

A reflexive journal was used during interviews to inform and guide the primary researcher. As an example of the transparency and awareness needed for me to perform as a nurse researcher, I recorded any biases and recognized that my analytical ideas would evolve. The first entry in my reflexive journal was my statement of positionality (see Appendix A). The reflexive journal was essential to my research process because data were collected and analyzed concurrently, which resulted in new concepts and ideas, including questions not considered a priori (Boland et al., 2017). Security measures (I was always logged onto UCSF's Ivanti platform) were taken to ensure that data collected on sensitive issues (e.g., personal health history) remained confidential. All initial and focused coding were done by hand. Data were stored in a secure location and will be professionally shredded; all electronic data files will be purged after all research papers are written.

Qualitative Data Analysis

As primary researcher, I prepared data for analysis, then transcribed the interviews into a Word file for analysis, word for word, using the Zoom platform. Next, transcripts were proofread for accuracy and organized into a format with a wide margin for hand coding and notes. The secondary researcher assisted me with the analytical coding.

Coding

Charmaz offers insight into two main phases of coding: initial and focused coding (Charmaz, 2014). Initial coding takes place at a granular level, breaking down all parts of the whole, analyzing every word, sentence, paragraph, as well as central themes, observations, and any other data (Charmaz, 2014). Although initial coding acts as a guide, pointing the way,

focused coding brings shape and sharpness by reflecting and reframing initial codes (Charmaz, 2014). Patterns and gaps reveal themselves during focused coding, helping to expedite and entrain the analysis (Charmaz, 2014). Generally, during the coding process, labels are generated to capture and define what is happening; this lends itself to becoming the conceptual framework for theoretical development (Charmaz, 2014). Such was the case for this dissertation research. Other tenets of grounded theory (e.g., that coding should remain open (Glaser, 1978, 1992) and acknowledge the researcher's positionality [Charmaz, 2014]) were also followed.

Data were compared to like data and similar themes in different data. This included chronological and situational changes that involved timing and environment in addition to where and how data may have been gathered (Charmaz, 2014). Codes were compared with codes that helped tease out or clarify emerging themes (Charmaz, 2014). Multiple, layered, iterative comparisons of the data shed light on similarities and differences, which advanced the development of themes (Charmaz, 2014). Making constant comparisons is the centermost tenet of [all] grounded theory (Charmaz, 2014); this was central to my process. As data comparisons ensue, abstraction increases (Charmaz, 2014). Grounded theory is not a linear research process; as data are collected, insight and analyses are created simultaneously (Charmaz, 2014), which was evident during my research. Maintaining flexibility with the concurrent collection of data, coding, and categorizing at the same time was helpful in gaining clarity, breadth, and depth analytically (Charmaz, 2014).

Charmaz (2014) developed a "code for coding," seven precepts to assist researchers like me. They remain open; stay close to the data; keep your codes simple and precise; construct short codes; preserve actions; compare data with data; and move quickly through the data (Charmaz, 2014). These precepts demystified the coding process and gave the primary and secondary

researchers an open and unstructured way of thinking about the data. The first precept, *remain open*, is grounded in Straussian practice; this is an overarching tenet in Strauss's belief about grounded theory in general, that it would be imperative to remain open because the method itself would continue to evolve.

Memoing

Memoing is essential in qualitative research (Charmaz, 2014) and a constant and key strategy during data collection and analysis. Memos are key to the entire research process because they are a repository of the thoughts and ideas that come to a researcher before, during, and after data collection (Charmaz, 2014). They are essential to the analytical and data gathering phases because they occur in concert with all phases of a research study, especially when building categorical containers (Charmaz, 2014). According to Prior (2011), memos serve as guides for researchers. Memoing assists with the identification of themes and categories. Exploration of outliers and divergence/convergence/complementarity were noted in this research. Figures and tables were used to represent the data. Memos were recorded by computer and handwritten notes and were securely stored. When qualitative data analysis concluded, there were identifiable concepts, dimensions, and relationships between them. Throughout this study, I used a secure virtual private network to connect to secured cloud storage administered by UCSF.

The participants' "stance," their central, organizing concept on surgical smoke emerged after 2-3 months of iterative analysis of the interviews. At that time, several themes were coming to light (e.g., awareness, symptoms, equipment issues, prior experiences with smoke), but there seemed to be something bigger in the data than these themes. Initially, the primary researcher coded for participants' philosophy of surgical smoke, illustrating their "take" or "elevator speech." The primary researcher analyzed the differences in abstraction between the bigger

theme and the more focused themes. As the two researchers continued to analyze the data, it became clear that there was an umbrella concept that encompassed the more focused themes. The primary researcher considered various labels for this more-abstract concept. Ultimately, the two researchers concurred that "stance on surgical smoke" best represented the data. To illustrate how this terminology and unifying concept emerged, the primary researcher wrote the following memo in the summer of 2025.

> Some [participants] have adopted strong statements about how they communicate and behave around surgical smoke, often feeling the need to protect others, and themselves, and even future perioperative teams. I have been calling this "personal philosophy." (Memo, August 11, 2025)

By early Fall of 2025, the concept of stance was taking root as illustrated in the following excerpt: "one of the first things I need to settle with is a new word for what people [participants] think about surgical smoke. Their opinion, indifference, actions taken, etc. around surgical smoke exposure in the operating room. One word that seems to embody this process of awareness/experience is "stance." I like this because it conjures up a visual as well as a tacit response and position that participants have in my study. People [participants] are 'settled' and yet they do demonstrate varied responses, from vocalizing doubt and uncertainty about what they know and what is unknown, both to themselves and the scientific community, around their experiences and thoughts of surgical smoke…Questions not previously considered come to mind to the participants as well as new thoughts, or new thinking…dawning awareness…all of these things, awareness and attitude, along with bodily senses/sensations and behavioral responses, combine to generate a person's stance…There is a timeless quality to stance; it can develop over a

> lifetime and change in an instant. With new knowledge, or changed knowledge, comes new interpretations of an experience. This new knowledge can be passive, coming from another source (person or scientific finding), or active, coming from the direct experience a participant has or has had. Depending on the weight of the experience around how the person values or believes what they think, feel, or hear secondhand, a new stance may or may not develop. (Memo, September 19, 2025)

Once Stance on Surgical Smoke was identified as a central, organizing concept for more focused themes, the primary researcher explored it with participants in the remaining interviews. Stance on surgical smoke is described in detail in the Results section (see Chapter 4).

Quantitative Data Collection Methods

Quantitative Research Question

How do perioperative team members describe their sensorial experience and perception of air quality around surgical smoke, as *measured* by the mAQP scale?

Quantitative Data Collection Sources: Air Quality Perception Scale

The AQP scale is a robust, reproducible, and validated scale that measures sensorial and perceived responses to air pollution "nuisances." It measures the frequency with which respondents perceive air quality to be concerning. Items were selected to address both nuisances (defined as *sensations and symptoms*) and risk perception (defined as *avoidance behaviors that indicate anxiety about the air quality*). The 22-item AQP scale has two main dimensions: Nuisance, 12 items on sensations and symptoms and Risk Perception, 10 items on anxiety and protective measures. This scale was built and evaluated using psychometric methods (Deguen et al., 2008). The response format indicates how often a nuisance is perceived using an ordinal scale: 0 (*never),* 1 (*occasionally*), 2 (*often*), and 3 (*always*). A higher score indicates a greater

perception of nuisance; a lower score indicates a lower perception of nuisance. Note that the term *risk perceptio*n (Deguen et al., (2012) may translate differently from French to English. The AQP scale is not measuring actual risk perception but the perception of air quality.

AQP scores are the sum of item-level responses and can range from 0-66. A score < 22 indicates a low level of risk perception; a score ≥ 22 indicates a high level of risk perception (Thongtip et. al., 2020). The AQP scale has been validated by follow-up studies (Deguen et al., 2012; Thongtip et. al., 2020).

A modified AQP scale (mAQP) was administered to participants immediately after the demographic questionnaire. This was a deliberate attempt to minimize response bias by allowing time between completion of the mAQP scale and interviews. The primary researcher's modification to this scale was approved by Dr. Jyu-Lin Chen, UCSF's School of Nursing (see Table 1.1). Multiple attempts were made to contact Deguen and colleagues, but they did not respond.

The AQP scale was developed by a research team in France to measure quality of life for people exposed to polluted air because many studies had focused on air quality satisfaction, which does not include the deeper subjective and objective components of risk perception and air quality. These components had not been combined before in an instrument or scale (Deguen et al., 2008; Deguen et al., 2012).

Validity

Deguen and colleagues (2008, 2012) addressed content validity by initially defining and refining the concepts and research question using a literature search and focus groups to examine the quality of life and air pollution as a new construct. This established domain identification and initial questions. Face validity was supported by working with experts and participants, including

students and lay people (Thongtip et. al., 2020). Convergent validity was not directly addressed. However, a backward Cronbach α curve did ensure unidimensionality, using fast clustering and separability of the set for the AQP scale, which is also a way to measure discriminant validity (Deguen et al., 2012).

Logical, Domain, Sampling Validity

Deguen et al. (2008; 2012) initially defined and refined the concepts and research question using a literature search and focus groups to examine the quality of life and air pollution as a new construct. Previous studies of risk perception and air pollution had only examined satisfaction around air quality (Deguen et al, 2008). The results of this step established domain identification and initial questions.

Face Validity

In the initial stages of development, Deguen and colleagues used experts in environmental health and safety to uncover and establish qualitative items for a subjective measure of sensorial experience and perception of air quality. The literature was sparse on the concept of quality of life as it relates to perceived air pollution. The focus groups included students of environmental health and laypeople with no knowledge of the topic. From this work, two main dimensions were identified (i.e., Sensorial Experience (Nuisance) and Air Quality Perception) and an initial 54 questions, which account for face validity.

Reliability

Overall, internal consistency of the AQP scale using Cronbach's α was reported to be 0.78 in the French study (Deguen, 2008) and 0.81 in a Thai study (Thongtip et. al., 2020), which are appropriate. The authors suggest conducting another study on a similar population to further confirm reliability. I may choose to assess internal consistency reliability at a later time. I have

not used my research data to address validity. However, this could be an interesting future study. Although this survey was originally developed to measure perceptions of outdoor air, modifying it for perceptions of indoor air, while being aligned with the original conceptual categories, has proved useful in better understanding perceptions of indoor air that contains surgical smoke.

For this dissertation research, all surveys, consent forms, demographics, and mAQP scale were done electronically on Docusign and Qualtrics, a secure web-based platform, immediately before administering the mAQP scale. Scores from the scale were calculated using Microsoft Excel version 16.106.3. Data were stored in a secure location until the dissertation research study was completed. Data will be professionally destroyed, and all electronic data files will be purged after data-based research papers are written.

Data Recording and Data Management

The electronic platforms used for data recording and management was Qualtrics. Qualtrics data were downloaded and analyzed using Excel (version 16.106.3), and R (version 4.5.2). UCSF's Ivanti platform provided secure storage.

Quantitative Data Analysis

In conducting analysis of the quantitative data, the primary researcher followed the following six steps: (a) prepared the data for analysis: scored the mAQP scale and collated demographics with each scale, (b) explored the data: inspected the data and conducted a descriptive analysis, looking for patterns, trends of scores, and outliers to examine and understand distribution and checked for any missing data and addressed.; (c) analyzed the data, using descriptive statistics for frequency, mean, and percentages of mAQP scale results and statistical testing (using R version 4.5.2); (d) represented the data using tables, figures and written statements to summarize the findings, culminating in a joint display table, when both

strands of data are merged; (e) interpreted the results, summarizing the main results and comparing and contrasting them with the original research question as well as identifying limitations, implications, and future research needed for specific audiences; (f) validated and interpreted the results using external standards to establish and reduce validity threats and examine internal consistency. When quantitative data analysis was completed, there were mAQP scale scores for each participant, descriptive and comparative statistics for the sample as a whole, and item-level descriptive statistics for use in the mixed methods analysis.

Potential Ethical Issues

The risks of conducting such a study as this were minimal because it was mainly informational and observational, based on the surveys and interviews. However, there are always risks to participating in research. The potential for cybersecurity breaches is always a possibility, which could lead to personal information being stolen and used to undermine privacy. There is also a potential for participants to identify quotes and realize that they disagree on the health risks of surgical smoke exposure, making for an uncomfortable rapport at work. I minimized these risks by always using the secure virtual private network to connect to secured cloud storage administered by UCSF and anonymizing the verbatim quotes to protect the privacy of all participants. Perioperative team members raised no concerns about risks or discomfort from participation. Reported benefits included, but were not limited to, the following:

1. Health and lifestyle changes have since occurred due to the experience, which generated new insights.
2. Several participants were pleased that they could contribute new knowledge to conduct in the surgical environment and perioperative nursing; and

3. Some participants demonstrated an increase in agency and empowerment, both personally and professionally. Privacy and security have been and will continue to be maintained, as outlined in the consent process for participation.

The primary researcher had no disclosures other than being a perioperative registered nurse and doctoral nursing candidate at UCSF's School of Nursing. There were no conflicts of interest.

Mixed Methods Integration

Mixed Methods Research Question

What are the emergent themes that *combine* both qualitative and quantitative dimensions of the experience of surgical smoke by perioperative teams?

According to Creswell and Plano Clark (2018), integration occurs in a convergent design when the results of each analysis, qualitative and quantitative, are merged. "Integration in a convergent design consists of the intent to match the results by comparing them and illustrating them with a side-by-side joint display in order to identify points of divergence or convergence" (Creswell & Plano Clark, 2018,). Because the goal of the mixed methods convergent design is to better understand the phenomenon of interest, and "obtain different but complementary data on the same topic" (Morse, 1991, p. 122), the data are best explained by examining the relationships between the two strands (Creswell & Plano Clark, 2018). In mixed methods, joint displays visually integrates data (Guetterman et al., 2015).

In addition, the primary researcher used informal diagrams and maps, which allowed her to infer and draw conclusions about the integrated data (Creswell & Plano Clark, 2018). Although many other ways to visualize data integration are emerging, the primary researcher decided on a joint display table for both strands of data. The end goal was achieved: A

conceptual framework was generated that captures the perioperative team's experience (both qualitative and quantitative dimensions) of surgical smoke in the operating room.

Dissertation Research Rigor

Making the case for using mixed methods also involves a degree of education around what a mixed methods study *is*. One of the first steps in establishing credibility is the choice of a title. Using "mixed methods" in a title is imperative, as well as choosing words that reflect and represent the purpose and type of research being conducted (Creswell & Plano Clark, 2018). Having a purpose statement, procedural diagram, and Results section that incorporates merged results into a joint display and/or diagram/map are essential elements in this dissertation research design (Creswell & Plano Clark, 2018). Additionally, the Discussion section must include an interpretation of merged data in a convergent design that answers the original research questions (Creswell & Plano Clark, 2018). I believe that my dissertation research aligns with all of these criteria, which establishes it credibility.

Disclosure of reflexivity (see Appendix A) is one of the hallmarks of qualitative research (Creswell & Poth, 2018). My orientation is this: I am a new mixed methods scholar, who is using grounded theory as an insider and as someone who has experienced the phenomenon under study (Creswell & Plano Clark, 2018). Unique criteria have emerged to evaluate the quality of mixed methods studies; I have ensured that this dissertation research aligns with those key elements and their application, as suggested by Creswell and Plano Clark (2018). Four elements were used as a guide, ensuring that this dissertation research aligned with the following four criteria and four application standards of the criteria, as suggested by Creswell and Plano Clark (2018). My statement of positionality (see Appendix A) establishes and begins transparency of reflexivity as it was the first entry in my reflexive journal.

Lincoln and Guba (1986) examined criteria such as *truth value* and *applicability* as well as *consistency* and *neutrality* (1989). Rigor and validity in quantitative research are referred to as credibility and trustworthiness in qualitative research (Sandelowski, 1986, 1993; Whittemore et al., 2001). Guba and Lincoln (1994) list the following descriptive terms that have been most used (Cope, 2014): (a) credibility – use of reflexivity and detailed transparency of methods used. (b) dependability – how replicable is the research; (c) confirmability – ability to communicate the research without bias transparently using direct quotes that are demonstrative of data analysis; (d) transferability – does the method transfer to other groups exploring similar research questions; and (e) authenticity – how closely and accurately does the data reflect the group being studied.

Additionally, Guba and Lincoln (1994) stress the importance of other criteria such as prolonged engagement, reflexivity, and audit trail journaling to deepen and solidify the credibility and trustworthiness of research. The primary researcher used member checking as a strategy, another essential and powerful strategy to ensure rigor in qualitative research (Cope, 2014). After interviews had been in progress for some time, the primary researcher asked participants to confirm and validate the themes and qualities that were emerging. Their responses to my findings and interpretation are integral to my research. Working with my dissertation committee, especially the secondary researcher, enhanced and ensured rigor.

Debate continues over the use of the term *validity* in mixed methods studies because it has been traditionally reserved for quantitative research. For this dissertation research, standard, recommended steps for qualitative and quantitative data analysis and interpretation were followed to ensure internal and external validity of both strands of data (Creswell & Plano Clark, 2018). Creswell and Plano Clark (2018) offer four guidelines to ensure validity in mixed

methods studies. 1) Use of a systematic, scientifically rigorous procedures for collecting and analyzing both strands of data must be followed; 2) Use of the standard term of "validity" for uniform use that is understandable and acceptable in most research audiences; 3) Validity is defined as "…employing strategies that address potential validity threats to drawing correct inferences and accurate assessments from the integrated data" (Creswell & Plano Clark, 2018, p. 251); and 4) Validity in mixed methods is unique and fluid for each individual design being used. In this case, a convergent, parallel design has been used.

For a convergent design, Creswell and Plano Clark (2018) recommend some basic validity threats and strategies. I addressed the four validity threats for my design by ensuring the following: (a) questions for both strands of data that addressed similar, related, or the same concepts; (b) using the same sample (and sample size) for convergence/divergence/complementarity comparison; (c) meaningful and clear data integration with joint display table and diagrams; and (d) new analyses when needed to address new and emerging results. The secondary researcher helped me to realize how positionality was affecting my interviews and analysis. An analytic pause midway through the interviews allowed me to refocus and gain new insight and tools on how to maximize richness and depth in the interviews. She also helped me to articulate emergent thematic findings. Our discussions allowed me to minimize unintentional bias in a way that was scientific and scholarly.

The fidelity of this mixed methods dissertation is high. Intention, reflection, and collaboration with my professors and dissertation committee members was well-planned and executed. For example, when designing grounded theory questions, I ensured that they shared a conceptually parallel resonance with the mAQP scale. The timing and order of the demographics form, encounter with the mAQP scale, and interviews were intentionally structured. There was a

pause of about 2 weeks between the initial intake/completion of the 22-item mAQP scale and interviews to reduce bias.

On a more macro level, the purpose of understanding the experience of surgical smoke and perceptions of air quality have been stated clearly, logically, and consistently in the purpose and research questions; they reflect each component of the mixed methods study. There is one qualitative question, one quantitative question, and one integrated question, mirroring the design of a convergent mixed methods study. The identification and application of the four criteria for mixed methods quality (Creswell & Plano Clark, 2018) have been followed.

This study is not without limitations. Its sample size is small. Although this is the recommended size for a mixed methods study, it may be perceived as small and seen as less generalizable to the experience of surgical smoke reported in the surgical literature. The sampling, though purposive, comprised various personnel. However, there was no way to know ahead of time the mix of roles in the final sample. It could have been skewed with one particular role, gender, age, or experience level. However, roles, genders, ages, and experience levels in the sample proved to be quite diverse, which is what enhanced variability and gave it richness and depth.

Using a modified quantitative scale (mAQP) is novel; though it has been modified to be in conceptual alignment with the original, it may not completely confirm or disconfirm participants responses. Another limitation could be that some members of the perioperative team just chose not to participate for reasons not stated. There are other opinions and experiences that could vary from what was described. Yet there emerged a continuum of experiences that captured a wide range of experience. These results have led to more data beyond the scope of this study. For example, future studies could quantize the qualitative data to examine the divergence and

convergence of team roles. The purpose of this study was to conceptualize the experience of surgical smoke.

Summary

The reason to collect both qualitative and quantitative data was to merge the two forms of data to bring greater and perhaps novel insight into the experience of surgical smoke, including sensorial perceptions of air quality in that environment than would be obtained by either type of data separately. The mixed methods approach brought qualitative and quantitative data together to create a broader and more comprehensive account of one perioperative team's experiences with surgical smoke.

My hope is that this mixed methods dissertation research will be used not only to advance the science of rigorous, well-planned, and executed research but also that these findings will advance the science of nursing in the perioperative specialty. Further research to validate this tool are recommended, as well as other modifications of the original AQP scale. I also hope that this methodology is used in other areas of air pollution, both indoor and outdoor, to better understand the experience of all smoke, air quality perception, and thus inform future policy.

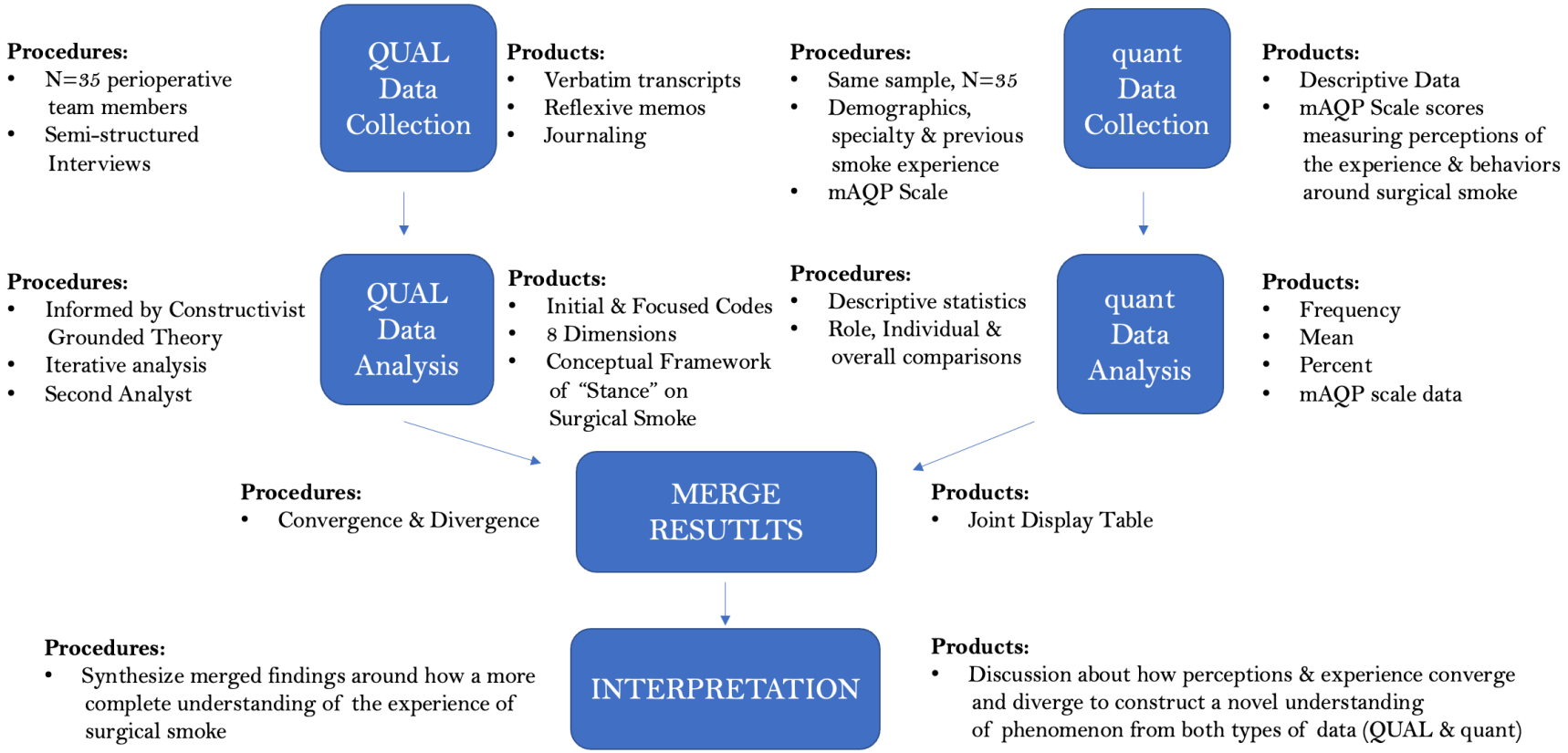

Figure 3.1

Mixed Methods Procedural Design

Note. This was adapted from Creswell, J. W., & Plano Clark, V. L. P. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage Publications.

Chapter 4: Results

Qualitative Results

Stance on the Experience of Surgical Smoke

How did the overarching concept of stance emerge? Here is the process of deriving stance as a finding. Once coding was underway, there were initial codes that were emerging such as sensory perception. As coding became more focused, the sensory perception had been even more refined (sight, smell, taste, etc.) and this code became part of the Awareness dimension. Around this time, I was about four months into the qualitative data collection and analysis. There was a pattern that was becoming clear; that persisted with the interviews. This pattern was not always easy to identify, it could be sometimes more subtle, yet there was always a sense of a participant having a sort of "take" or "personal philosophy" around their experience with surgical smoke. I could see that it was always present, just not always in the same presentation. By presentation I mean that some participants were clear and vocal, while some said very little.

Whatever they shared, I was beginning to sense that there was this bigger thing that they were all sharing. There was this image of the participant standing in front of me, with hands on hips, and an air of authority about them as they articulated what they thought. It was like taking a stand. It was the certitude of what they believed, thought, felt, sensed. It was everything that they knew that moment combined with everything they had ever experienced being conveyed in the interview. I began to land on the word "stance", a word that was embodying all of the dimensions that were emerging; I had about four of them at the time. I stayed open to what else the data was telling me, held loosely to this concept of overarching stance, as I continued my interviews and analysis. This is how the concept of stance emerged in my analysis.

The inquiry around the experience of surgical smoke led to the development of a conceptual framework. Participants described multifaceted, interrelated perspectives on the

phenomenon of surgical smoke. I conceptualized these perspectives as their "stance" or their "take" on surgical smoke. The concept of *stance* has three properties: It is ***multidimensional,*** it ***changes over time,*** and the dimensions are ***interrelated***. The concept of stance exemplifies how each participant is literally "standing" in their own way of thinking about and experiencing surgical smoke, then deciding on action or inaction in the way of a response.

Dimensions of Stance

Eight dimensions of stance were identified: Awareness, Knowledge & Beliefs, Personal Impressions, Symptoms, Meaning, Behavioral Responses, Team Dynamics, and Past Experiences. Each dimension is based on data from participants in all roles (e.g. anesthesiologists, perioperative nurses, physician assistants, scrub technicians, and surgeons). Each dimension is conceptually unique yet interrelated to the others (see Figure 4.1**)**. The 8-way Venn diagram illustrates the interrelatedness of all eight dimensions of stance conceptually.

Each participant's stance was their own unique and dynamic way of seeing, thinking about, and experiencing surgical smoke. Within each dimension there was considerable variation in participants' experiences. The dimensions were dynamic and ***changed over time***. Change could occur gradually over years, or in a defining moment. ***Interrelatedness*** describes the way the eight dimensions connect with each other in varied ways. No dimension exists in isolation.

Awareness

The dimension of Awareness is defined as the consciousness, attention to, and sensitivity around the perception of surgical smoke with the senses (sight, hearing, taste, touch, and smell). Awareness varied from "no perception" of surgical smoke to "sensory awareness" to "going deeply into the body" I termed this variation the "Continuum of Awareness" (see Figure 4.2).

Following are verbatim quotes from participants that exemplify their awareness of surgical smoke. For some, there was little to no awareness: *"I have never actively thought about it";* and *"it hasn't been a big thing for me – that's about it."* Others noted the presence in more sensorial detail such as *"you can see it, and you can smell it…it's visible, and I would almost say that you can hear it too because the bovie makes that sound when they start burning stuff"* and *"I'm trying to breathe through my mouth, but it still tastes like smoke."* Other responses fell further to the right on the continuum. For example: *"Sometimes it's minimal, sometimes it's really thick and you can see it"; "it's pretty strong"*; and *"smells are going directly into my body…those particles get into your body – deeply into your body."* There were many examples of how being pregnant contributed to an increased awareness level, such as stating *"very aware in pregnancy."*

Proximity to the source of the surgical smoke shaped participants' awareness. For example, there was more awareness if the individual was physically closer: *"I am aware of it when it's there and if there's more of it or I can actually smell it then it bothers me, you know, to think, oh, I am breathing this in all the time and I am not even right there at the – with the surgeon."* Here the participant is identifying two things: the smell of surgical smoke leads to being bothered, and the realization that she is breathing it in, even though she is not right next to the surgeon at the source point. The source point is the actual place where the bovie meets the tissue it is cauterizing, causing smoke to be emitted.

Knowledge & Beliefs

The dimension of Knowledge & Beliefs pertains to the body of information and beliefs participants held about surgical smoke. Knowledge is information broadly agreed upon and verifiable with current research. On the other hand, beliefs are individual viewpoints, or opinions

that may or may not have a basis in fact, but are not necessarily widely shared or considered verifiable information.

Knowledge

Participants described three main areas of knowledge: the *rationale* for electrocautery use, the *source* of surgical smoke, and the *contents* of surgical smoke. Examples of the *rationale* for electrocautery use include: *"Instead of using a knife, using a cautery tool to cut, so that you don't get as much blood in the field because you can cauterize and cut at the same time."* Here the participant describes the reason why electrocautery is used and how it helps with visibility and efficiency. Another participant stated that cautery is *"a technique we use to stop bleeding."* Another corroborates this with *"it's the smoke coming from the bovie to stop bleeding",* and that surgical smoke is [a]*"…byproduct and smell of burning tissue in order to control bleeding and separate delicate tissue."*

The following statements describe more closely what happens at the *source* when cautery is used: *"Smoke coming from the surgical site because of something intentionally produced"*; "*a visual or an odor that is perceived by the surgeon or the staff that is due to the burning of the tissue"*; *"the smoke that comes from burning flesh"*; and *"smoke produced by surgery."*

The following examples illustrate knowledge about the *contents* of surgical smoke: *"Output from the cautery device…burning flesh." "It's literally atomized bits of tissue of the patient that's being aerosolized, and superheated, and dispersed in the air."* Other participants' described the contents more generally, such as *"the plume of smoke that's created by bovieing or after using electrocautery during surgery on tissue"; "it's a byproduct of the tools that we use to control hemostasis";* and *"aerosolized material that is released in the air, after bovie electrocautery has taken effect on the tissue."*

The only contents mentioned by team members were the fact that it was human tissue and sometimes had disease or cancer associated with it. Though surgical smoke was compared to cigarette smoke, no other contents (such as volatile organic compounds or particulate matter) were mentioned. Only the biological source of the smoke was noted. When concern was voiced, it was tied to the contents having to do with a known unwell or diseased patient: *"…[If] someone I know is super sick or has an infectious disease, it is being atomized into the air."*

Beliefs

There were several types of personal beliefs around contact with surgical smoke such as, *"I can't imagine that the surgical smoke is beneficial by any means. So, there's only room for it to be harmful or neutral – and I feel like at some point it has to be harmful";* and *"It can't be good. I imagine it can't be good for you."*

A persistent and common belief was that proximity to the source point affected exposure. As one participant said, "*since I'm above it, I'm the one getting hit the most."* Another participant offered their thoughts on proximity and their own placement around the operating table when they stated, *"I feel for the tech [surgical scrub technician assisting the surgeon]…or anyone closer."* This is a clear example of the belief of many participants that closer proximity to the source point equals a greater degree of exposure to the surgical smoke. Another expressed a similar point: *"I just kind of have empathy for the people that are right by it."* On the other hand, several participants who were not at the sterile field believed the following: *"I do feel that I'm potentially at less…exposure than the surgeons themselves."*

There was a pattern in the beliefs about proximity in that that the farther away one is from the source of the smoke, the less exposure they believed occurred. For example, *"If I'm circulating, I'm in the periphery, maybe my exposure isn't as direct, but when you're at the field,*

clearly when you're at the field, you're at much greater risk." There were also beliefs about protection. For example, if there was a drape creating a barrier, the belief was that it was a protection from the exposure to surgical smoke: *"... I'm just not in the surgical field to the same amount that the surgeons and the techs…so proximity, for sure. The physical barrier that I have of the drape gives me some space for it to dissipate, I suppose."*

Some participants had complex beliefs around their proximity:

> *"I'm usually somewhat remote, even if it's only a few feet. I'm not right there. I'm not right there at the actual spot where it's being…produced. I think we're all sharing the same air in there, but I think it's more like the protection you get from x-rays with distances, you know. It's the square of the distances [that] dilutes things, so I think it's just dilutional…dilutional with distance issue. I don't think the drape offers any protection at all. That's the exact same with x-rays. The intensity of the x-ray is the square of the distance, so distance has a really major impact in reducing the intensity."*

Many participants reflected on the belief that there are still many unknowns related to not only healthy tissue being cauterized, but cancerous and diseased tissue as well. Following are several examples where participants described the unknown, or what was not known, around exposure to surgical smoke: *"There's a lot that's unknown that we're breathing, things that people don't even understand the consequences of."* Many expressed doubt with what they personally perceived: *"there is so much unknown"*, as well as what they perceived the scientific community to know about exposure to surgical smoke: *"I don't think they really know."*

Some participants expressed uncertainty about what to believe. For example, *"I don't think it carries carcinogenic risk like campfire smoke or cigarette smoke does, but I just don't know for certain"*; and *"what bears out in the literature, I'm just not sure."* Other participants

spoke about their uncertainly with comments such as *"there could be health risks that we don't fully understand with breathing in vaporized tissue";* and *"we don't fully understand how surgical smoke can be a risk factor."*

Sources of Knowledge and Beliefs

There was a range of responses around where participants learned about surgical smoke in their education and training experiences. For some, it wasn't memorable or notable. For example,*"...my first time smelling it would be when I was in school on rotation, thinking it smelled bad, but not thinking anything else about it"*; and *"we did not have a specific talk in school…although maybe I just don't remember. Nothing stands out. It definitively wasn't impressed on us strongly if it was."* Several participants shared that there was no mention of surgical smoke in their training, for example *"I don't feel like the new grads are told what the dangers of the smoke are."* In response to a questions about whether the topic of surgical smoke was covered in school, they replied *"no, not at all."* Others had a story or a defining moment to share around how they learned about surgical smoke such as:

> *"I had an attending who would always say, when the suction wasn't on, 'lung cancer, lung cancer!' he would make a big deal about it. He said that someone he trained died of non-smoker's lung cancer a few years after completing residency."*

Many different sources and examples of where participants learned about surgical smoke were mentioned. Here are some: *"Just some reading online"*; *"different in-services"*; *"medical newsletters on listserv"* and *"heard people talk about it."* Some participants reflected on the lack of education: *"No pointed education from an employer."* Some noted the scarcity of education around surgical smoke overall *"There's so little education."* Additionally, there was a sense of "missed" education and *mis*education in these examples:

"Very big miseducation of what surgical smoke is and how it affects you, or maybe just unknown because when I came to the O.R. I never really was informed of surgical smoke, nor was I informed of the implications of breathing it in long term and it wasn't until I randomly came across this article where I was like, oh, wait, that's actually really bad for you to be smelling, so that's not common knowledge I feel. It's either withheld or just not known. It's always a public understanding like for cigarettes, if you're around cigarette smells, then you might get lung cancer. And I feel like that is not emphasized enough in surgery."

Personal Impressions

Personal Impressions refers to very individual, even idiosyncratic, descriptions of what surgical smoke is like. These personal impressions are thoughts, observations, and sensations that were vividly experienced, but not necessarily shared. Personal impressions include volume, behavior, personification, smell, and vivid visuals of surgical smoke.

Volume

Several participants remarked about the volume of surgical smoke, often noting the way it appeared and moved. For example, *"Sometimes it's minimal, sometimes it's really thick, and you can see it. But I think it depends on the tissue, and how hot the bovie is, and what exactly we're doing…it's very procedure dependent"*; *"you'll see more of it in certain cases and less in others, so it also depends on what kind of case it is."* Procedures that had a large volume of surgical smoke included breast cases in general, plastic surgery cases such as abdominoplasties and gender alignment, big, open abdominal cases, and transurethral prostatectomies.

When asked to define and describe surgical smoke, one participant stated *"…it does actually create a little bit of smoke when it makes contact with the skin"* and *"it's not like it's*

smoke like a fire, you know, where the whole place is filling up with smoke, but it's a small amount of smoke that can rise up." These statements note the volume as compared with other kinds of smoke generation, such as a fire, and then begins to touch on what it does, which is to rise up. This is the point where surgical smoke begins to take on a way in which it "behaves."

Smoke Behavior

Smoke behavior refers to the perceived movement of surgical smoke around the surgical suite. Some examples of smoke in the immediate vicinity of the source point, i.e., the bovie, include the following: *"If you don't suction it or have a suction bovie, then it spreads around the room"*;*"...smoke that can rise up from the surgical area.."* Here the participant describes the smoke as "rising up" in a vertical manner, reflecting the direction of the smoke. Another example is the movement around the room: *"If you don't suction it, or have a suction bovie, then it spreads around the room."* These are all examples of smoke moving inside the surgical suite. Some participants perceived various ways the smoke seemed to dissipate in rooms of different sizes. For example, *"...smaller operating room suite versus a larger one that we are in…there's more room to dissipate";* and another who stated, *"it gets superheated [the tissue] and gets dispersed in the air"*

With the advent of laparoscopic and robotic surgeries, or "closed" cases , smoke within the body cavity, is ventilated through ports into the room. The following statement illustrates how this happens: *"In particular cases, like robotic…even when the smoke is inside the person's body cavity, it escapes in the room"* This is in contrast to when the smoke is coming from an "open" case, where the smoke dissipates directly into the air. There was a range of perceptions around open versus robotic/laparoscopic cases being either more or less smoky than the other. Some reported less smoke with "closed" cases and more smoke with "open" cases while others

reported the exact opposite. There are also "closed" cases like the transurethral prostatectomy where the cautery is in the bladder, completely in fluid, yet still the surgical smoke from the vaporized tissue, i.e. the prostate gland, is present in the room throughout the continuous dissection required to complete the case.

Some participants had personal impressions around how the dissipation of surgical smoke related to them during a case, for example: *"The physical barrier of the drape gives me some space for it to dissipate";* and *"Where does it go. I feel there's got to be some that I'm still inhaling."* Another type of impression includes *"the smoke continues to cause some type of disruption in surgical visualization."* Another angle of the behavior of smoke it that it is "*predictable, you can anticipate it*."

Personification

Personification of smoke was the term I used when the smoke seemed to take on a character-like presence, or a personality. Examples include *"Dirty cells flying around"*; *"like germs worming"*; *"I see the smoke circling around my scrub tech."* Other examples are: *"At baseline, I think of it like poison";* and *"there's nothing you can do to get it out of the room."*

Smell

The smell of the smoke was one the first things that participants noticed. Many said that the smell was unique and unlike anything else they had ever smelt. For example, *"I don't know, I can't associate the smell directly with anything. You know, it definitely is not like a barbecue food type of smell. It's like, there's a definite smell of flesh, and I can't really describe it. But I can't really associate it with anything else";* and *"it has a particular smell, it's not like a bonfire, it's not like a forest fire, it's not like your fireplace at your house. It's flesh. It definitely has its' own smell…you just immediately know what the smell is when you smell it"*; *"I think what is more*

bothersome is the smell of burning tissue"; and *"it smells like dead flesh, and sometimes it's pretty strong, and if we're both bovieing at the same time, it's a lot."*

Smell was the most common sensorial finding and had many types of unique descriptions. This finding was very notable for participants around how particular surgical smoke smells. Here are some examples: *"It has a very specific odor that once you smell it, you will always remember it, and you can identify it very quickly";* and *"The first thing that comes to my mind is just the indelible smell…it's that smell memory that comes, is the first thing that comes to mind. Sometimes it's just a thick scent in your nose…it's just sort of there. I don't think it's particularly malodorous, but it's not…particularly pleasant either; that smell is just sort of ingrained in your brain."*

Conveying the smell of surgical smoke was a challenge for participants. For example, *"It was weird, because there's no other smell like that. The bovie smell of skin burning, it doesn't always smell the same, and some people that are more…not the healthy population? It's kind of weird. It's like what you put in your body…and then flesh will smell different for different patients, so it's very weird. I don't know how to explain it, but there's nothing like bovie smoke, and you can't explain it to anyone. It's something they have to experience. It's just a weird thing…it's burning flesh, and it smells weird, and it's odd."*

Association of surgical smoke with food was another finding. For example, *"I've heard people comment all the time – oh, I love the smell of the bovie in the morning, like it's your coffee or something."* Participants described surgical smoke with many cooking and barbeque analogies. Some examples include: *"…it's like when you're roasting meat, on a BBQ"*, *and "it smells like barbeque, which is a positive thing, because [I] enjoy food… this [association] is food."*

Another participant shared their memory around experiencing the first whiff of surgical smoke: *"My fear was going into the OR and seeing and experiencing that [surgical smoke] was… I don't want to associate that with food. Which is kind of a weird thought. You think about it, it's cauterizing, in a sense, kind of burning or charring, and I try not to associate that with cooking, which is weird to say but when I first had that experience, catching a whiff of the surgical smoke, it was different…it's kind of weird, but it's not something that was off-putting right away."*

Several participants compared surgical smoke to cigarette smoking: *"It's like smoking unfiltered cigarettes in the OR";* and *"it's as if you're smoking and we all know that smoking causes lung problems. So, I've always worried about that."* Multiple participants used the word "unpleasant" or "not pleasant" when describing the smell of surgical smoke. For example, *"…unpleasantness…I don't love it…I'm relieved it [human tissue] doesn't smell good"; "it's unpleasant sensation-wise, as far as the smell";* and *"it's not a pleasant smell by any means, so it takes some getting used to."*

While some noted the way surgical smoke moved inside the room, others noted the movement outside the room, through their sense of smell. For example: *"It would just be plumes and plumes of smoke…the whole hallway smelled like bovie smoke";* and another participant *added "sometimes you can smell it in the hallway…so if other people are noticing that aren't even in the room with those cases, that's a problem. It shouldn't even be smelt outside the room. If it's that bad outside the room, then how bad is it inside the room? On the field?"* One memory recalled was *"I just thought, oh, it's gross, it smells bad in the morning and people would be like, just wait 'til you smell this one, and it would be like dead bowel or something, and I'd be like ew, it was just a gross smell…we all thought…someone's bovieing."*

Vivid visuals

Vivid visuals are statements that describe surgical smoke in novel and memorable ways. For example, *"like a piece of steak on a frying pan…"; "a branding iron…like on a cow"; and "It's like standing at the barbeque, right over the barbeque, and a big [piece of] fat from the steak or the chicken catches on fire, and it's in your face, suffocating you, and you're trying to save someone's life."* Some descriptions were not only vivid visuals, but also verged into a personification of the smoke, giving the smoke a personality, motive, almost pre-meditated movement as in this example *"I see the smoke circling around my scrub tech" and "like germs worming."*

Symptoms

The Symptoms dimension includes physical sensations reported by the participants with exposure to surgical smoke. The types of symptoms mentioned involved the five senses: throat irritation, cough, difficulty breathing, headaches, migraines, malaise, nausea, gagging, and lightheadedness. There was a range of symptoms shared. Examples include: *"…the smell is so awful you literally are almost gagging because it's – it's such an uncomfortable, unpleasant smell";* and another who said *"…you feel a little nauseous, but it's not too much…sometimes you get dry eyes";* and someone else who shared they felt the surgical smoke exposure was *"…making me feel a little lightheaded or eyes watering…feeling irritated nose and back of my throat, it irritated my eyes, feeling like they're watering a bit, maybe from the smoke, from cauterization."* Other symptoms included *"pain in my chest"* and *"chest burning."* For some, the long-term exposure was attributed to actual worsening of symptoms: *"I've just noticed over my career…more headaches, stuffy nose….."*

For some participants, the impact of the exposure to surgical smoke did not incite a specific symptom, but a more general feeling, for example, *"...so it's not a pleasant smell. It doesn't make you feel good."* One participant compared it to a memory from her past when she smoked cigarettes: *"It's the sensation of a deep ache and it feels like I can't get a full breath."* Another participant noted that *"it can make you feel not great"* and *it's disturbing sensory-wise."* Some reflected around sensitivity: *"I just don't think I'm that sensitive to the smoke, certain people are way more sensitive to the smoke"* and someone else who said *"I've gotten so much more sensitive to smoke."* Sensitivity is included here as it was a topic that came up around symptoms.

While some participants had physical symptoms, others did not. For example, *"I'm thankful I don't really have any physical symptoms. I just think it's probably not great for my health"*, and *"I don't think in the O.R. [operating room] it's ever affected me. Physically."* There were other participants who could not ensure their symptoms were from exposure to surgical smoke. For example, *"some days I'm coughing or my throat hurts, and I never know what I can attribute to the OR, or not…I don't know if I'm getting sick more often because of the surgical smoke. I don't know that I've seen any direct effects of it."*

Meaning

Meaning is the way that participants framed what exposure to surgical smoke meant for them personally and potentially for others, both in the present, and in the future. Meaning often extended to what the exposure meant for colleagues, the unborn of pregnant team members, families of team members, and even the perioperative teams of the future. For the Meaning included concern for health, risk, cancer, disease transmission, proximity, worry about

cumulative effects, bodily violation, death, and indifference. For every category, there was a range of experience.

Concern for Health

Concern for health included concerns for self and others. Specific concerns included perceived risk, especially around cancer, disease transmission, and pregnancy. Some expressed the constancy of the concern, as in this example: *"I'm still cognizant of breathing, breathing the smoke,– I just keep thinking of how it's going to affect my health...."* Others had specific events or things they had heard such as *"I've heard stories about people who have had awful outcomes from breathing surgical smoke and it's just always been in the back of my mind."* There were more general comments regarding concern such as *"it always disturbs me when I'm smelling the smoke in the room."* There was also concern for loss of life, as in the following example*: "I always have this fear that one day I'm going to die of a lung related issue, even though I'm not a smoker, because of the smoke in the O.R. [operating room]."*

Here are vivid examples of concern for health: *"Smells…fumes are going right into [my] nose and bloodstream";* and *"I would imagine that particles and smoke and molecules that are not safe enter from the surgical suite into my body and everybody else's body who's breathing it."* Beside directly stating feelings of violation from the exposure to smoke, some had directly associated their current illness with surgical smoke: *"I question if [surgical smoke] exposure was a triggering factor around my Lupus."* One participant shared *"I have lung cancer. I had a right middle lobectomy without ever smoking a cigarette or a joint in my entire life…all the genetic testing was negative."*

For some, surgical smoke meant risk: *"I feel like it's a real problem and we know there are real health risks, and our solutions are not adequate."* Others expressed ambivalence, as in

this example: *"You sort of think that surgeons have been inhaling this for decades and people seem to do okay, so maybe it's not that hazardous, but you sort of worry about what you're breathing in."* Another participant stated their lack of concern around risk of exposure to surgical smoke by stating *"I don't actively think about it [risk] too much."*

Some participants were specifically concerned about the risk of cancer: *"It's probably carcinogenic…little by little, it'll start adding up over time. And then it'll probably snowball, you know, that's how cancer develops, right? It's one cell and then it starts multiplying little by little, and all of a sudden, it's out of control. That's something I worry about";* and *"I'm not a smoker, but I'm smoking…I'm gonna be very upset if I get lung cancer and I don't smoke."*

Several participants spoke of a known colleague who is undergoing treatment for lung cancer that has been related to her long-term exposure to surgical smoke. Her experience heightened the meaning of surgical smoke for her teammates: *"One of our coworkers has been undergoing treatment for lung cancer, and it's probably a really tough sell, and a really tough situation to prove that, you know, her condition was probably exacerbated by just being in the OR for decades and being exposed to it."* Some shared their connection between surgical smoke and cancer, such as this association: *"I feel like the more I am inhaling, the higher my chance of cancer…so just a cancer diagnosis is what I'm thinking about all the time. When I smell smoke, I think about cancer";* and *"I feel like the more I am inhaling, the higher my chance of cancer."* Another example of the perceived association of surgical smoke with cancer was: *"If grilled meat is a carcinogen, I'm sure human flesh, or tissue, is a carcinogen too."*

There was a range of responses about the possibility of disease transmission though surgical smoke. Several participants thought there was a *"theoretical chance of disease transmission",* while others described things like viruses, bacteria, cancer cells, and unknown

contents that they believed might contribute to contracting a disease. Some had vivid images of disease transmission such as *"I just feel like the smoke is coming in and tumors are growing in my larynx, bacteria and viruses are just in there, I'm going to get HPV or EBV or something."* Some believed *"if you cauterize it, it's dead, you can't transmit live, active, transmissible HPV if it's in the smoke"* ,while also acknowledging that *"there's still controversy. If you ask 100 doctors, they're probably going to give you different answers."*

Some participants worried about the cumulative effects of surgical smoke: *"I feel like the more I am inhaling, the higher my chance of cancer";* and *"one of my coworkers has lung cancer from…well, they don't know… I mean they don't know what the source is for sure, but they [the coworker]thinks it's from the bovie smoke….so over time, I think it's gonna build up.";* and *"…that's the stuff I worry about, it's not the acute symptoms of it, now being healthy (at a young age), it's when I'm pottering around the O.R. [operating room] at 60, how's that going to look, and how am I going to feel, and the issues that may arise and complications may crop up at a later date."*

One participant said *"Just the concern for possible future health risks if you were exposed to it consistently, over a long, long period of time."* Here they are bringing up time and consistent exposure and how that is always in their mind. Another stated *"…we are in the operating room almost every day, breathing that in…it's harming me because it's in the air and I can smell it."* Some simply stated *"I think it's gonna build up";* and *"little by little, it'll start adding up over time, that's how cancer develops, right?"*

Indifference

Indifference is the lack of concern about being exposed to surgical smoke. Here are examples that demonstrate the state of being indifferent: *"Surgical smoke was never a big deal to*

me, or to any of my colleagues, as far as I know"; "it hasn't been a big deal to me"; and *"I have never been worried about it. It hasn't bothered me."*

Behavioral Responses

The dimension of Behavioral Responses refers to actions taken, or not taken, by participants in response to surgical smoke. Sub-categories include breathing patterns, moving (repositioning or relocating) the body, leaving the room, airing out the room, advocating for policy & practice change, asking for smoke evacuation, using regular suction, and using personal protective equipment (PPE). Other behavioral responses included showering and washing clothes: *"take a hot shower so I can breathe and clear my nasal passages";* and *"immediately want to take a shower and wash all my clothes."* While some participants shared action taken, others may respond internally. Internal responses are avoidance strategies since those who were not as aware or sensitive to the smoke did not externally alter their behavior.

Breathing Patterns

One of the most pervasive behaviors was around altered breathing patterns. There were several variations that included stopping breath: *"When I'm smelling a lot of surgical smoke, I try to stop breathing"*; holding breath: *"This is goofy, but sometimes I find myself holding my breath"* and *"…I find myself trying to hold my breath"*; and shallow breathing: *"…maybe if I breathe shallowly during this debridement of this wound…."* Another participant noted *"I usually don't experience it too much, so when I do, it's very apparent because I can't break [scrub]…[I'm] literally breathing in smoke the whole time and I'm trying to breathe through my mouth, but it still tastes like smoke",* while another participant described a particular scenario and type of case: *"Usually breast reductions when they're doing the skin or the tissue, sometimes I'll hold my breath, because I don't want to smell…I'm retracting, up in the field, and I really don't*

want to breathe at this moment, when there's so much smoke. I'd rather pass out than breathe this." One participant offered this on breathing practices they adopted: *"It's like when you smell smoke, that's your body's way of saying, don't breathe, you know?"* The state of being pregnant also caused some to not want to breathe the smoke: *"Especially when I was pregnant, I feel like I had to be very loud about having adequate suction."*

Moving the Body

Other behavioral responses included moving the head or moving the body. For example, *"...so, I'll just bovie through this really quickly, and just kind of turn my head, or whatever"; "I might just tilt my head";* and *"I try to avoid it if I see a cloud of a lot of smoke."* Those who were at the sterile field yet able to move away could do so: *"I step away from the surgical field more"; " I just kind of stand back a bit."* Those who were not at the sterile field and/or scrubbed in with sterile attire tried others tactics for moving away, such as leaving the room. This response is usually only for certain roles, like the perioperative nurse who is circulating. All other roles must stay in their place. Usually, anesthesia is at the head unless that is the operative site. All surgeons, surgical scrub technicians, scrub nurses, and physician assistants are all in their positions around the patient, next to the source of the smoke. One participant stated *"I don't want to say I avoid standing at the drape but it there's a lot of smoke; I definitely won't hang out there."*

Leaving the Room

Several participants responded by leaving the room briefly. For example, *"...I'll go outside and take a deep breath";* and *"I think my first thought is – this is so nasty. followed by – should I leave the room? And then, usually I'll step out for a second, then I come in and the smell is still there. So, there's no real escaping it";* and *"I find myself trying to hold my breath, which is almost silly because I get to the point where I'm like gasping for breath, but then I open the*

door to the core and take a breath out there." This illustrates the very temporary ability to leave the room while circulating a case. Only the circulating perioperative nurse has this option (Appendix F). Anesthesiologists can sometimes step away, but only if they have relief, and that is rare. Relief is usually reserved for long cases or if there are two anesthesiologists in a case such as a liver transplant or if the patient is on cardiopulmonary bypass.

Airing Out the Room

This is a practice that is fairly common during smoky cases, as one participant stated, *"I have seen nurses air it out, open the door and try to push smoke out. I have seen it a bunch, everywhere."* Other practices include opening the door and walking out of the OR into the sub-sterile area as exemplified by *"I open the door to the core and take a breath out there";* and *"I'll step out for a second."*

Advocating for Change in Policy or Practice

Some participants shared their strong desires to begin to make a case for policy and practice changes: *"The thing about surgical smoke is it's predictable. You can anticipate it. You know when the bovie is in hand, and so that sets up a standard that you can minimize the impact, and you know, if we go to [mega city known for poor air quality], we can't do anything about the pollution…[we] can't do anything to prevent or solve that problem, other than avoidance…You gotta get to the bottom-line conclusion. This probably has something to do with OR smoke. I feel very strongly about educating our peers";* and *"I think the suction bovie should be mandatory";* and *"I've always been a supporter of trying to get this handled in some way because we are breathing this stuff."*

The Right to Breathe Clean Air

Another behavioral response is to advocate for the right to breathe clean air. One example pertained to medical students who are paying to be in the operating room for their rotations: *"…If they perceive there's a risk in the operating room, they have the right to say 'I don't want to be in there unless there's a way to reduce the smoke risk'…the students have a right to be protected."* Others mentioned that they had a right to protect themselves: *"I have a right to protect myself";* and *"you can still use the bovie if you want, but the staff has a right to use all of available resources to protect themselves."*

Asking for Smoke Evacuation

Some participants said, *"I'm usually the one suggesting it",* while others shared *"I feel like maybe I should."* This is an area with a lot of nuances. Some think a person needs to have strong communication skills, and others try to "sneak it in" or get rid of regular bovies so that the only one available is the smoke evacuation. Some don't feel comfortable asking unless they have good rapport within the hierarchical nature of the OR. Several participants shared their reasons for choosing to ask, or not ask, based on the relationships within the team that day. Others don't ask and just announce that it will be used, going outside of traditional norms of "surgeon preference", while some surgeons shared that *"I wish they would just ask me."* Others who don't care one way or the other, but feel strongly that it is their "right" not to be so exposed if smoke evacuation can mitigate it.

Using Regular Suction

This was a common way to respond for those scrubbed in, whether they were operators or assistants. Some operators and assistants expressed that this was *"better than nothing"* and how they often would *"…just use regular suction."* Some expressed that they knew it wasn't the

correct or recommended practice, while others did not acknowledge that. Other responses around using regular suction, which does not have an ULPA (Ultra-Low Particulate Air) filter, were *"that's technically incorrect because there's no filter there."*

Using Personal Protective Equipment

Some participants expressed a general sense of wondering about the use of personal protective equipment, PPE. For example, *"maybe I should be protecting myself in a more significant way";* and *"maybe there are other things I should be doing when I am in these smoky situations."* Others wondered about what type of mask was best to protect them: *"I don't know if I should be wearing another type of mask",* or *"maybe I should just start double-masking."* Some participants were more certain about the protection of the mask: *"The fact that we always wear masks…it automatically protects us. Even if there is smoke"*; *"…unfortunately I always grab probably the least protective, because it's more comfortable on my face for all day long."* Some felt that perhaps a mask wasn't enough protection and said *"should I just wear a PAPR* (Powered Air-Purifying Respirator) *?"*

Here are some responses in which a sense of protection from PPE is evident: *"To me, it's like I am kind of behind a curtain, right? And so, it's also how close to the surgical field I am. I wear glasses, so I don't think I get it in my eyes directly."* Here it's as if not only the curtain but also the fact that glasses are worn give the participant some sense of security and safety from the exposure to the surgical smoke. To further illustrate this sense of protection some feel they have is the following: *"We wear masks in the O.R. [operating room] so it's not like I'm inhaling smoke directly."*

Only a few participants mentioned wearing an N95 mask (filters at least 95% of particles ≥ 0.3μ) in surgery: "*It's uncomfortable but you get used to it."* N95s are known for being

uncomfortable. Others reflected on situations where they would wear one, such as *"I do not wear an N95 unless it's an HPV* (Human Papilloma Virus) *case and I probably should wear an N95 in a prostate case as well."*

Acclimation

Here are some examples of how participants described facets of acclimation: "*it takes some getting used to*"; *"I think I'm just used to it";* and *"I think I've just been around it so long that it's just…a constant there for me. I don't think about it. And sometimes I'll think, oh, it's probably not healthy to breathe that in, but then I think I've done it for so long that I'm still here, so maybe it's just [that] some people are more sensitive to smells than others."* Another angle on acclimation includes a sense of protection from the use of a mask: *"I think the fact that we always wear masks in the O.R.[operating room]…it automatically protects us. Even if there is smoke…you know, you're just so used to it that…I don't worry about it."*

Another remark around acclimation is: *"It's no longer present in my mind. I don't see that surgical smoke at all."* This comment suggests an out of sight, out of mind perspective. Some shared that how they noticed it changes for them during a case: *"I feel like it dissipates after a while";* and *"I notice it the most when I walk out of the room and walk in again."* Another participant described how they became acclimated to surgical smoke: *"Over time, you just get used to it, jaded to it, you know, it's kind of like when I saw the first incision…as a med student, I actually passed out in the O.R. [operating room]…and then I went ahead and was doing liver transplants for ten years, you know, buckets of blood."* One participant shared *"you just stop thinking about it."*

Tolerance

For many participants, a sense of resignation or tolerance was expressed as *"an unavoidable hazard that there's nothing we can do about it"; "it's just something we see, we occasionally smell, and tolerate"*; *"it's a workplace hazard that we just have to deal with."* There was a sense of this exposure to surgical smoke being the norm and a sense of "going it alone", or being on one's own around it, with nothing to be done to change it.

Bravado

There were participants who felt they had been around it for so long and were still seemingly "ok", that they made a weak case for taking any action to mitigate the surgical smoke. This attitude moves from acclimation to tolerance to a sort of bravado in some of the comments such as, *"it hasn't stopped me from doing my job…you know, shake it away and keep on"*; *"I gotta do my job, I just don't step away"*; *"you're just taught not to complain";* and *"the mission had to be accomplished, so I just kept moving."* There was also reported bravado, for example, *"…it's interesting…they kind of play it off. They're like 'oh, I used to work where none of us used it' …but we have the technology now – we should use it – instead of playing it down, you know?."*

Team Dynamics

Team Dynamics refers to the relationships and interactions amongst the perioperative team members. There were various examples of relationships and interactions around the experience of surgical smoke. As an example, equipment issues may at first appear not to have anything to do with team dynamics. However, once the interactions are examined, there are impacts on relationships and teams that are affected by use, availability, and efficacy of smoke

evacuation equipment. The following examples all relate to the dimension of team dynamics and illustrate the types of issues found in this group of participants.

Surgeon Preferences

Surgeon preferences varied not only between operators, but between personal operating style, techniques, and service lines. For example, *"I know if I'm working with Dr. _____, [this references the surgeon style] I'm gonna be breathing way too much bovie smoke, because she's just one of those people that, when she does her cases, there's a lot of…there's a lot more bovie smoke than other people"*; and another scenario where there is a clear preference not to use the bovie: *"You try to impose a suction bovie, and they're like, 'I don't like it. Throw it off the field. It's too cumbersome,"* and *"No, they just don't like it and they're like, 'I'm not going to do it'. And I'm like, all right then."*

Others experienced openness to use of the bovie when offered a choice: *"You hand them a suction bovie, and they're like 'sure thing'."* One operator shared *"the nurse, the scrub techs frequently say 'do you want to use the smoke evacuator?' and then I say I don't like to use it, blah, blah…but the person assisting me doesn't want smoke in their face…I immediately say, of course, turn it on."* These are a few of many examples of interactions around surgeon preferences. They reflect the range of responses in the data.

Hospital culture was described by one participant who reflected on hospital messaging to staff: *"We don't have a hierarchy, we're all coworkers, we're all friends, and so you need to be able to speak to each other"…*and then they interjected *"[yet] there is a hierarchy…it's the surgeon, they're in charge."* Another participant shared a different viewpoint about culture: *"They are extremely collaborative…everybody is of equal status. And there aren't any princesses. And there is not fit throwing. They huddle before the case starts…everybody is well-*

supported…." These examples show the range of responses related to how surgeon preferences are variable based on the culture in the hospital.

Concern for the Well-Being of Others

Another aspect of team dynamics is when participants express concern for others who are being exposed to surgical smoke: *"Maybe for people that are there more often, the anesthesiologists and the nurses and stuff…maybe it's more concerning.."* This includes concern for the unborn: *"pregnant colleague near the field…concern for birth defects";* and perioperative team members in the surgical suite: *"I have empathy for the people that are right by it."* Additionally, there was concern for patients breathing surgical smoke: *"What does it do to the patient breathing these things?"* ; and *"patients are being exposed to it."* Finally, there were strong and clear statements such as *"we have a responsibility to protect people who don't understand"*, indicating that some participants view their role as protective, conveying a sense of ethical duty.

Conversations Around Smoke Evacuation

One participant shared a conversation they had witnessed around whether or not to use surgical smoke evacuation. At first the participant thought this conversation was *"kind of crazy, but maybe it made me [the person listening] think about it."* Though this was a conversation witnessed by a team member, the participant confirmed that these types of conversations involve *"not just doctors, it was doctors, nurses, techs…."* This example shows how decisions around smoke evacuation can affect other team members. Witnessing disagreement on use of smoke evacuation led to the participant reflecting more deeply on using smoke evacuation.

There were some participants who could not recall ever having heard any discissions around surgical smoke *"I actually don't overhear conversations. We talk about everything, and*

we don't talk about – I don't hear much about [surgical] smoke"; and another participant who stated that their colleagues *"felt the same way"* , indicating that many participants felt certain that their colleagues shared the same view as they did. The range of types of conversations that were witnessed or not was notable, as were those who stated that there was no difference of opinion around the use of surgical smoke evacuators. These data demonstrate that different experiences around surgical smoke conversations, heard and unheard, can affect the culture and perceptions of other team members.

Communication

Some perioperative team members were direct and clear in their messages towards others around surgical smoke evacuation. For example, *"If you're not keeping yourself safe, it's my job to keep you safe, and we're gonna use a smoke evacuator."* Some felt that in order to be heard or effective *"you have to be good at public speaking, even though you're in a room with four people",* recounting that when you are working with people who have different priorities, you must make your case for using a smoke evacuator and be able to*" back up your claims."*

Relational skills also were noted as being important. If they were *"feeling brave that day"*, they *might* have a conversation; but if they didn't have good rapport with the surgeon, they might not feel comfortable asking. Another participant noted the role of agency around asking in order to get desired results: *"I have suggested it in the room, and usually they're pretty OK with utilizing it, if I request it. But they'll never go out of their way to like, get it themselves, or ask for it themselves."* Some shared the experience of having another person in the room suggest smoke evacuation: *"I'm like, thank God! That's such a great idea!"*

More perspectives on smoke evacuation conversations are from participants who had never felt there had been dialogue on the topic: *"I have never witnessed nor been a part of the*

conversation of 'hey, why don't we try this, because it's super smoky in here' from anybody in the room…I don't think it would go all that great because I don't think they're accustomed to it. I think they need to be forced into it." There were others who decided to ask if the conditions became unbearable: *"If he's really going crazy with the cautery, then usually I ask him if I can do it anyway and he lets me do it…but that's usually after I have stood there for five minutes just breathing in huge amounts of burning human flesh."*

There were those who did not choose to speak up around asking for surgical smoke evacuation as evidenced by stating that they did not ask: *"not actively, during the case."* Many participants also shared that the fear of speaking up was pervasive. Some had witnessed and some had felt it themselves, depending on how confident overall they were feeling that particular day with the particular combination of perioperative team members. Some voiced fear around asking for evacuation: *"…fear of speaking up…maybe other people don't feel comfortable speaking up because then they'll be labeled, or there'll be pushback, or there'll be retaliation, or you know kind of put in a basket, like 'they're difficult'."*

Other examples of communication were collaborative and included witnessed exposures where another team member noted discomfort and intervened on behalf of a colleague: *"The smoke's just coming up into my [scrub person's] face and the [circulator] is like, 'do you want a smoke evacuator'? And they're [surgeon] like 'it doesn't do anything'. I'm [scrub person] like 'let's just get it anyways'…that kind of thing is defeatist."* This example illustrates how powerful it can be to have a teammate help advocate for smoke evacuation. In the end, the participant says it is defeatist. Even when the circulator asked, it was still debatable and deemed to not "do anything" around evacuating the smoke. The circulator persisted and the scrub person was able

to get the evacuation. This interaction still left the scrub person feeling defeated but validated and supported by the circulator.

One participant shared a story on how to communicate differently, showing innovative strategy: *"When you're in clinicals, and you're talking to your instructors about how to about practicing effective communication, and doing things that you feel and you know in your gut, or in your heart, that this is the correct thing to do…you just take the steps to circumnavigate and make it a non-issue. It's like let's get this done. So, I would throw the old bovies away and bring the smoke evac ones in and be like 'sorry, this is what they pulled, and this is what I threw off, we're already prepped and draped, let's just go, you know, let's just go' kind of appealing to the efficiency angle of the providers, rather than just trying to bring up a good point. Because nobody wants to hear a good point when you're on a runaway train and you have to keep forward momentum."*

This approach avoided any direct communication. Instead of a conversation where the outcome would be likely not using evacuation, the scrub person eliminated options. Rather than slow the case down, they made their preferred option the only one readily available. To get another regular bovie required a wait. Knowing that the surgeon would not want to wait hinged on the hope that smoke evacuation would be used. Another type of communication was non-verbal such as, *"you can just read body language…around it…or facial expressions…even like a little vocal expression"*, and *"if we handed a doctor, like ENT* (Ear, Nose, and Throat) *or Vascular, a smoke evacuation bovie, they might not even notice…we know the ones who don't like it, and we know the ones who do like it, but we don't push the ones who don't know the difference."*

Conflicting Priorities

Conflicting priorities could occur when any of the team members felt that something else was more important than smoke evacuation. Various perspectives were shared such as *"It's honestly not something that I walk into the room and be like, 'hey, I need to have the evacuator' because there's 150 other things that I'm thinking of"* and "*I'm usually focused on my case, but I always do worry about the secondhand effects of the smoke."* Both examples reflect the immediacy of the moment and the way getting the case accomplished overrides a sense of safety, even when it is on the conscience of the participant.

There are also examples that demonstrate sensitivity towards colleagues as in this comment: *"There are people that are very cognizant of the smoke, and they want something done about it, which I certainly appreciate."* This example shows a team member's awareness and appreciation of a viewpoint that is different from their own.

Equipment Issues

Some team interactions revolved around issues with the surgical smoke evacuation equipment. Such interactions included various mechanical issues, interactions, barriers to use, personal beliefs and innovation. Some mechanical issues are operator reported events such as clogged suction devices: *"The problem is when those evacuators are too close to the tissue, then you're sucking up fat and then you're clogging the tissue";* and *"especially if there's a lot of fat and a lot of tissue that gets clogged, which gets a little annoying, but it hasn't really been affecting my efficiency."* The noise level of the smoke evacuation equipment was also noted: *"it's noisier for me with the suction bovie…"* and *"…doesn't like the sound of the suction so a lot of times he doesn't like me to hook up the suction."*

Others spoke of equipment-related interactions related to asking to use smoke evacuation: *"I have gotten pushback because they don't like the bovie pencil, because they think it gets in the way, they don't necessarily treat me differently but they're just against the idea of using it."* One team member spoke of frustration around inconsistency in evacuation, filibuster, and defeatist attitudes around the issue of surgical smoke evacuation, both getting it to work on a systems level, and in the moment, during the case: *"Most of the time, I would ask, is the bovie suction on? And they would say yes. And I was like, is it on continuous? And they're like, yes. And then they would check. I would say I know it's not on continuous because I can hear that it's not on continuous, you know? It's like filibustering."* This was from the perspective of the operator, who wanted smoke evacuation but had repeatedly felt that it was not a priority for the other team members that she perceived was due to the repeated difficulties to getting the equipment running and defeatist attitudes around getting it to work properly.

Barriers to Use

There were many barriers to equipment use, including lack of standardization: *"It's not really standardized, which also makes it kind of confusing and makes you...kind of be like, okay, never mind. I don't have time to figure this out. We need to get the case going. Which also makes me brush it off. Like okay, maybe it's not as important or, like maybe we don't have time for this, like I don't even want to look at this right now.."* Here the participant believed it would be better to have just one type of evacuator, as they had experienced in another operating room, to make smoke evacuation easier to figure out and use.

For some, obtaining the smoke evacuation bovie soft supplies and machines was *"...so seamless, resources and materials for the actual machines and soft supplies…they have plenty…there are no hitches in their supply chain."* To the contrary, others reported *"we do need*

more resources…not just take one or two bovies and move them around to the rooms who we know need it. I think it needs to be accessible on every single machine that we have." These examples illustrate the disparity of experiences around getting necessary equipment and supplies for having surgical smoke evacuation.

Participants also voiced personal beliefs around smoke evacuation experiences and practices: *"It's just a little bit annoying, but I think it's better than inhaling all that smoke. So, for me, it's worth the hassle";* and *"To me, it's [smoke evacuation] prevention."* Others shared their thoughts on their observations of perioperative team members' use of smoke evacuation equipment. For example: *"I don't think anybody imposed it on her. I think she has an interest in keeping herself and her staff safe."* Another issue concerned the efficacy of the equipment: *"What I think is that they're not effective enough…you're still breathing in a lot of the smoke"* and *"…but I think the efficacy of the equipment is questionable…I don't really know, maybe there is a lot of research, I don't know, but to me, I still smell smoke."*

Innovative ideas were voiced by many participants, for example, *"perhaps the technology could be enhanced [so] that we don't have the exposure we have"* was a common sentiment amongst several participants. Others shared their ideas to further modify existing smoke evacuation equipment from the device to evacuation built into the bed, and other ideas to improve mitigation strategies and results.

Past Experience

Past Experience is defined as life experiences around exposure to other types of smoke that frame or become an integral part of the way participants situated and interpreted their relationship with surgical smoke. Past experiences could be those from earliest memory until the

present day. A clear example that aligns with formative experiences with smoke was shared in a story by one participant:

"So, nobody smoked in my family growing up, but my grandfathers on both sides died of lung cancer due to smoking. I know that in my family, they all seem to have lung issues that are exacerbated by smoking…I have a cousin who smoked and then his lung collapsed randomly, and I have a brother who smokes, and he has asthma. So, I just feel like in my family, maybe lungs are predisposed to be reactive to smoke. So, I always have this fear that one day I'm going to die of a lung related issue, even though I'm not a smoker, because of smoke in the O.R. [operating room]." This participant was also trained with an attending physician who would say 'lung cancer, lung cancer' during surgeries that did not have active smoke evacuation. These two experiences combined, e.g., the family history of lung issues combined with the early training, caused her to be very aware and fearful of the possibility of adverse health effects. She connected these events and experiences herself during the interview.

During the member checking phase, another participant stated that *"… something that can influence my stance, of course, that is huge, is my mom is a current smoker since I was a kid. Obviously, you know, that can definitely influence my stance…you know, get the secondhand smoke kind of thing. So, that's something huge I should being up that is influencing me."* There were other participants who shared how being in or around a lot of cigarette smoke was not something they had noticed at the time as they were growing up but many confirmed that upon reflection, it was something that affected them and how they now view surgical smoke. These experiences were also on a range, with no concern or connection to a great deal of concern and connection with how they view their exposure to surgical smoke.

Many participants reflected on the recent wildfires when thinking about possible health impacts from surgical smoke exposure. For example, *"If there are fires outside, and people are saying, shelter in place, we've had big fires, living in [West Coast State] and it's not good for you to be outside with what's burning. Then how is it ok for us to be in a case where this is burning right in our face? It just doesn't make sense."* Another participant offered this analogy as she related her exposure to driving around during the wildfires *"Here's the other thing with the wildfires is they suggested you change your car filters sooner because it gets in your car filter when you're driving. And that makes sense, you know? So, when you relate it to bovie smoke and a filter, it's like, 'yeah', using a smoke evacuator makes sense."*

Due to increased awareness on the adverse effects of smoke generally due to climate change, and wildfires, another participant expressed concern for her son's current health status, wondering if the smoke from the fireplace in their home had contributed to or caused his asthma: *"We always had our fireplace going and that's where I would breastfeed him…and I am wondering if that's what gave him asthma…that's what I always wonder and worry about."* This has been a recurrent thought over the years that continued to the present time as she was thinking and sharing about her own exposure to surgical smoke. This participant was beginning to connect surgical smoke exposure with all smoke exposure over many years.

Another participant shared about the concern for their small child breathing in the smoke from the wildfires and so they invested, on a meager salary, in an air purifier due to worry over the quality of the air: *"We certainly had those air quality index days…and I had a very young child at that time, and so I worried about her and certainly just tried to maximize the air purification as much as we could."* Sharing this story with me was another example of how

participants framed their current concerns around surgical smoke exposure with their past experiences and behaviors.

Occupational

Previous smoke experience also occurred in other jobs. One participant, who previously was a first responder, described how bothersome surgical smoke is was all relative: *"When you're in an environment where you have a lot of smoke in your face, then when you get a little bit of smoke like in the operating room, it's sort of…again, it's all in perspective. So, if I hadn't had an experience where there were rare but real times when I experienced smoke as a hazard as a first responder, I might think that [surgical smoke]]is a lot of smoke. So, it's all perspective of life experiences.* Divergently, another perspective was: *"Whether it be smoke outdoors in a fire compared to smoke indoors, I feel like the carcinogens are the same."* Again, these responses demonstrate a range of experience around past exposure to smoke and how it creates the frame for how surgical smoke exposure is perceived.

Other Kinds of Smoke

One question that was asked on the interview script was if participants saw surgical smoke as its own kind of smoke or was it in a different category than other kinds of smoke. Several different types of replies ensued, and some even changed their answer over the course of the interview. Here are some examples of the range of responses received *"I don't really define different types of smoke"; "I think it's worse"*; *"I would say it's in a class of its' own, honestly"; "when I'm in public and someone smokes around me, I hate it. And I think I have the same reaction when it comes to surgical smoke."* The reason these responses are important to the conceptual understanding of how surgical smoke is the same as or different from other kinds of

smoke is because these experiences and beliefs often shape the way that surgical smoke is perceived and experienced.

There were veterans in the sample, almost half of whom were on the National Burn Pit Registry, who compared exposure to burn pits to exposure to surgical smoke: *"Everything that is generated goes into a burn pit and just burned, and so there's no evacuation of any sort…I mean it's just in the environment. I don't think I was particularly aware of it, you'd just see the haze in the air, but we walked everywhere we went, and we weren't wearing any masks…."* This example shows how previous exposure to other smoke, in a stressful environment without a choice around the exposure, may have been the background for some comparisons between surgical smoke and other types of smoke. Not all who were exposed to burn pits connected their experiences in the same way, reflecting again the range of experience that is affected by previous exposure in a non-concerned way, a neutral way, or a concerned way.

To wrap up this section on the dimensions of stance, an early hunch that there was , a larger finding, more than a few dimensions, emerging, and that experiences with other smoke were a part of these dimensions. In a memo on September 20, 2025, I wrote *"I can see that stance is an overarching theme, or major finding, in my quest to understand the experience of surgical smoke in the operating room. Along the way of describing this personal philosophy, or stance, some themes emerged that all fit under this umbrella of stance. The way a stance gets developed is via, or by way of, knowledge and experience. For example, depending on the role and training of the various perioperative team members, training and life experience have a part in the knowing and experiencing. It is interesting and notable that I considered the connection between other kinds of smoke experienced and surgical smoke experience…."* The hunch was validated as an important part of the findings around the dimensions of stance.

Change Over Time

As noted above, current stance on surgical smoke is in flux over time. As a person's experiences build over time, their awareness level can change, which then becomes new knowledge and beliefs. Participants referred to change over time around their own beliefs and experiences around smoke and the training in the operating room they received. The concept of *change over time*, the second property of stance, has four main types of change over time which are *gradual* change in practice and policy, *dawning awareness*, *defining moments*, and *new thinking*.

Gradual Change

Gradual changes in practice and policy describe the external changes based on participants' observations on how surgical smoke awareness has changed over the years. *"I think it's [tolerance for smoke of any kind] changed over time. People are nowadays, or in recent years, much more sensitive or reluctant to be exposed to smoke, possibly because so few of them actually expose themselves to smoke now. I have seen people not wanting to get even the slightest whiff. Yeah, people don't like it."* This change related the overall tolerance for smoke, wherever it is.

Many participants reflected that changes in technology and evolving surgical techniques have resulted in a decrease of surgical smoke overall: *"…1984 was when I first worked in the operating room, and I would say that surgery was much cruder than it typically is now, there was a lot of overuse [of the bovie] I would say it was just in small amounts, a daily occurrence."* *Gradual change* in practice and policy also included things like knowledge, as in what is known both to participants and in the body of literature they have seen. Also included was how those changes were experienced over time, as they observed and encountered them: *" I can say*

overall, I have noticed over my career, even over the last 13 years, that there's definitely been a little bit more awareness, which I appreciate, because I am bothered by it."

Others noted how different events such as the pandemic and an increase in wildfires related to climate change have piqued discussion around the impact of exposure to surgical smoke: *"I think we know about risks of occupational hazards with firefighters that are breathing more smoke, and we know about the risks of breathing in toxic smoke after wildfires and we know with cigarettes, secondhand smoke has a negative impact on health."*

Some participants spoke to the generational changes they observed, noting less tolerance with newer generations for breathing surgical smoke. Some spoke to the future and how they see things changing in the years ahead: *"surgeons have kind of been changing…slowly…their feelings towards things with smoke evacuation."* Here is an example that reflected several participants' sharing around gradual changes they had observed and thought about: *"I feel like more people are using it [smoke evacuation], I've noticed…most of the plastics people definitely have converted to them, which is great. I don't think general surgeons use them. I know some of the ortho doctors use them. I think it just depends. But I think if the surgeons get more data on it and get pushback from the staff for wanting to protect themselves, I think they would be willing to switch it up and use those things because it's not hurting you to use them. If anything, it's bettering."*

Gradual change was evident in the way that participants observed many levels and types of changes around their exposure to surgical smoke. For some, it was noted in those around them, for example, *"we had a surgeon for the longest time who would never use those [smoke evacuator bovies], and then she had kids. She is finally using them."* While gradual changes are

more closely related to external changes in practice and policy, the last example shows an observed change between one team member and another.

Dawning Awareness

One way that people rendered their individual experience of change over time was with a gradual, slow and steady dawning awareness that was a result of taking in some of the gradual change around them and integrating it into their own practices and observations. *"I just didn't think about it, it was just a part of the O. R. [operating room]…but then, just becoming more aware of it and worried about how it might affect me. I probably didn't feel the same before we talked about your study…I just didn't have the thought processes behind it, you know, this probably isn't very good for me, and all of that. It was just, one of those things, everybody's doing it, then, it's fine. And then we talked about it, it's like whey aren't people worried about this?"*

Dawning awareness is where a person crystalized several dimensions of their experience over time to arrive at a new stance. It was descriptive of the slow movement of a person changing their entire stance on an individual level. Dawning awareness is an embodied and integrated way a person began to take in and take hold of several aspects of one or more dimensions of stance, such as in this example *"Now I'm definitely spending a lot more time thinking about smoke, thinking about ergonomics, thinking about my own personal longevity and the longevity of everyone around me. Now that I've kind of gotten my cases down, I really just want to focus on everyone, and my [own] well-being, and making sure I don't develop any chronic illnesses from operating."*

Defining Moments

Another type of personal change over time was termed a *defining moment*. These were usually recounted as a story, describing a specific person, event, or revelation that happened all at once. Such a deep and personal impression occurred that their stance was changed in that instant. Many were compelled to then share their newfound stance with others. These participants had a confidence that gave them many ways to educate and communicate with colleagues about the effects of exposure to surgical smoke. Defining moments seemed to result in a more solidified stance on surgical smoke than they had previously had. For example: *"I feel like before she talked to me, I didn't think about it."* This example was from participant who had been influenced by the sharing from a colleague with such compelling information about exposure to surgical smoke that the participant, from that point on, went from not worrying or caring to taking action and educating her peers around the hazards of exposure to surgical smoke. This was so important to the participant that she came back to it a couple more times during the interview.

New Thinking

New thinking describes an emergent phenomenon when participants, in response to their interview questions and personal, in-the-moment reflection, articulate feelings and thoughts that are bubbling up to the top around their experiences. Some examples of new thinking that emerged occurred as a response to enrolling in my study as they took the two surveys, awaited their interviews, and had time to think about surgical smoke: *"I have never actively thought about it. Those questions really made me think…hmm, there's something there…I mean, should I be worried about it? I have never been worried about it. It hasn't bothered me. I grew up where there was a lot of air pollution. You know, I guess nothing really ever happens to me, I don't*

know, it's never bothered me to the extent that I felt like I should do something about it, or I should protect myself from it, or you know, even talk about it."

Another example of new thinking was when, after having said that campfire smoke was a positive association, a participant later said, "*I think I lean more towards, I just think all smoke is bad, whether it's like exhaust or campfire, or cigarette. It's all negative. I would more group it all."* This example of new thinking occurred in the moment: *"It's funny that I didn't even think of like, well, what about using an N95?"* It suggests that she had not translated the use of PPE (described in other situations like the pandemic and wildfires), to the operating room, until that moment. Other examples of new thinking occurring during the interview include the following: When asked if they had ever suggested smoke evacuation, one participant said, *"No, but I think I will. And there are some scrub techs out there that suggest it too, which I need to take a stand and suggest it myself because I'm looking out for myself, right?."* Several others noted their new thinking as they would say, *"I hadn't ever thought of that before…"* or *"maybe I need to try wearing an N95 next time,"* or *"a different mask,"* or *"educating myself more on that topic",* etc. In general, the interviews did elicit many examples of new thinking, which also had a range of experience and opinion on the topic.

Asking this particular question was interesting. Some would pause and often contradict themselves or demonstrate new thinking in the moment. Some would begin the interviews with one stance on surgical smoke. Then, after reflecting while being asked new questions they may not have ever thought of, it was clear me, based on comments that were made in the moment, that this was new thinking. Some participants had immediate answers, while others talked themselves in or out of their stance in the moment. There were examples of associations which

participants related to me during the interviews that influenced their thinking and how it has changed over time.

The first example is around a campfire, and how now, just like at the campfire, they cannot avoid the smoke. In response to question "when I say the word 'smoke', what comes to mind?, the participant shared this story: *"I think about when you're sitting at the campfire, and you're in your seat, and the smoke's coming towards you, and it hurts, and you're coughing, and then you move to another seat, and the smoke follows you around the whole campfire. Has that ever happened to you? Like somehow it's always smoked, like in your face, no matter where you go. That's what I thought about."* After having said that campfire smoke was a positive association, later in the interview, the participant stated *"I think I lean more towards, I just think all smoke is bad, whether it's exhaust, or campfire, or a cigarette – it's all negative. I would more group it all."* This statement is also a very good example of how the very experience of being interviewed and having to articulate thoughts on beliefs can generate new thinking.

The second example is around "good smoke and bad smoke" and how the participant changed their stance by relaying this thinking during the interview. *"I mean, there is good and bad smoke, right? We do burn a lot of incense in our house, even in the evenings, and in temples, and that is a good smell to me. That is good smoke…there's the rose and sandalwood, and they make these incense sticks with it, and that's what you always smell, and you associate it with a peaceful place, maybe? I think it's more to do with the smell than the smoke itself. I mean, it's not so much the smoke – it's the smell that triggers that memory. It's normal."*

The ideas around "good smoke" and "bad smoke" were present with several participants. Some even reflected in the moment, often changing their stance as I asked questions. There was a general consensus around how the wildfires and the pandemic had helped to shift their stance:

"Being around wildfires, and of course the pandemic, has heightened my awareness of respiratory diseases and impacts on health from the air we breathe and has made me more aware for surgical smoke and other risks."

All of these types of change over time are the result of various locations worked and their respective policy and practices around surgical smoke. Participants' own learning from personal reading, conversations, conferences, and thinking about things, including their formative years and exposure, informed their perspective and changed over time. The more recent experiences of airborne contaminants during the pandemic and the uptick in wildfires related to climate change also contributed to the way their thinking changed. These experiences during the pandemic and wildfires changed how they thought about and experienced surgical smoke over time.

Some participants described all four types of change over time across some or all of the eight dimensions. Others may have honed in on one thing right during the interview, voicing new thinking in that moment. Some shared responses and stories that demonstrate gradual change, in themselves or in others around them. Gradual change also included things like knowledge, as in what is known both to them and in the body of literature they have seen, and then how those changes were experienced over time, place, or person as they observed and encountered over time and experience. Having these moments of change over time were born from their experience, igniting another "round" of integrated inquiry and the cumulative cycle of how stance changes over time.

Interrelatedness of Stance

Interrelatedness is the third property of stance. Interrelatedness of all eight dimensions is the way in which they connect and influence each other in each individual's stance. No dimension exists in isolation from another. Following are four examples that illustrate the

interrelatedness of multiple dimensions of stance. The entire data excerpt is presented first. Then I point out the dimensions that it contains.

Here is one example of how a participant connected the multiple dimensions that shaped her of stance on surgical smoke: *"I don't know, once again, the research or the data, but I view it [surgical smoke] on the same level of danger as secondhand cigarette smoke or pollution or smog, that it's unhealthy and can lead to systemic effects. It can lead to cancer. So, I myself just view it as something that I just don't – I'd rather not have around – and just avoid it."*

For a closer look, "*I don't know, once again, the research or the data…"* is from the Awareness and Knowledge (unknown) dimension. *But I view it [surgical smoke] on the same level of danger as secondhand cigarette smoke or pollution or smog"* pertains to Meaning and Past Experience. "*That it's unhealthy and can lead to systemic effects. It can lead to cancer"* is related to the Meaning dimension. Lastly, "*So, I myself just view it as something that I just don't – I'd rather not have around – and just avoid it"* is an example of the Behavioral Response dimension. Therefore, this one answer holds four of the eight dimensions.

Here is a second example: *"It seems different. It seems caustic. It seems dangerous. Because specifically, like when we are specifically cauterizing some kind of tumor, of cancer, or some unknown origin, we don't know what we're breathing in. What does that mean – what kinds of things am I introducing into my body that might cause disease in me? And I'm not of childbearing age. So, you know, I'm in the sunset of my life – but I think of the younger nurses who don't even think about any of these things, and what it might mean for them."*

For a closer look: *"It seems different. It seems caustic. It seems dangerous"* is of the Personal Impressions, i.e. verging on personification of surgical smoke as a 'dangerous' entity. *"Because specifically, like when we are specifically cauterizing some kind of tumor, of cancer, or*

some unknown origin, we don't know what we're breathing in. What does that mean – what kinds of things am I introducing into my body that might cause disease in me?" exemplifies the Knowledge, Meaning, and Personal Impressions dimensions. *"And I'm not of childbearing age. So, you know, I'm in the sunset of my life – but I think of the younger nurses who don't even think about any of these things, and what it might mean for them"* exemplifies the Meaning and Team Dynamics dimensions. This example has four of the dimensions embedded within this excerpt.

A third example of interrelatedness is the following: *"Walking down the hallways of the OR and smelling the smoke and knowing it's from the bovie and it's burning flesh and kind of being appalled that I could smell it not so far away from where it's actually coming from, it makes me think about our filtration systems and how well they actually work, if they work at all, and just things like that, and how much it affects my health."*

For a closer look: *"Walking down the hallways of the O.R. [operating room] and smelling the smoke"* relates to the Awareness dimension. "*Knowing it's from the bovie and it's burning flesh"* relates to the Knowledge dimension. *"Being appalled that I could smell it not so far away from where it's actually coming from"* exemplifies the Personal Impressions and Meaning dimensions. *"It makes me think about our filtration systems and how well they actually work, if they work at all"* exemplifies Team Dynamics, i.e., equipment issues on a systems level. Finally, "*how much it affects my health"* exemplifies the Meaning dimension. This example has five of the eight dimensions.

A final example of the interrelatedness of the dimensions of stance is the following: *"Smoke in general is not good for your throat, your eyes, your tissues, your lungs. Just any part of your body. It's something that's invisible, you can smell it. You might be able to see it, but a lot of times it just permeates through all your membranes and you're not aware of it."*

Here is a closer look: *"Smoke in general is not good for your throat, your eyes, your tissues, your lungs. Just any part of your body"* from the Knowledge & Beliefs dimension. *"It's something that's invisible, you can smell it. You might be able to see it"* from the Awareness dimension. *"But a lot of times it just permeates through all your membranes and you're not aware of it"* from the Personal Impressions dimension. This example has three of the eight dimensions.

Quantitative Results

For this mixed methods study, the quantitative research question was, How do perioperative team members describe their sensorial experience and perception of air quality around surgical smoke in the operating room, as measured by the modified Air Quality Perception Scale (mAQP)? Data from the demographic survey is reported, followed by results of the mAQP scale survey. Scores from the mAQP scale, overall and by role, are described.

Demographics

The sample ($N = 35$), members of the perioperative team, compromised 7 anesthesiologists, 10 perioperative nurses, 3 physician assistants, 9 scrub technicians, and 6 surgeons. Participants ranged in age from 29-72 years old. Sixty-three percent identified as female, 34% as male, and 3% preferred not to answer. Seventy-four percent were White, 26% Asian, 6% Black or African American, and 3% Native Hawaiian or Other Pacific Islander; two participants identified with more than one race. Ninety-one percent identified as non-Hispanic or Latino, 6% as Hispanic or Latino, and 3% as Other. Eighty-three percent were board certified in their specialty; 17% were not. Twenty percent were veterans and, of those, 43% were listed on the Airborne Hazards and Open Burn Pit Registry, which was established by the U.S. Department of Veterans Affairs in 2014 (see Table 4.1).

mAQP Scale Scores by Role

The total score possible on the mAQP scale was 66. Actual scores ranged from 1-50, with 50 being an outlier. Averages for scores are indicated in ascending order for each role, see Figure 4.3. In this study, eight participants (23%) had a score greater than or equal to 22, which was what the original authors used to measure the "extent that air pollution is a nuisance" regarding perceptions around outdoor air pollution (Deguen, et al., 2012, p. 2043). A score of 22 or higher indicates poor air perception or a high level of risk perception; a score lower than 22 indicates good air quality perception or a low level of risk perception. Seven of the eight participants who had an mAQP score of 22 or higher were women (see Figure 4.4). By role classification, four were surgical scrub technicians, three were perioperative nurses, and one was a surgeon. This group scrubbed at the surgical field, except for one, where surgical smoke is generated. Seven participants (19%) had an mAQP score of 6 or lower; 71% were male. Of those seven, formal roles included anesthesiologists, two surgeons, and one physician assistant. This group comprised predominantly male anesthesiologists and surgeons.

Generally speaking, most participants "always" saw smoke ("see") in the operating room, but most "never" had symptoms or behavioral responses when compared with the visual cue. Most participants "often" or "always" noted an unpleasant smell and saw surgical smoke. Overall, roughly two thirds of the participants did not seem to notice surgical smoke or have behavioral reactions to it . Interestingly, surgical scrub technicians and perioperative nurses had the highest scores; anesthesiologists and surgeons, among the most highly educated members of the team, had the lowest perception scores. The scores for the three physician assistants were similar to those they assist, surgeons.

These results cause one to wonder what education on surgical smoke exposure and safety training in the workplace medical personnel receive. Surgical scrub technicians and perioperative nurses may be receiving more information than other roles. Or it could be different information or gradual change over time, as was indicated in the interview data.

The mAQP scale scores for all 35 participants are displayed in a histogram (see Figure 4.5). The median score was 13. The minimum score was 1; the maximum score was 40, with an outlier score of 50. The interquartile range (Q3-Q1) was 14. Data were skewed to the left. The groups who were least concerned with poor air quality from surgical smoke were the anesthesiologists, surgeons, and physician assistants. Perioperative nurses and surgical scrub technicians proved to be the most concerned about poor air quality. Individual mean scores were calculated (see Table 4.2) for every question on the mAQP scale. After the unit of the paired individual question was matched to a dimension, there were four total. Mean scores were then averaged per dimension. For example, the Meaning Dimension captured two questions on the mAQP scale: "worried about health" and Question 21, "think your quality of life was being degraded," with mean scores of 1.37 and 1.03, respectively.

Global and Role mAQP Scale Scores

Seventy-five percent of responses fall under the original mAQP scale cut-point score of 22, the perception of poor air quality, at 21. This means that roughly 25% of participants viewed the air quality to be poor, as defined by the mAQP scale. The standard deviation of the global box plot is 11; the median is 15. By role, mAQP scores show some overlap in ranges and in order of median scores, ranging from 1-8 with a median of 7 for anesthesiologists; 3-22 for surgeons (median of 9), 1-17 for physician assistants (median of 114), 10-29 for perioperative nurses (median of 19), and 10-50 for surgical scrub technicians (median of 20).

Statistical Analyses

Because data from the mAQP scale survey did not have a normal parametric curve, a Kruskal-Wallis Test, followed by pairwise Wilcoxon Rank-Sum Test, were performed to accurately identify differences between the independent group roles. The statistical program R (Team, 2020) was used to calculate the scores. The Wilcoxon Rank-Sum Test returned a chi-squared value of 16.658, with four degrees of freedom and a *p* value of .002253, indicating a statistical significance between groups. The Kruskal-Wallis Test revealed two significant *p* scores: between anesthesiologists and perioperative nurses, $p = .00075$ and between anesthesiologists and surgical scrub technicians, $p = .0010$. A pairwise Wilcoxon Rank-Sum Test was performed to elaborate the Kruskal-Wallis Test findings.

Mixed Methods Results

A joint display table was used to examine convergence and divergence of the qualitative and quantitative results. The columns in Table 4.3 display the eight qualitative dimensions, verbatim quotations for each dimension, the mAQP items most closely aligned with each dimension, and the mean score for each item. The rows show where convergence and divergence occurred between qualitative and quantitative results. Four qualitative dimensions converged; four did not. These results show the strong convergence of the dimensions in the qualitative analysis and the ability, or conceptual "fitness" of the mAQP scale, to capture half of the dimensions of the experience of surgical smoke.

Convergence of Dimensions with mAQP Scale Questions

The quality of convergence was strong between the mAQP questions and the four dimensions from the concept of stance. The Awareness Dimension exhibited the strongest example of convergence. Questions 17-20 dealt with the sight and smell of surgical smoke.

During interviews, all of the participants referred to such sensory awareness, often multiple times. This finding was evidence of the strong convergence in the Awareness Dimension. The Meaning Dimension was conceptually aligned with two mAQP questions: “worried about health” and Question 21 ,“think quality of life was degraded.” This strong and persistent finding was evident among those who were more concerned and more aware. The Symptoms Dimension was conceptually paired with Questions 2-8. This mean is likely much lower and may reflect the qualitative finding that not everyone was sensitive to surgical smoke and not everyone had symptoms.

The Behavioral Responses Dimension paired with mAQP Questions 9-16 and 22, behaviors that individuals might exhibit in response to surgical smoke. The dimension with the most mAQP questions paired with it (9-16 and 22), but weakest mean scores, which was convergent with the QUAL findings because not everyone was as bothered by the exposure. “Thinking about calling out sick” and “calling out sick” were questions that pertain to behaviors on the mAQP scale survey but were not mentioned in participant interviews. Perhaps interviewees were reluctant to express their thoughts or actions about calling out sick with a colleague, even in her role as researcher. Or perhaps interviewees just neglected to share this on the day they were interviewed on Zoom.

Question 14, “change mask,” was included in the mAQP scale survey but not expressed in interview data; only “maybe I should double mask,” a conceptually close behavioral response, was shared in an interview. Question 15, “wash hands and face,” also showed up as a positive response from some participants on the mAQP scale, but it was not the exact wording as the question prompted. There were two conceptually close behavioral responses from two

interviewees who said that they wanted to "take a hot shower so I can breathe and clear my nasal passages" and "…take a shower and wash all my clothes."

Divergence Between mAQP Scale Responses and Qualitative Results

Five questions on the mAQP scale diverged from the qualitative findings: one in the Symptoms Dimension, two in the Behavioral Responses Dimension, and two in the Meaning Dimension. No one mentioned the symptom "dry throat" due to exposure to surgical smoke. However, the qualitative data reveals several other kinds of throat irritation and issues. Two questions did not converge with the qualitative data in the Behavioral Responses Dimension: Question 9, "think about calling out sick," and Question 10, "call out sick." Finally, the Behavioral Responses to Questions 14, "change your mask," and 16, "drink more water than usual," were also not mentioned in the interviews but were included on the mAQP scale.

Conceptual Closeness for One Question

Although Question 15, "feel the need to wash your hands or face," was not addressed as such in the interviews, "take a hot shower," "take a shower," and "wash all my clothes" were similar enough conceptually to consider it a convergent finding for this question.

Convergence and Divergence of Dimensions of Stance with the mAQP Scale

The joint display table illustrates the convergence and divergence of merged data by using conceptual pairing of the two types of data (see Table 4.3). This renders a more complete understanding of the experience of surgical smoke, the aim of this dissertation research. The joint display table maps out both the qualitative dimensions and the subcategories that emerged during interviews. The narrative that follows accompanies the joint display table and expands on the contents. The richness of this data set goes well beyond the conceptual confines of this study. The dataset allows future studies to investigate differences in ages, roles, and other demographic

factors. For the purposes of this dissertation research, conceptual dimensions of stance and the subcategories were explored. Additionally, divergence of the quantitative data from the qualitative findings is addressed in this chapter.

Joint Display Table for Mixed Methods Results

The joint display table shows the dimensions and results of the mAQP scale that combine both the qualitative and quantitative dimensions of the perioperative team's experience of surgical smoke. All eight dimensions of stance are addressed in order of the original presentation in the analysis of the qualitative data. Each subsection provides examples of convergence and divergence, as they apply, for each dimension of stance. The questions on the mAQP scale were exceptionally effective in capturing a lot of shared experiences, but not all of the experiences revealed in the interview data. Based on the joint display table, the concept of stance was more nuanced and complex than the mAQP scale was able to elicit from the quantitative data alone.

Four dimensions of stance were convergent, four were not, in the mAQP results. The table is a map of the merged results. The conceptual pairing comprises all eight dimensions of stance conceptually paired with questions on the mAQP scale. Four dimensions of conceptual pairing were included on the mAQP scale: Awareness, Symptoms, Meaning, and Behavioral Responses. The four dimensions of stance not conceptually paired with questions on the mAQP scale were as follows: Knowledge and Beliefs, Personal Impressions, Team Dynamics, and Past Experience.

Awareness Dimension

The participants' sensorial awareness exemplifies the strong and clear convergence of the four quantitative questions on the mAQP scale as they reflect this visually in the histograms (mAQP Questions 17-20) with spread out variations of means. This exemplifies the correlation

of the qualitative data with the quantitative data. The Awareness Dimension had the strongest and clearest convergence of the four dimensions between the two types of data.

Knowledge and Beliefs Dimension

This dimension was not included in questions on the mAQP scale, which is an example of divergence between the two types of data. Most of the qualitative data addressed the rationale for using the Bovie machine, the contents of surgical smoke, and where it comes from. In addition, other areas in the qualitative data not captured by the mAQP scale included what is unknown, the uncertainty about hazards and the impact of exposure to surgical smoke, early training experiences pertaining to surgical smoke, and education sources.

Personal Impressions Dimension

This qualitative dimension was not part of the mAQP scale. Although this dimension does not need measurement, the mAQP scale could invite narrative response to these open-ended questions, What is surgical smoke like for you? and What is the smell like for you? because responses in the interviews were rich and detailed personal impressions. The qualitative data was an exceptionally vivid and visceral dimension, with original and unique descriptions of surgical smoke, including personification by several participants. The way smoke moved was not captured and would be difficult to measure the "behavior" of surgical smoke. However, smoke volume could be estimated in a future mAQP scale question, based on the range of responses given during the interviews in this subcategory.

Symptoms Dimension

Quantitatively, the Symptoms Dimension was striking for low mean scores, which converged with the qualitative data in that symptoms were not much of a concern for most participants. In the histograms, mAQP scale Questions 2-8, the means did not have much spread,

indicating that symptoms were not very present. The symptoms where convergence occurred included watering eyes, cough, and headaches.

Symptoms that were divergent in that they were on the mAQP scale but did not show up in interviews included dry eyes, nausea, gagging, and a dry throat. The mAQP scale did not assess whether the onset of feeling ill was caused by surgical smoke or not. The mAQP scale did not have questions to capture the responses of those participants without symptoms.

Meaning Dimension

Question 1 on the mAQP scale, "feel worried about health," had the highest mean score of the two questions in this section. It had an almost normal distribution when compared with histograms of all 22 questions, indicating a range of responses. In the qualitative data, health concerns related to breathing surgical smoke were extensive. Several findings such as concern about cancer, disease transmission, pregnancy outcomes, cumulative effects, bodily violation, death, acclimation, bravado, proximity, and indifference demonstrated divergence in the two types of data. Convergence was found between the qualitative Meaning Dimension and Questions 1 and 21, "think quality of life degraded." This dimension also reflected an intensity and level of concern that indicated strong convergence with these two mAQP findings.

Behavioral Responses Dimension

Questions 9-16 and 22 on the mAQP scale aligned conceptually with the Behavioral Responses Dimension. The histograms for these questions were all skewed to the left and were mostly not present. Convergence in this dimension was evident: opening the door, stepping out of the smoky room, and attempting to air out the room. Although no participant said that they "thought about getting a different assignment," one did say that they "never felt like I should say 'hey, I can't work in this room today."

In response to another question, “feel the need to wash hands and face,” that was not directly correlated with the qualitative response but was conceptually close enough to include as convergent, one participant said that they “immediately want to take a shower and wash all my clothes” after a shift. The final question, “change mask,” had a close conceptual relationship with this response, “should I double mask”?

Team Dynamics Dimension

This is another dimension that incorporates complex and multiple findings that were divergent inn the two types of data. There was a range of preferences voiced by surgeons and other members, concern for others, communication patterns and strategies, conflicting priorities, equipment issues, barriers to use, and innovative solutions. Another issue that arose was the right to breathe clean air.

Past Experience Dimension

This dimension too diverged from responses to the mAQP scale. There are examples of how participants’ past experiences with other kinds of smoke impacted how they view exposure to surgical smoke. In the qualitative data, this dimension also exposed a range of past experiences with other types of smoke. Some participants had grown up where indoor and/or outdoor air pollution was prevalent, for example, in a household where family members smoked, in an area with extremely poor air quality, or in a career like a firefighter medic where exposure to other kinds of smoke was to be expected.

Meta Inferences

Based on the mixed methods results, there is an opportunity to better characterize the symptoms burden from surgical smoke. The mAQP scale is missing some important things. New findings in the qualitative research that were not found in responses to the mAQP scale were part

of the symptom burden. The symptoms were more broad in the qualitative data than the mAQP scale could elicit. A notable and important finding: Question 2, “red eyes,” had a low mean and was extremely skewed in the histogram distribution. Several participants mentioned “watery eyes” and other ophthalmologic symptoms. This exemplifies the need for more precise characterization of the surgical smoke experience to better understand all symptoms reported. For example, the question could be rewritten to be more generic by asking about eye symptoms in general, leaving a wide range of possible answers instead of limiting to just “red eyes.”

In the Behavioral Responses Dimension, the mAQP survey questions reflect actions a participant might take; in the qualitative data, more and different behavioral responses include advocating for policy and practice change and asking for smoke evacuation. Examples of divergence included variations of altering breathing patterns, moving one’s body, asking for smoke evacuation, using regular suction, and using personal protective equipment. Although the quantitative and qualitative data had some convergence, a more detailed mAQP scale could include these behavioral responses for a more robust and more detailed conceptualization of the surgical smoke experience. The richness of this dimension (e.g., the multiple participants who shared their varied breathing patterns) exemplifies a behavioral response that could be further studied and applied to other types of respirable workplace hazards.

The Meaning Dimension yielded a variety of especially rich and robust qualitative data. The depth and breadth of the participants’ concerns for their health, well-being, disease burden, unknown risk of exposure, pregnancy outcomes, cumulative dose response, acclimation, tolerance, bravado, and perceptions of proximity demonstrate the extent to which perioperative teams are experiencing stress silently in an environment with many other considerations, while bringing patients safely through surgery. More specific questions should be added to the mAQP

scale to more accurately capture the findings in the interviews. This exemplifies where merging data in mixed methods research illustrates the convergence, with enough divergence, to use qualitative data and quantitative data to round out the conceptualization of the experience of surgical smoke.

Figure 4.1

Conceptualization of the Experience of Surgical Smoke "Stance"

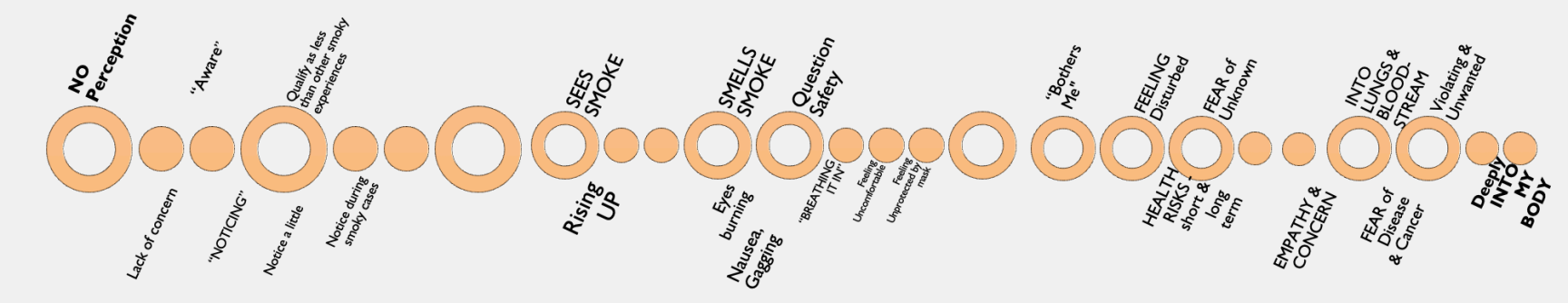

Figure 4.2

Continuum of Awareness

Table 4.1

Characteristics of Demographics (*N* = 35)

Role on Team				
	Anesthesiologist	MD-A	7	20%
	Perioperative Nurse	RN	10	29%
	Physician Assistant	PA	3	8%
	Surgeon	MD	6	17%
	Surgical Scrub Technician	ST	9	26%
Gender Identity				
	Female		22	63%
	Male		12	34%
	Preferred Not to Answer		1	3%
Race				
	Asian		9	26%
	Black or African American		2	6%
	Native Hawaiian or Other Pacific Islander		1	3%
	White		25	74%
Ethnicity				
	Hispanic or Latino		2	6%
	Not Hispanic or Latino		30	91%
	Other		1	1%
	Preferred Not to Answer		2	2%
Age				
	Median = 47			
	Range = 29 - 72			
Years of Experience				
	Mean = 12 years			
	Range = 0 - 30+ years			
Board Certified				
	Yes			83%
	No			17%
Smoker			2	6%
Non-Smoker			33	94%
Veteran Status				
	Yes		7	20%
	Burn Pit Registry		3	43%
	No		28	80%

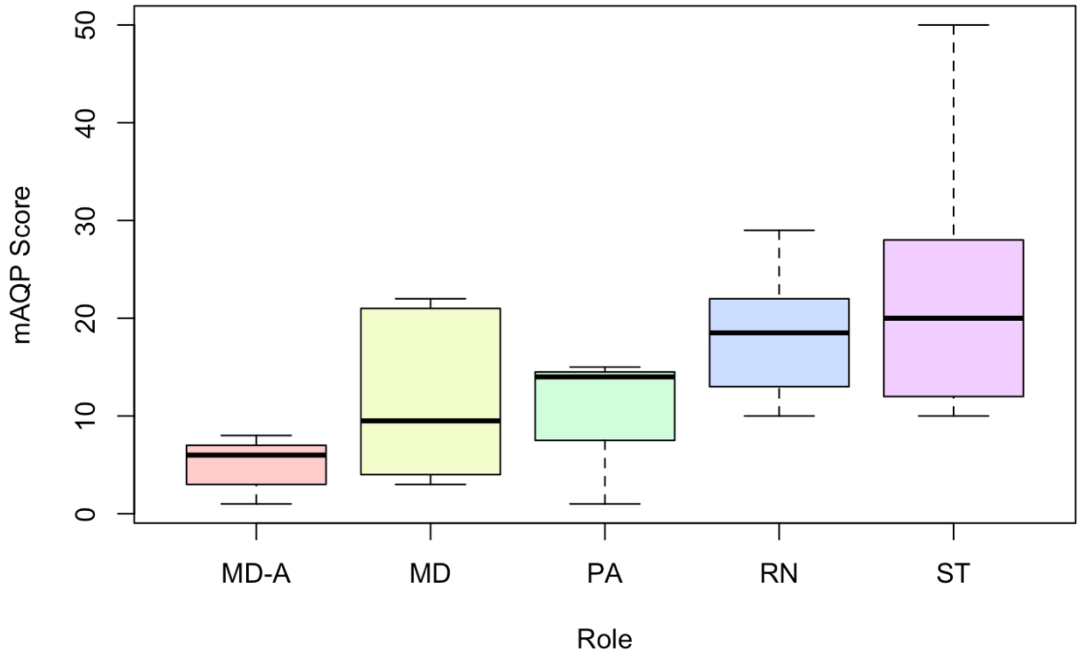

Figure 4.3
mAQP Scores by Role

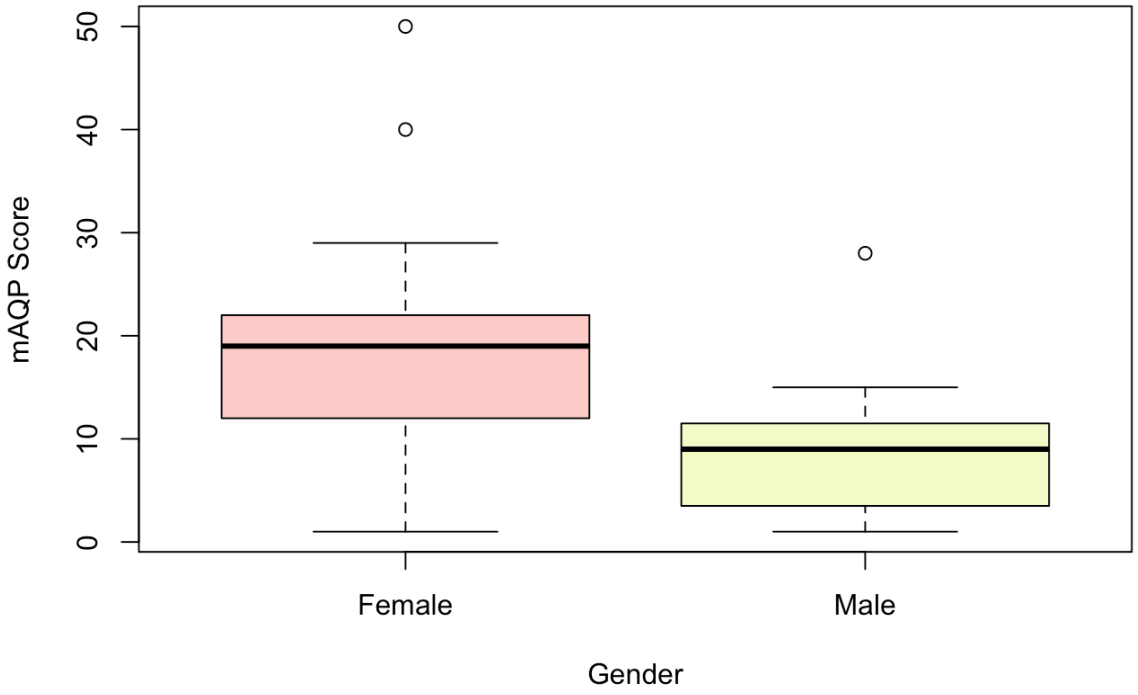

Figure 4.4
mAQP Scores by Gender

Table 4.2
mAQP Questions Mean Score

Over the Past Week, as a Result of Surgical Smoke, Did You

mAQP Question	Mean
1. Feel worried about your health	**1.37**
2. Have "red" eyes	**0.2**
3. Suffer from nose irritation	**0.62**
4. Sneeze	**0.45**
5. Have a dry throat	**0.57**
6. Cough	**0.54**
7. Have difficulty breathing	**0.31**
8. Suffer from headaches	**0.42**
9. Think about calling out sick	**0.08**
10. Call out sick	**0.05**
11. Open the sub-sterile door or main OR door	**0.28**
12. Walk out of the operating room into sub sterile	**0.48**
13. Attempt to air out your room	**0.31**
14. Change your mask	**0.51**
15. Feel the need to wash hands or face	**0.71**
16. Drink more water than usual	**0.54**
17. Smell an unpleasant smell in the hallway	**1.2**
18. Smell an unpleasant smell in your suite	**1.91**
19. See smoke plume around the sterile field	**1.88**
20. See smoke plume in your suite	**1.17**
21. Think your quality of life was being degraded	**1.02**
22. Think about getting a different assignment	**0.51**

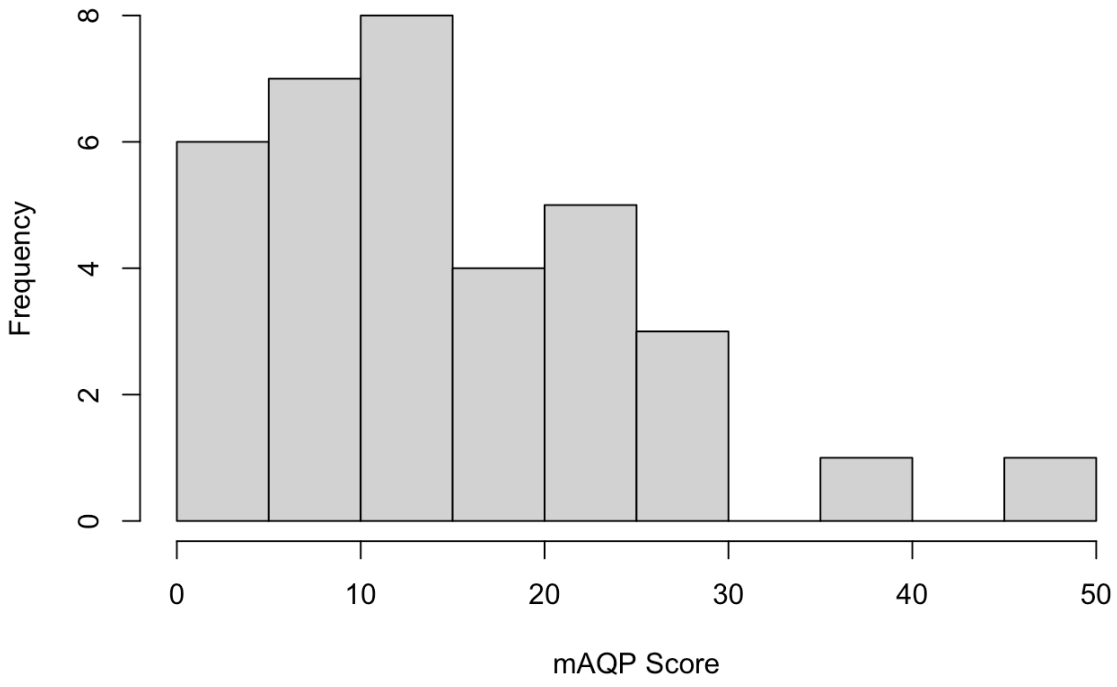

Figure 4.5
Global mAQP Score Distribution

Table 4.3
Joint Display Table

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
	Awareness	17	Smell unpleasant smell in hallway	1.2	"the whole hallway smelled like bovie smoke" "walking down the hall in the OR and smelling smoke"
		18	Smell unpleasant smell in suite	1.9	"it's' not a pleasant smell by any means" "it's such an uncomfortable, unpleasant smell"
		19	See smoke around sterile field	1.9	"I'm more seeing it, smelling it later"
		20	See smoke in suite	1.2	"you can see it" "under the OR lights you can actually see a lot of the particles blown around, it's thick…"
"the bovie makes that sound when they start burning stuff" "it's audible"	Hear				
"trying to breathe through my mouth but it still tastes like smoke"	Taste				
	Symptoms	2	"Red" eyes	0.20	"I noticed my eyes were red" "I got really bloodshot eyes one day"
		3	Nose irritation	0.63	"stuffy nose" "I get really congested and my nose gets really irritated"
		4	Sneeze	0.46	"I know my body reacts because sometimes I sneeze"
		5	Dry throat NOT DUE TO SS EXPOSURE	0.57	**" dry throat" this was for burn pit smoke**
		6	Cough	0.54	"I'll cough of something" "I feel the need to cough"
		7	Difficulty breathing	0.31	"feels like I can't get a full breath" "hard to breathe"
		8	Headaches	0.43	"I've noticed over my career…more headaches"

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"sometimes you get dry eyes" "irritates the cornea"	Dry eyes				
"it absolutely causes watering of the eyes" "my eyes water"	Watery eyes				
"I get burning of my eyes" "burning feeling in my eyes"	Burning Eyes				
"I get irritated eyes"	Irritated Eyes				
"it's constantly going through my nose and making it stuffy"	Stuffy nose				
"burning in my sinuses" "can't get the smell out of my nose"	Irritated nose				
"the smell is so nauseating" "it makes me really nauseous"	Nausea				
"smell is so awful you are literally almost gagging"	Gagging				
"feeling irritated back of my throat" "irritate my throat, lungs…"	Throat				
"making me feel a little lightheaded"	Lightheaded				
"it'll just trigger a migraine"	Migraines				
"It can make you not feel great" "disturbing sensory-wise"	Malaise				
"I'm thankful I don't have any physical symptoms" "I don't think I'm that sensitive to the smoke	No symptoms				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
[SS]…certain people are just way more sensitive"					
"I never know what I can attribute to the OR, I don't' know if I'm getting sick more often because of the surgical smoke"	Previous Illness v. SS				
"pain in my chest" "deep ache and I feel like I can't get a full breath"	Chest Pain				
	Meaning	1	Worried about health	1.37	"I worry when I smell it…it's affecting me if I could smell it" "it's as if you're smoking and we all know that smoking causes lung problems. So, I've always worried about that."
		21	Think quality of life degraded	1.03	"we're in this for the long haul; we have to do our best to try to stay healthy as possible, just for quality of life"
"what effects long-term on me & my health?" "It's unhealthy, it can lead to systemic effects"	Concern for Health				
"surgical smoke is a carcinogen" "when I smell the smoke, I think about cancer"	Cancer				
"theoretical chance of disease transmission" "there's still controversy; if you ask 100 doctors, they're probably going to give you different answers"	Disease transmission				
"very aware in pregnancy" "only in my pregnancy when I've noticed a lot of smoke have I really	Pregnancy				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
thought I wonder if this is not so good for me"					
"when I'm that old are my lungs gonna be bad?" "little by little, it'll start adding up over time, that's how cancer develops, right?"	Worry about Cumulative effects				
"I question if [SS] exposure was a triggering factor around my Lupus" "I have lung cancer. I had a right middle lobectomy without ever smoking a cigarette or a joint in my entire life and the genetic testing was all negative"	Bodily violation				
"I always have this fear that one day I'm going to die of a lung related issue"	Death				
"when you're at the field, you're at greater risk" "we wear masks in the OR so it's not like I'm inhaling smoke directly"	Proximity				
"surgical smoke was never a big deal to me" "I have never been worried about it. It hasn't bothered me"	Indifference				
	Behavioral Responses	9	Think about calling out sick	0.09	NOT IN INTERVIEWS
		10	Call out sick	0.06	NOT IN INTERVIEWS
		11	Open sub-sterile or main OR door	0.29	"I open the door to the core & take a breath out there"

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
		12	Walk out of OR into sub-sterile	0.49	"I'll step out for a second…the smell is still there… there's no real escaping it"
		13	Attempt to air out room	0.31	"I have seen nurses air it out, open the door and try to push smoke out. I have seen it a bunch, everywhere"
		14	Change mask	0.51	NOT IN INTERVIEWS- "should I double mask?"
		15	Feel need to wash hands & face	0.71	**"take a hot shower so I can breathe and clear my nasal passages"** **"Immediately want to take a shower and wash all my clothes"**
		16	Drink more water than usual	0.54	NOT IN INTERVIEWS
		22	Think about different assignment	0.51	"I barely want to do my job now and I'm getting paid **very well I think"** **"I've never felt like I should say, 'hey, I can't work in this room today" - OPPOSITE**
"I hold my breath" "I don't want to breathe…when there's so much smoke"	**Altering Breathing Patterns**				
"I'll just bovie through this really quickly, and just kind of turn my head"	Moving the head				
"step away from the surgical field, try to distance myself" "I just kind of stand back a bit"	Moving the body				
"I feel like maybe I should"	Asking for SSE				
"we just use regular suction" "better than nothing"	Using regular suction				
"I don't know if I should be wearing another type of mask"	Using PPE				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"it's uncomfortable but you get used to it"					
"people just keep brushing it under the rug, ignore it" "it's just not happening fast enough"	Change				
"just accustomed to breathing" "it's just a constant for me"	Acclimation				
"it's a workplace hazard that we just have to deal with" "it's unavoidable"	Tolerance				
"you're just taught not to complain" "the mission had to be accomplished, so I just kept moving"	Bravado				
"I have a right to protect myself" "they have a right to say I don't want to be in there unless there's a way to reduce the smoke risk"	The right to Choose				
"it's only a matter of time before the smoke regulation in the OR becomes part of OSHA compliance"	Policy & Practice				
"we're humans at an advanced level of technology…we get more research into things and new things become discovered and we have to					

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
react or otherwise we'll just become the next asbestos"					
'"it almost makes me feel like we are living in the dark age. Dealing with exposure that we could potentially prevent"					
	Knowledge & Beliefs		Not captured in mAQP		
"a technique to stop bleeding" "aerosolized tissue"	What is Known				
"there is so much that is unknown" (related to what is known about surgical smoke exposure)	What is unknown				
"I don't think it carries carcinogenic risk like campfire smoke or cigarette smoke does, but I just don't know for certain"	What is uncertain				
"we did not have a specific talk…nothing stands out" "when I was a resident, we were fulgurating genital warts…I am going to get genital warts in my nasopharynx because of this…"	Training Experiences	No information			
"…it smelled bad but not thinking anything else about it"	Training Experiences	neutral			

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"when the suction wasn't on, my attending would say 'lung cancer, lung cancer!' "	Training Experiences	Information			
"different in-services" "medical newsletters on listserv"	Education Sources				
	Personal Impressions		Not captured in mAQP		
"sometimes it's minimal, sometimes it's thick" "it's very procedure dependent"	Volume of smoke				
"most cases with big incisions" "number one is breast"	Volume – Case type				
"spreads around the room" "smoke is rising up"	Behavior				
"smaller OR suite versus a larger one, there's more room to dissipate"	Behavior – Room Size				
"even with the smoke is inside the person's body cavity, it escapes in the room"	Behavior – Case Type (open or closed)				
"the physical barrier of the drape gives me some space for it to dissipate"	Behavior - Perceived				
"predictable, you can anticipate it"	Behavior - Anticipation				
"dirty cells flying around" "like germs worming" "I see the smoke circling around my scrub tech"	Personification of Smoke				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"not something that was off-putting right away" "unlike any other smell"	Smell - unique				
"the smell is an indelible memory" Once you smell it, you will always remember it"	Smell - indelible				
"it smells like BBQ" "I try not to associate that with cooking"	Smell – Food Associations				
"it's like smoking unfiltered cigarettes in the OR" "like second-hand cigarette smoke"	Smell – Cigarette Associations				
"a branding iron, like on a cow" "like a piece of steak on a frying pan" "it's not like a bonfire, it's not like a forest fire, it's not like your fireplace at your house. It's flesh."	Vivid Visuals				
"I feel like I can't get the smell out of my nose and everything smells like it and my food tastes like it, which is really gross"	Taste				
	Team Dynamics		Not captured in mAQP		
"they just prefer their bovie that they're used to" "throw it off the field"	Surgeon preferences				
"pregnant colleague near the field…concern for birth defects"	Concern for others				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"patients are being exposed to it"					
"sometimes it's received well and sometimes not" "I don't feel as free to speak up" Most of the time you can just read body language, or facial expressions"	Communication				
"there's 150 other things that I'm thinking of" "there are moments when I'm so rushed"	Conflicting priorities				
"smoke evacuators get clogged" "Efficacy of equipment is questionable"	Equipment issues				
"smoke evacuator was always in the way" "it's noisier"	Barriers to use				
"it hurts my face, so I won't wear it" "N95's are not comfortable"	Barriers to PPE–N95				
"could be better designed"	Innovation				
	Past Experiences		Not captured in mAQP		
"in my family lungs are predisposed to be reactive to smoke so I always have this fear that one day I'm going to die of a lung related issue even though I'm not a smoker [but] because of the smoke in the OR"	Predisposed				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
"my mom is a current smoker, since I was a kid, obviously that can affect my stance…it's not something I prefer"	Self – Parent who smoked				
"I grew up in a polluted city. Nothing really happen[ed] to me"	Raised in polluted city				
"When I pass by someone on the street who's smoking a cigarette, I try to go as far away from them as possible, but when you're in the OR you really don't have a choice"	Day to Day & Choice?				
"I was a paramedic, getting called to fire scenes…the SS in the OR is not that intense" "you have to keep some [SS] in perspective"	Previous Occupational				
"I really don't define different types of smoke" "there's good smoke and bad smoke"	Others				
"I do understand positive smoke, like candles…incense…church incense" "except if I'm at a BBQ, the smell of smoke is not favorable"	"Positive Smoke"				
"surgical smoke is negative. I cannot see it's a positive thing" "I just think all smoke is bad, whether it's exhaust	"Negative Smoke"				

Quotes from Dimensions Absent in mAQP DIVERGENCE	Stance Dimension	mAQP Question #	mAQP items	Mean	Quotes from Dimensions Present in mAQP CONVERGENCE
or campfires or cigarette. It's all negative" "it makes me think of smog and air pollution, which I don't want to be around as well"					
"if it's not good for you to be outside with what's burning, then how is it OK for us to be in a case where this is burning?"	Wildfires				
"the surgical smoke in the operating room is not that intense"	Occupational Firefighter				
"...if you were walking around and it was in the air, you just kept on like normal" "you breathe in all that garbage for seven months. It's not great"	Occupational Burn Pit				
"...coughing, **dry throat**, nares will get dry...headache or get dizzy"	Burn pit symptoms				
"camping, mostly a pleasant experience, warmth, and coziness"	Other kinds of smoke Pleasant Memories				

Chapter 5: Discussion

Discussion

This mixed methods dissertation research offers a novel understanding of how surgical teams experience surgical smoke. The richness of the qualitative findings are compelling, confirming that the experience of surgical smoke is a broader and deeper phenomenon than previously understood. The data were organized into conceptual dimensions and then grouped under the overarching concept of stance. The mAQP scale survey, which measured perceptions and symptoms of surgical smoke, provided the quantitative findings. The mAQP results show that most people do not perceive exposure to surgical smoke in terms of poor air quality. Data analysis shows that, while the mAQP scale is a conceptually sound and reliable instrument for measuring some aspects of convergence in the qualitative dimensions of Awareness, Meaning, Behavioral Responses, and Symptoms, it did not converge at all with the other four dimensions: Knowledge and Beliefs, Personal Impressions, Team Dynamics, and Past Experience. This conceptualization of stance is a significant contribution that advances the science of surgical smoke, enhances understanding, and presents more targeted and nuanced opportunities for future research.

Stance is a model of the multidimensional, interrelated, and dynamic findings of the participants' experience of surgical smoke. More than a list of themes from the two strands of data, this finding is a mid-level abstraction, an interpretation of the data. This research did not begin with a preconceived framework, rather a methodological one that was informed by constructivist grounded theory. Because little has been developed conceptually in the field of surgical smoke science, this research offers a foundation and conceptual basis for understanding the experience of surgical smoke more deeply. The conceptual model of stance shows how all the pieces, or dimensions, work together in a dynamic way. Without the use of grounded theory, the

dimensions would have been just a list of themes. A thematic analysis would not have done the data justice; it was exceptionally rich and when combined with the quantitative data, it became richer. The term, *stance on surgical smoke*, is specifically and conceptually tied to the data, which gives it structure and strength. As Sandelowski (1993) stated, "the very purpose of grounded theory research is to produce theory" (p. 214). This dissertation research has produced a conceptual framework, a precursor to theory development.

Understanding the experience of surgical smoke is described by a larger qualitative component, participant interviews, and measured by a quantitative component, the mAQP scale. The mAQP items had a convergent presence of their own, in the interviews, without being directly elicited. There are now substantive findings and solid evidence of this convergence. Although the mixed methods approach yielded more findings than would have been found using only one approach, more can be gleaned from what the experience of surgical smoke means to perioperative teams. Overall, the four dimensions that were not present on the mAQP scale (Knowledge and Beliefs, Personal Impressions, Team Dynamics, and Past Experiences) have weight and a necessary presence when new policies and implementation strategies are considered. Although the mAQP scale was novel and captured many of the common elements of the experience of surgical smoke, there were more data that enriched the results of this mixed methods study. The interviews captured the range of participant responses in all eight dimensions of stance.

Although Figure 4.1, which displays the Eight Dimensions of Stance, is complex, it uses the classic Venn diagram to illustrate conceptual overlap (Mahoney & Vanderpoel, 2015), with shared and interrelated dimensionality. The point at which all dimensions connect in the center is where stance resides, reflecting the truth in the data of each participant's stance, which

comprised different amounts of the various dimensions. The only improvement on the figure of stance would be to represent it in three dimensions, with individually sized dimensions that show each participant's uniqueness. For example, the amount and degree of each dimension that makes up a person's stance would correspond in size (larger for more) and degree of connection (varies with personal experience) with other dimensions. Each interview provides a snapshot in time of a participant's stance, demonstrating its dynamic nature and how it changes over time. This property of the uniqueness of stance has emerged and will be addressed in the future as another finding of this dissertation research. Time did not allow for it to be fully analyzed.

Limitations

Before further interpretation of the findings, this dissertation research has some limitations to acknowledge. The first to consider is my positionality (see Appendix A). As an inside outsider, a perioperative nurse with experience as both a scrub and circulating nurse, conducting research where I work, may be seen as a limitation, but it can also be seen as a strength. It was a strength because I had access to the operating room, members of the perioperative team were motivated to join the study, and the leadership of the surgical services team and the hospital's Institutional Review Board supported the study. This may also be viewed as a limitation because I had an existing rapport and working relationship with every participant. Again, this may also be a strength because trust with the perioperative team had already been earned, and interested team members were assured that their anonymity would be protected, which allowed for honest responses and real experiences to be shared and recorded. The richness of the data was notable for its range of responses, dispelling the possible conclusion that everyone who participated was generally not in favor of exposure to surgical smoke.

Sample Bias

Participants were free to add comments to the demographics survey. Twenty-nine responses were given to this question, Is there anything you would like to change about surgical smoke in the operating room? If yes, what would you like to change? Six participants declined to comment for unknown reasons. Perhaps they saw no need to change procedures about surgical smoke in the operating room. This result leads one to believe that there was a bias in the sample toward mitigating exposure, which is a potential limitation to this study because most participants stated that they were inclined to favor smoke evacuation and reduce their exposure (see Table 4.1).

The Hawthorne Effect

As the study progressed and became a topic of conversation among team members, answers in both strands of data may have been influenced. This is an unavoidable phenomenon. On the other hand, nearly all of the participants promptly completed the surveys and availed themselves for interviews as soon as possible. If this dissertation research increased awareness, it may have caused unforeseen and unknown consequences across a range of beliefs, practices, and even policy in this hospitals' operating room. Some participants continued to share with me on occasion how their awareness had increased and how they had modified their personal and professional practices. Shortly after the study began, a new surgical smoke evacuation policy was put into effect at the site.

The mAQP Scale

Modifications to the AQP were based on the primary researcher's 22 years of experience as a circulating perioperative nurse. For example, two questions addressed bodily movement away from the sterile field as a behavioral response. Only a circulating nurse could do this. Most

of the questions on the mAQP scale dealt with awareness, symptoms, and meaning, which would minimize the impact of bias on the scores. Further, the mAQP scale was modified from the original AQP scale, which was designed by Deguen et. al., (2008) to measure perceptions of and symptoms caused by outdoor air pollution. There are differences between indoor and outdoor air pollution. Due to perception bias, people generally perceive indoor air pollution to be less harmful (McCormick & Rider, 2025). However, exposure to particulate matter and volatile organic compounds, perceptions of risk in general, and certain behavioral responses remain conceptually true and aligned to the instrument, as modified. The fact that the mAQP scale found conceptual convergence with the interview data and findings minimizes this concern.

Strengths

Conceptual Contribution

Notwithstanding these limitations, this study provides original insights on the experience of surgical smoke in the operating room. To the best of our knowledge, this is the first study to conceptualize the experience of surgical smoke using mixed methods. Overall, this dissertation research contributes new knowledge and understanding for the conceptual advancement of the *experience* of surgical smoke. The results confirm that the experience of surgical smoke is a broader and deeper phenomenon than previously known. The conceptual framework and model of stance also illustrate how the dimensions are interrelated and how they change over time. The uniqueness of stance is a fourth property that will be developed in a future paper.

Methodological Strengths

First, by gathering both qualitative and quantitative data in a mixed methods study, clear and conceptually strong data converged to yield a foundational conceptualization of the experience of surgical smoke. This may contribute to more and different studies that further

corroborate the findings, reflecting trustworthiness and rigor in and of the method. For example, a future study could use the missing dimensions (four in total) to create a more complete version of the mAQP scale. This would allow for replication of the entire mixed methods study in another operating room, using the new version of the mAQP scale, and compare results. In addition, there were two analysts, which is an expected hallmark of trustworthy qualitative research (Creswell & Poth, 2018).

Second, the primary researcher used constructivist grounded theory (Charmaz, 2014) to inform qualitative data collection for the interviews and analysis. This was an intentional and methodologically sound decision because both grounded theory and mixed methods share the same philosophical foundations, which emerged from pragmatism (Creamer, 2022). These qualities render this study methodologically strong and rigorous because all of the methods were in compatible alignment.

Third, careful and thoughtful modification of the original AQP scale (Deguen, 2008) and creation of an interview guide (see Appendix G) appendix that shared conceptually similar elements was a strength that contributes to the rigor of the results (see Table 4.3.). There was saturation for most major qualitative findings toward the final third of the interviews. Data saturation can also be considered an expression of rigor (Creamer, 2022). Additionally, the convergence and divergence of comparing two strands of data allowed for richness as well as depth and breadth of the participants' experience of surgical smoke. Continuing to improve and validate the mAQP scale could be tailored to extend to other exposures in community settings.

Finally, data analysis used the validation strategies of reflexivity, member checking, triangulation of both strands of data from the 35 participants, and extended time in the field (Creswell & Plano Clark, 2018).

Sample Heterogeneity

The range in age, gender, years of experience, and team role were all valuable in obtaining the most variety in responses; this allowed for a natural reflection of a normal distribution in a given sample. To have ranges in the participants' responses in all eight dimensions of stance is a strength because it reflects a sample that was heterogeneous, bringing forth diverse thoughts, experiences, and responses. This heterogeneity minimizes sample bias.

Timing

The timing of this dissertation research is noteworthy because it reflects what many people worldwide are thinking and experiencing with poor air quality due to the global challenges and responses to climate change. This research may heighten awareness in new ways in the perioperative community, having a synergistic impact and becoming a catalyst that bridges the experience of surgical smoke with all smoke (So et al., 2022). Although direct causal proof of surgical smoke exposure with adverse health outcomes has not been established, the conceptual and actual similarity between indoor and outdoor air pollution may facilitate more research, which could inform policy for all types of hazardous respirable exposures.

Implications

A gap in the literature has existed on how perioperative teams experience surgical smoke. Only recently have some studies begun to explore the experience of surgical smoke from the perspective of perioperative teams (Ball & Gilder, 2022; Barber, 2022; Golda et al., 2019; Ilce et al., 2017; Lotfi et al., 2022; Michaelis et al., 2020; Moon et al., 2021; Rodrigues & Winnington, 2024; Soysal et al., 2023; Vortman et al., 2021) and, more recently, have used an existing theoretical framework to better understand this phenomenon (Ball & Gilder, 2022; Barber et al., 2022; Rodrigues & Winnington, 2024). In the past nine years, there have been ten articles (Ball

& Gilder, 2022; Barber, 2022; Golda et al., 2019; Ilce et al., 2017; Lotfi et al., 2022; Michaelis et al., 2020; Moon et al., 2021; Rodrigues & Winnington, 2024; Soysal et al., 2023; Vortman et al., 2021) that have begun to advance a conceptualization of aspects of surgical smoke exposure such as awareness, coping, mitigating, protecting, and changes in practice and policy.

Specifically, this study contributes to how the phenomenon of the experience of surgical smoke is conceptualized through the construction of a conceptual model. Previous studies in the literature referenced in the scoping review for this study used a theory or model a priori whereas this study relied on constructivist grounded theory methods which provided data that was grounded in actual experience. The findings are different from other studies because of this methodological approach. The results are foundational which gives a truer understanding of experience around this particular exposure. This study brings new and different information than previously documented in the literature around surgical smoke exposure.

Some unique data of this study are the various roles and how they perceive their experience. This is useful to target education. Team Dynamics were found to be very rich in details around hierarchy in the operating room and various organizational climates. This information is a "way in" to more deeply understand and develop multidisciplinary ways of communicating around this exposure. How stance can change over time is another novel and useful finding that can help with planning, expectations, and overall dynamic nature of how team members can experience change over the course of their careers in the operating room.

Although there has been some coherence with existing literature, notably Barber et al. (2022), to go beyond the issue and explore knowledge, perceptions, and attitudes to surgical smoke, this study provides a conceptual model that future researchers can use to further explore and deepen other dimensions of this exposure. My study has shown that the term *experience* is

not expansive enough to encompass or fully describe the actual experience of surgical smoke, as found in this study. This dissertation research has compelling and powerful data that constructed a theoretical framework around the central concept of stance. These findings contribute a more nuanced understanding and new way of thinking about the experience of surgical smoke: *stance*.

Chinn & Kramer (2018) articulate how this dissertation research was accomplished when they state an assumption of the science of nursing "…that an objective reality exists, and that truths about it can be understood through inferences based on observations and understandings that are verifiable or confirmable by other observers" (p. 11). Although the research methods were qualitative, the empirical qualities of the nature and structure of data collection and analysis and co-construction of the interview process exemplify the truth in this data. Additionally, two analysts were engaged in the process, adding reliability to codes and conceptual development. Others who read this dissertation research may be inclined to agree, or disagree, on the objective truth of stance as a conceptualization of the experience of surgical smoke.

The challenge ahead lies with educating perioperative teams about the latest research and recommended practices. Five team members, all with different roles, shared when and where they learned about surgical smoke. It was clear that all roles lack education about surgical smoke, what is recommended to mitigate exposure, and what is known and not known in the scientific body of literature. The caveat here is that the literature contains "evidence" that is not methodologically strong and remains heterogeneous due to the many ways it has been measured and compared in various types of cases in various settings around the world. Examples of ways to consider educating perioperative teams include, but are not limited to, standardized information tailored to various roles, mandatory annual updates in the workplace, and annual testing that incorporates the latest evidence-based practices around surgical smoke exposure.

To date, and to the best of my knowledge, no universal industrial hygiene standard (Lewis & Schick, 2022) has been adopted that ensures rigor and accuracy in capturing the contaminants in surgical smoke. Many variables must be considered such as case type; operator style and usage of cautery; heating, ventilation, and air conditioning systems; architectural design; and tissue type. The current body of literature reports so much variety with these and other variables that it is difficult for perioperative teams to agree on what is harmful in exposure to surgical smoke. The mAQP scale could be expanded, ultimately creating new tools for education, and targeted, role-based interventions. These tools could also guide policy. Adding different questions to the mAQP based on the four divergent dimensions (Knowledge & Beliefs, Personal Impressions, Team Dynamics, and Past Experience) would allow for a greater understanding of how teams use what they know to inform the experience of surgical smoke. Understanding what may at times be in the unconscious or distant memory may be the key to unlocking and shifting current behaviors and beliefs around exposure to surgical smoke.

This study also reveals misconceptions about Bovie smoke. Such misconceptions may be due in part to the inconclusiveness of the causal effects of surgical smoke and types of outcomes that can range from symptoms to full-blown diseases. These cases are extremely difficult to prove. Although there is a known causal link between exposure to other types of smoke such as cigarette smoke or wildfire smoke, the link between exposure to surgical smoke and exacerbation of respiratory and cardiovascular symptoms and certain types of cancer has not been proved. Yet, direct evidence is not needed to recommend mitigation and protection. Although the mAQP scale captured many important aspects of the surgical smoke experience, different questions could be added, becoming tools, for further education, research, and policy development.

Implications for Future Research

The merging of qualitative and quantitative data clearly demonstrates the need for a more nuanced and robust understanding of the dimensions of Awareness, Symptoms, Meaning and Behavioral Responses. For the Awareness Dimension, other senses such as hearing and taste could be added to the mAQP scale and a question that elicits where a person is on the continuum of awareness. Knowing this would enable future policy changes at both the sterile field and regulatory level to be meaningful and impactful. Of note, the qualitative data in this study (QUAL + quan) not only was the larger and more in-depth strand of data but also was analyzed before the quantitative data. It was clear early on during the analysis that the Awareness Dimension described a continuum (see Figure 4.2) of the participants' experience. Because mean is an indicator of central tendency and is of interest in mixed methods, it was interesting to see how the distribution mirrored an early finding in the Awareness Dimension.

Early on during data collection and analysis, "being aware" began to show up as a vast range of experiences, as described in the interviews. Once quantitative data analysis began, after completion of the interviews, responses to Questions 7-20 on the mAQP scale attributed to the Awareness Dimension (see Table 4.3) had the highest means and the strongest convergence of the four dimensions on the scale that the qualitative data captured. This is an example of clear convergence. It also affords a future study the opportunity to further describe and define how the dimension of awareness develops. The findings from a future study like this could guide and inform future strategies and policies to reduce harmful exposures.

The mAQP scale could be renamed the Operating Room Air Quality Perception scale or the Perioperative Team Members Air Quality Perception scale, which would reflect the human element and diversity of team members versus the type of room where surgical cases are

performed. A more prescriptive and specific name could be the Surgical Smoke Perception scale, but this sounds like other acronyms in use at this time. With any name change, the continuity of the original name, AQP scale, and its modification for this dissertation research (mAQP scale), is lost. On another note, it is an entirely new and data-based way to examine how perioperative teams experience surgical smoke, so it has perhaps earned a new title. Rigor is evident in the content of the questions based on the convergence and divergence of the two types of data during the merge phase of analysis in this mixed methods study.

A note on the mAQP scale. This has been a good bridge between how outdoor air quality has been measured by citizens and the modifications I made that aligned conceptually and was renamed the mAQP scale for this study. Too long of a scale can be tedious, although most participants in this study completed their survey within 1-2 minutes, largely due to contents and design, optimizing user compatibility. Proposal of a new scale may now emerge from this dissertation research, it should not exceed 40 questions, although the final number must align with the qualitative findings of where the divergence was noted between the two types of data. The advantages of adding questions from the missing dimensions and using it in future studies will further validate the scale and lead to new findings which would further guide interventions.

Replicating this study elsewhere is one way to expand the conceptualization of the surgical smoke experience of stance. It is, however, a time-consuming endeavor, requiring at least two analysts. Another important reason to replicate this study is that most environmental contaminants, work related or elsewhere, are respirable (OSHA, 2017). The AQP scale has already been applied to Thai workers in a silica mine to better understand their experiences, attitudes, and behaviors on the job (Thongtip et. al., 2020). This scale was developed in France to better understand how French citizens perceive outdoor air quality as a way to improve quality of

life (Deguen, 2008). The original AQP was validated conceptually and modifying it from outdoor to indoor air pollution was a useful starting point to conceptualize the experience of surgical smoke in the operating room. Further modifications of the instrument, based on this study's qualitative findings, are timely, and other modifications could be useful in the light of climate change.

The experience of the hazardous exposure to surgical smoke in the operating room is more nuanced than previously known. The effects of smoke of any kind are known to cause harm to the human body. The range of experience is unique to every participant, therefore a range of approaches, such as various modalities of communication, need to be put in place for all those who are considering and who already work in the operating room. Describing and measuring the experience of surgical smoke now has constructed a conceptual foundation. Moving forward, having this foundation invites other studies to corroborate the findings and applications to other types of respirable air pollution.

It is essential to ensure that the field of *giving* health is healthy, too. The practice of using electrocautery for surgical hemostasis and tissue dissection needs to evolve after over 100 years of use. Having the findings of this research may not only be a bridge between surgical smoke and all smoke, but also the bridge between not only health for the patient in the form of surgical intervention, but for the perioperative team members as well. There is an opportunity to impact the way we understand, think, and act around surgical smoke that goes beyond what we know, what is recommended, and allows for new ways of thinking about surgical smoke. This new thinking is the catalyst for change and innovation.

Policy is the main vehicle to ensure that the health and well-being of the perioperative team is protected while they are giving care to others. Investing in research and development for

new technology that will drive this is essential. Having a stance on surgical smoke may impact how perioperative teams are feeling about their work, their health, and their job choice overall. This may contribute to fear, overwhelm, and burnout. Some of these may be unconscious and this could possibly lead to an unsafe work environment, with potential for error amongst the team members. It could then lead to distraction, and adverse outcomes for the patient.

The vigilance with which perioperative teams protect the sterile field should also be the vigilance with which they protect their own health and the health of team members. Being *conscious* perioperative team members is necessary for not only the protection of the self, but the system as a whole. The data speaks for itself. Many *are* concerned in deep ways, even if they are not as "sensitive" or noticing the smoke. Due to the global impacts of climate change, many are now experiencing raised awareness — even if not consciously connecting the surgical smoke to all smoke.

Conclusion

As a result of the global shift in climate, the increase of events like wildfires, communicable diseases, and events like the COVID-19 pandemic, there will be opportunities to create meaningful and relevant practices and policies for health and well-being. Understanding how people perceive and experience risk, especially as it relates to air quality, would enable policy makers and employers to create informed and useful policies and implementation strategies that protect citizens and workers, respectively. The timing to conduct more studies like this dissertation research is optimal because many people now understand what particulate matter is and how harmful it can be one's health. Understanding stance on the individual (role) and collective (team) levels allows for targeted education and informs effective and realistic policy development and implementation to ensure this hazardous exposure continue to be mitigated.

Based on what we know about smoke, the hazards and harm to the human body are clear (So et al., 2022). This dissertation research built a conceptual bridge between what is known about smoke in general and surgical smoke. Now more than ever, people understand the importance of breathing clean air. In 2018, the World Health Organization held the first Global Conference on Air Pollution and Health in Geneva, Switzerland. This took place just a few weeks after I spent two months there as a health policy intern with the organization's Department of Noncommunicable Diseases on global smoking cessation interventions. The team was fascinated with surgical smoke exposure. We all saw correlations and shared concerns. Collaboration with this department and others while at WHO deepened my knowledge and instilled a desire to conduct this mixed methods dissertation research. Complex issues call for complex methods. We all deserve to breathe clean air.

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Appendix A

Statement of Positionality

As a certified, registered perioperative nurse in the operating room, I acknowledge my positionality as a professional who has been working in the operating room environment for the past 21years. Throughout those years, I have been an engaged member of my professional association, the Association for periOperative Registered Nurses, AORN, and have served at the local, state, national, and global levels. I am an advocate for my patients and colleagues, that we may practice in a safe working environment, using our local policies and procedures, while incorporating our knowledge and expertise around the Recommended Practices of AORN (AORN, 2024), using the Guidelines (AORN, 2024), and relying on communication, collaboration, and commitment to safe practices of the art and science of professional nursing.

As a perioperative registered nurse, I am aware of the physical effects that breathing surgical smoke can have on one's body and mind. With that said, I believe that breathing smoky, contaminated air that contains particulate matter, known toxic gaseous air that is also laden with bioburden, should be avoided whenever possible. Multiple studies have documented the untoward contents of the smoke which contains known carcinogens and mutagens. I am now performing my role at the highest level, as a burgeoning nurse scientist and doctoral candidate at the University of California, San Francisco School of Nursing.

My hope is that this mixed methods dissertation research using grounded theory will build a stronger case than other studies have to date in order that we may better understand, through the formulation of a framework, theory, or model, a body of knowledge that is able to advance the field of perioperative nursing and occupational and environmental health in the operating room to a new level. The end result I hope for is this: that this dissertation research may lead to policy that is grounded in experiential data that will ultimately lead to articulating new solutions and best outcomes towards a safe and healthy operating room environment for all.

Merideth D. Lewis

July 31, 2024

Marin County, U. S.

Appendix B

PRISMA ScR Scoping Review Checklist

Table. PRISMA-ScR Checklist

Section	Item	PRISMA-ScR Checklist Item
Title	1	Identify the report as a scoping review.
Abstract		
Structured summary	2	Provide a structured summary that includes (as applicable) background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.
Introduction		
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.
Methods		
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).
Summary measures	13	Not applicable for scoping reviews.
Synthesis of results	14	Describe the methods of handling and summarizing the data that were charted.
Risk of bias across studies	15	Not applicable for scoping reviews.
Additional analyses	16	Not applicable for scoping reviews.
Results		
Selection of sources of evidence	17	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.
Characteristics of sources of evidence	18	For each source of evidence, present characteristics for which data were charted and provide the citations.
Critical appraisal within sources of evidence	19	If done, present data on critical appraisal of included sources of evidence (see item 12).
Results of individual sources of evidence	20	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.
Synthesis of results	21	Summarize and/or present the charting results as they relate to the review questions and objectives.
Risk of bias across studies	22	Not applicable for scoping reviews.
Additional analyses	23	Not applicable for scoping reviews.
Discussion		
Summary of evidence	24	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.
Limitations	25	Discuss the limitations of the scoping review process.
Conclusions	26	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.
Funding	27	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy documents).

Appendix C

Database Search Strategy Tables

PubMed The searches were completed on March 18, 2024 No date limits were applied		
#	**Search Syntax**	# of Articles
1	(“perioperative nurse*” OR "Perioperative Nursing"[Mesh] OR “perioperative nursing” OR “perioperative personnel” OR “surgical nurse*” OR “operating room nurse*” OR "Operating Room Nursing"[Mesh] OR “operating room nursing” OR nurses OR "Nurses"[Mesh] OR surgeons OR "Surgeons"[Mesh] OR “surgical team” OR “surgical personnel” OR “scrub tech” OR “scrub technician” OR "Operating Room Technicians"[Mesh] OR “operating room technicians” OR “scrub nurse” OR anesthesiologist* OR "Anesthesiologists"[Mesh] OR “operating room*” OR "Operating Rooms"[Mesh]) AND (“surgical smoke” OR “cautery smoke” OR “surgical plume” OR “diathermy plume” OR “diathermy smoke” OR “Smoke/adverse effects”[Mesh] OR “indoor air pollution” OR “indoor air pollutants” OR “occupational air pollution” OR “occupational air pollutants” OR ("Air Pollutants"[Mesh] AND (indoor OR occupational))) AND (“lived experience” OR burnout OR "Burnout, Professional"[Mesh] OR attrition OR “intent to leave” OR “adverse effects” OR "adverse effects" [Subheading] OR “adverse event*” OR headache OR "Headache"[Mesh] OR nausea OR "Nausea"[Mesh] OR vomiting OR "Vomiting"[Mesh] OR fatigue OR "Fatigue"[Mesh] OR “physical symptoms” OR "Signs and Symptoms"[Mesh] OR “signs and symptoms” OR hazards OR attitude OR "Attitude"[Mesh] OR hoarseness OR "Hoarseness"[Mesh] OR cough OR "Cough"[Mesh] OR stress OR “Stress, Psychological”[Mesh] OR "Stress, Physiological"[Mesh] OR “job stress” OR "Occupational Stress"[mesh] OR "occupational stress" OR “well being” OR wellbeing OR resilience OR "Resilience, Psychological"[Mesh] OR "Depression"[mesh] OR depression OR "Personal Satisfaction"[mesh] OR "personal satisfaction" OR "Work-Life Balance"[mesh] OR "work-life balance" OR flourishing OR thriving OR "Mindfulness"[Mesh] OR mindfulness OR "workplace support" OR "workplace control" OR "personal accomplishment" OR "Achievement"[Mesh] OR achievement OR grit OR distress	**883**

	OR "Depersonalization"[Mesh] OR depersonalization OR "Suicidal Ideation"[Mesh] OR "suicidal ideation" OR suicidality OR "Anxiety"[Mesh] OR anxiety OR "leave of absence" OR "Sick Leave"[Mesh] OR "sick leave" OR "personal time off" OR "reduced work hours" OR "reduced hours" OR absenteeism OR presenteeism OR absences OR efficiency OR "Efficiency"[Mesh] OR productivity)	

Web of Science The searches were completed on March 18, 2024 No date limits were applied		
#	**Search Syntax**	# of Articles
1	(“perioperative nurse*” OR “perioperative nursing” OR “perioperative personnel” OR “surgical nurse*” OR “operating room nurse*” OR "operating room nursing" OR nurses OR surgeons OR “surgical team” OR “surgical personnel” OR “scrub tech” OR “scrub technician” OR “operating room technicians” OR “scrub nurse” OR anesthesiologist* OR “operating room*”) AND (“surgical smoke” OR “cautery smoke” OR “surgical plume” OR “diathermy plume” OR “diathermy smoke” OR (smoke AND ”adverse effects”) OR “indoor air pollution” OR “indoor air pollutants” OR “occupational air pollution” OR “occupational air pollutants”) AND (“lived experience” OR burnout OR attrition OR “intent to leave” OR “adverse effects” OR “adverse event*” OR headache OR nausea OR vomiting OR fatigue OR “physical symptoms” OR “signs and symptoms” OR hazards OR attitude OR hoarseness OR cough OR stress OR “psychological stress” OR “physiological stress” OR “job stress” OR “well being” OR wellbeing OR resilience OR depression OR "personal satisfaction" OR "work-life balance" OR flourishing OR thriving OR mindfulness OR "workplace support" OR "workplace control" OR "personal accomplishment" OR achievement OR grit OR distress OR depersonalization OR "suicidal ideation" OR suicidality OR anxiety OR "leave of absence" OR "sick leave" OR "personal time off" OR "reduced work hours" OR "reduced hours" OR absenteeism OR presenteeism OR absences OR efficiency OR productivity)	**547**

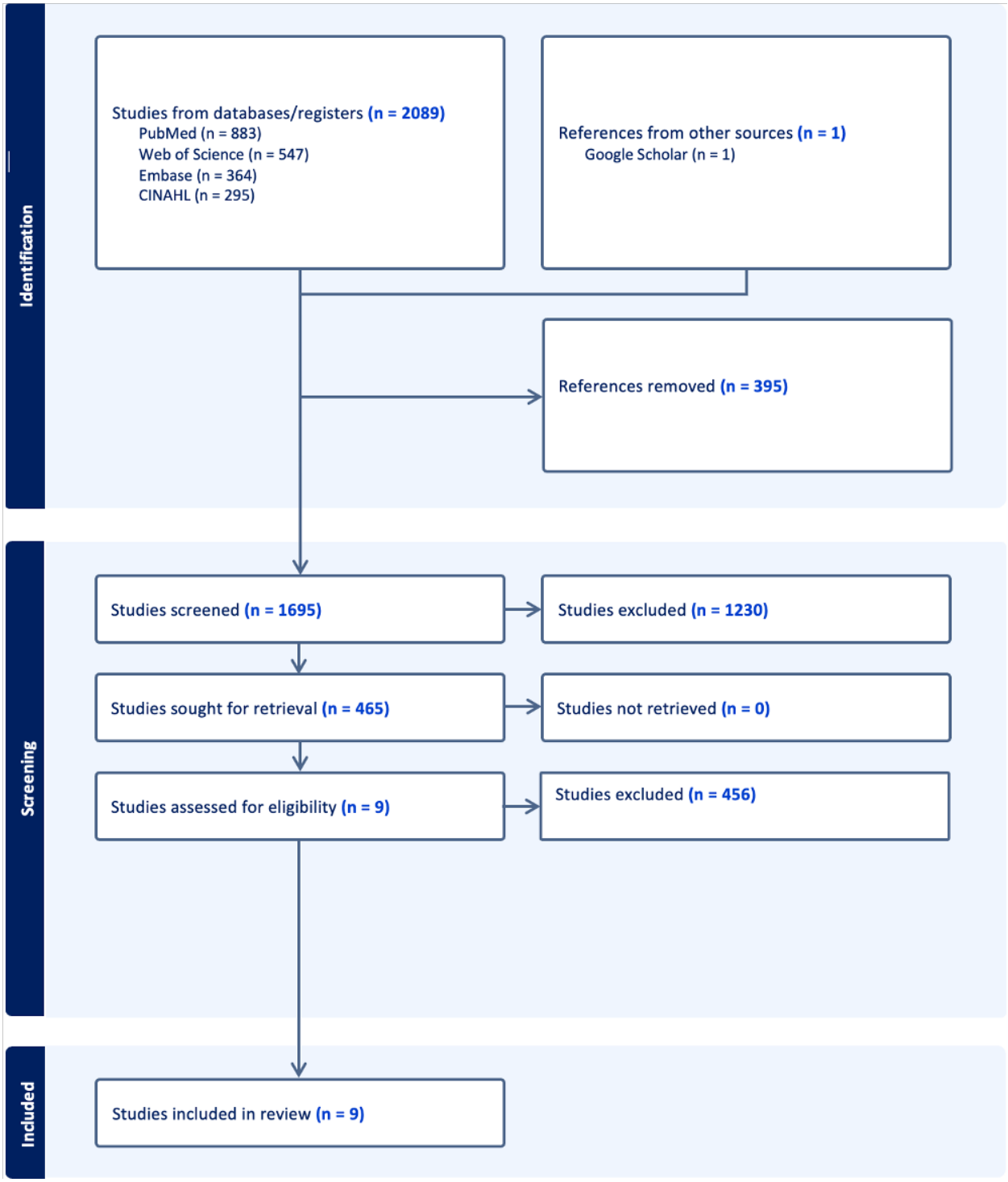
Embase The searches were completed on March 18, 2024 No date limits were applied		
#	**Search Syntax**	# of Articles
1	('perioperative nurse' OR 'perioperative nursing'/exp OR 'perioperative nursing' OR 'perioperative personnel' OR 'surgical nurse'/exp OR 'surgical nurse' OR 'operating room nurse'/exp OR 'operating room nurse' OR 'operating room nursing'/exp OR 'operating room nursing' OR 'nurses'/exp OR nurses OR 'surgeons'/exp OR surgeons OR 'surgical team'/exp OR 'surgical team' OR 'surgical personnel' OR 'scrub tech' OR 'scrub technician' OR 'operating room technicians'/exp OR 'operating room technicians' OR 'scrub nurse'/exp OR 'scrub nurse' OR 'anesthesiologist'/exp OR anesthesiologist OR 'operating room*') AND ('surgical smoke'/exp OR 'surgical smoke' OR 'cautery smoke' OR 'surgical plume' OR 'diathermy plume' OR 'diathermy smoke' OR (('smoke'/exp OR smoke) AND ('adverse effects'/exp OR 'adverse effects')) OR 'indoor air pollution'/exp OR 'indoor air pollution' OR 'indoor air pollutants' OR 'occupational air pollution' OR 'occupational air pollutants') AND ('lived experience'/exp OR 'lived experience' OR 'burnout'/exp OR burnout OR 'attrition'/exp OR attrition OR 'intent to leave' OR 'adverse effects'/exp OR 'adverse effects' OR 'adverse event'/exp OR 'adverse event' OR 'headache'/exp OR headache OR 'nausea'/exp OR nausea OR 'vomiting'/exp OR vomiting OR 'fatigue'/exp OR fatigue OR 'physical symptoms' OR 'signs and symptoms'/exp OR 'signs and symptoms' OR hazards OR 'attitude'/exp OR attitude OR 'hoarseness'/exp OR hoarseness OR 'cough'/exp OR cough OR 'stress'/exp OR stress OR 'mental stress'/exp OR 'mental stress' OR 'physiological stress'/exp OR 'physiological stress' OR 'job stress'/exp OR 'job stress' OR 'well being'/exp OR 'well being' OR 'wellbeing'/exp OR wellbeing OR 'psychological resilience'/exp OR 'psychological resilience' OR 'depression'/exp OR depression OR 'satisfaction'/exp OR satisfaction OR 'work-life balance'/exp OR 'work-life balance' OR 'flourishing'/exp OR flourishing OR thriving OR 'mindfulness'/exp OR mindfulness OR 'workplace support' OR 'workplace control' OR 'personal accomplishment'/exp OR 'personal accomplishment' OR 'achievement'/exp OR achievement OR 'grit'/exp OR grit OR 'distress'/exp OR distress OR 'distress syndrome'/exp OR 'distress syndrome' OR 'depersonalization'/exp OR depersonalization OR 'suicidal ideation'/exp OR 'suicidal	**364**

	ideation' OR 'suicidality'/exp OR suicidality OR 'anxiety'/exp OR anxiety OR 'leave of absence' OR 'sick leave'/exp OR 'sick leave' OR 'personal time off' OR 'reduced work hours' OR 'reduced hours' OR 'absenteeism'/exp OR absenteeism OR 'presenteeism'/exp OR presenteeism OR absences OR 'efficiency'/exp OR efficiency OR 'productivity'/exp OR productivity)	

CINAHL **The searches were completed on March 18, 2024** **No date limits were applied**		
#	**Search Syntax**	# of Articles
1	(“perioperative nurse*” OR “perioperative nursing” OR “perioperative personnel” OR “surgical nurse*” OR “operating room nurse*” OR "operating room nursing" OR nurses OR surgeons OR “surgical team” OR “surgical personnel” OR “scrub tech” OR “scrub technician” OR “operating room technicians” OR “scrub nurse” OR anesthesiologist* OR “operating room*”) AND (“surgical smoke” OR “cautery smoke” OR “surgical plume” OR “diathermy plume” OR “diathermy smoke” OR (smoke AND ”adverse effects”) OR “indoor air pollution” OR “indoor air pollutants” OR “occupational air pollution” OR “occupational air pollutants”) AND (“lived experience” OR burnout OR attrition OR “intent to leave” OR “adverse effects” OR “adverse event*” OR headache OR nausea OR vomiting OR fatigue OR “physical symptoms” OR “signs and symptoms” OR hazards OR attitude OR hoarseness OR cough OR stress OR “psychological stress” OR “physiological stress” OR “job stress” OR “well being” OR wellbeing OR resilience OR depression OR "personal satisfaction" OR "work-life balance" OR flourishing OR thriving OR mindfulness OR "workplace support" OR "workplace control" OR "personal accomplishment" OR achievement OR grit OR distress OR depersonalization OR "suicidal ideation" OR suicidality OR anxiety OR "leave of absence" OR "sick leave" OR "personal time off" OR "reduced work hours" OR "reduced hours" OR absenteeism OR presenteeism OR absences OR efficiency OR productivity)	295

Appendix D

Prisma Flow Chart



Appendix E

Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
Ball, K., & Gilder, R. E. (2021). A Mixed Method Survey on the Impact of Exposure to Surgical Smoke on Perioperative Nurses. *Perioperative Care and Operating Room Management*, *26*, 100232.	To identify perioperative nurses' experiences, including symptoms, identified as related to surgical smoke' identify other factors related to their experiences; and to identify expressions used to describe concerns with Surgical smoke.	"Mixed Methods qualitatively descriptive, quantitatively explanatory," exploratory study using a 61-imultiple-choice items online survey	A convenience sample of N=1304 perioperative nurses' members of AORN **Setting: United States**	Frequency distribution of symptoms reported, creation of a dependent variable through the creation of a score based on aggregation of symptoms. A non-parametric predictive mathematical modeling method, chi-square-automatic-interaction-detection to identify associations between the reported symptom score (dependent variable) and other factors of interest (independent variable) One "write in" qualitative question analyzed with NVIVO	Participants reported an average of 2.38 symptoms, with 28% reporting 4 or more symptoms. Higher report of symptoms was associated with exposure to surgical smoke, absenteeism due to exposure to SS, having read articles about SS exacerbation of pre-existing symptoms due to SS< and being told a symptom is related to OR work. Nurses' narrative centered on concerns over long term exposure, exacerbation of symptoms, and some reports of evacuation systems implemented during COVID19 pandemic.
Barber, L., Lane, R., Holmes, L., Murray, N., & Hamill, J. K. (2022). Surgical smoke: how an issue in healthcare fits a planetary health framework. *The New Zealand Medical Journal (Online)*, *135*(1560), 18-36.	To discover thoughts & ideas on surgical smoke issues and policies; to formulate ideas for environmentally & socially responsible solutions	**Cohort Survey - email** REDCap online survey on perceived risks, current exposure & measures to minimize exposure 23 questions with a section to provide more information	Perioperative nurses, anesthesia techs, anaethestists, and surgeons – in children's hospital in N. Z. N=462 for survey; 160 (35%) wrote in free text response	Quantitative data– exposure converted to ordinal factor, perceived risk used & support for smoke-free policy used linear model Qual – reflexive thematic analysis with constructivist theoretical framework	Support for a smoke-free policy was positively correlated with the perceived risk of electrocautery smoke Themes developed around nature, society & technology Framework was developed around themes

Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
		1 free-text question on how to address surgical smoke	38% response rate (highest response rate from anesthetists) 89% support smoke-free policy **Setting: New Zealand**	Reflexive thematic analysis for the qualitative data Coding & theme review Then merged with Planetary Health Framework	
Golda, N., Merrill, B., & Neill, B. (2019). Intraoperative electrosurgical smoke during outpatient surgery: a survey of dermatologic surgeon and staff preferences. *Cutis*, *104*(2), 120-4.	Evaluate perceptions on SS & how information on the potential harm of SS changes perceptions	Survey [mail type not specified] REDCap survey 17 questions with a section for open comments	N=437 members of the American Society of Dermatological Surgeons MOHS N=402 surgeons N=35 staff members [no significant difference in responses between surgeons & staff] **Setting: United States**	Pre-post, statistical analysis of preintervention responses using proportions and CI estimates Bhapkar test for marginal homogeneity used to assess if information changed responses Free text assessed for themes SAS v. 9	Pre SS risk information results: 64.5% never or very rarely used smoke evacuation 19.5% used it nearly every case 54.4% noticed smoke during procedures 35.5% bothered or troubled by the smell The degree of noticing smoke strongly correlated with smoke evacuation Post SS risk information results: Once they had the information, they were more willing to use evacuation, noticed the smell more frequently and were bothered by it. The information did not change their work satisfaction or show any differences between the roles of physician &staff

Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
					"Information may affect perceptions & smoke may be harmful" "More research needed to determine health effects of SS & how best to limit risks" highlighted concern about cost & regulatory challenges since "risks are not settled in science"
Ilce, A., Yuzden, G. E., & Yavuz van Giersbergen, M. (2017). The examination of 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.	To research the problems (symptoms) experienced with SS & precautions that need to be taken	"Descriptive Research Design" Completed instrument "Data Collection Form of Surgical Smoke Risks and Precautions" Two parts, demographic & symptoms, use of smoke evacuation tools, and hospital protocol on SS	University hospital Turkey N=81 N=36 doctors & 45 nurses (scrub & circulating roles) 51.9% male 48.1% female **Setting: Turkey**	SPSS descriptive statistical analysis	Problems for nurses & doctors from exposure to SS: headache, watery eyes, cough, sore throat, hair odor, nausea, drowsiness, dizziness, sneezing & rhinitis along with other respiratory, cardiovascular, and neurological issues including nasopharyngeal lesion 91.1% of nurses used surgical masks 86.1% of doctors used surgical masks to protect themselves from smoke
Lotfi, M., Zamanzadeh, V., Aghazadeh, A., Khordeforoush, H., & Rahmani, P. (2022). Attitude, preventive practice and perceived barriers among perioperative and anesthesia nurses toward surgical smoke hazards during the COVID-19 outbreak. *Perioperative Care and Operating*	To determine attitude, preventive practice, and perceived barriers among periop & anesthesia RNs of SS hazards	Cross-Sectional Descriptive study using a 17-item questionnaire on attitude, practice, and barriers around SS	Nurses (2 groups – perioperative & anesthesia nurses) in Iran Tabriz University N=262 Stratified random sample **Setting: Iran**	SPSS16 – descriptive statistical analysis Direct relationship between attitude & practice scores	Direct and significant relationship between attitude and practice scores Main barriers to prevention & dealing with hazards of SS in ORs were reported in management and equipment barriers Recommendations: Adopt strategies for prevention of SS hazards by strengthening knowledge, attitude & practice as well as equipment and

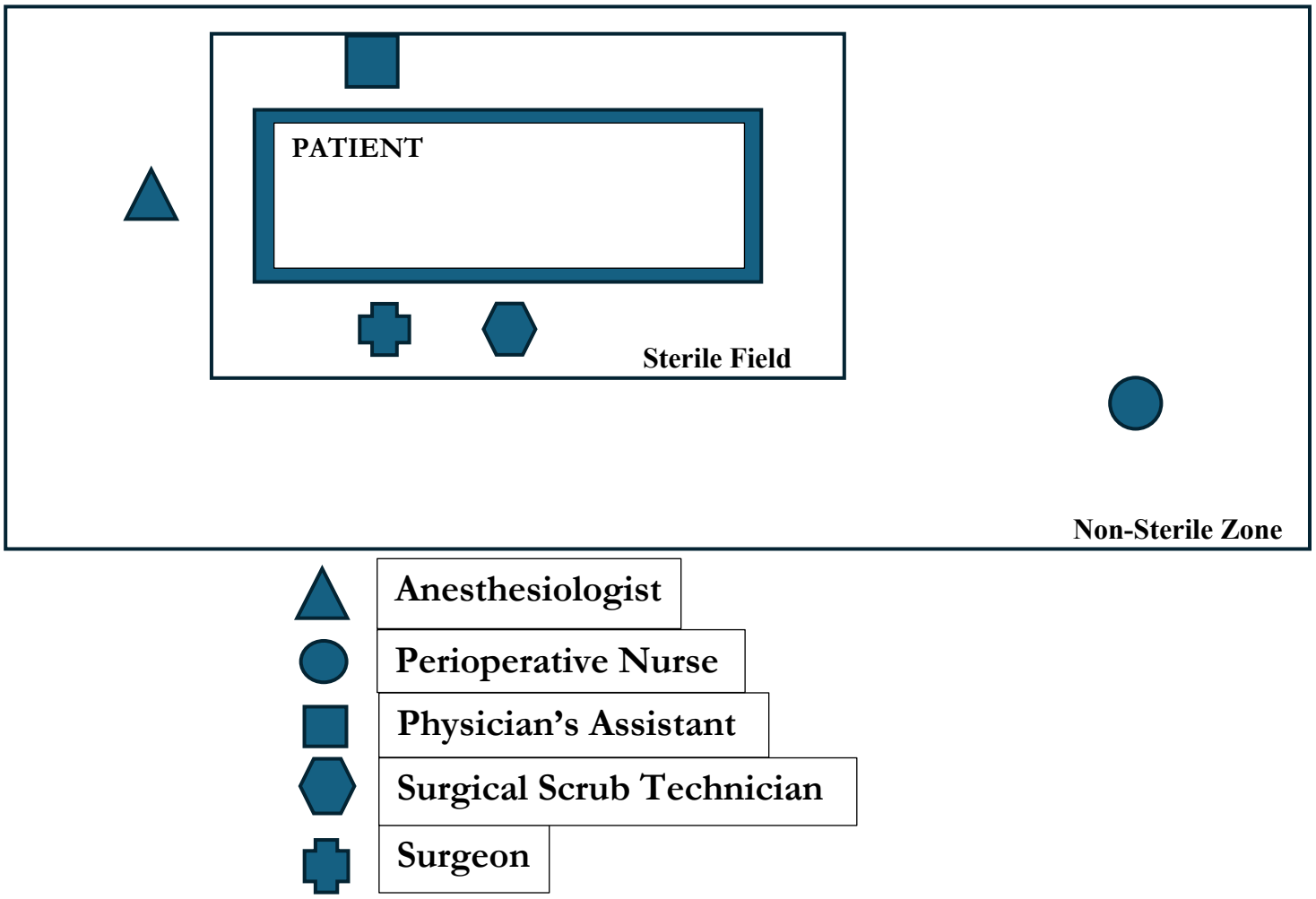
Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
Room Management, *26*, 100234.					support of managers to implement SS evacuation
Michaelis, M., Hofmann, F. M., Nienhaus, A., & Eickmann, U. (2020). Surgical smoke—hazard perceptions and protective measures in German operating rooms. *International journal of environmental research and public health*, *17*(2), 515.	Knowledge & attitudes SS Systematically evaluate the state of SS protection in Germany with insight of knowledge & attitudes	Questionnaire Mixed Methods - embedded	Surgeons 5% response rate (rr) Surgical Scrub Techs 65% rr Inpatient & Outpatient surgery settings 12 industrial interviewees **Setting: Germany**	Survey questions – descriptive statistics	50% of the surgeons in hospitals & 70% in outpatient settings "mostly" or "always" paid attention to avoiding SS v. 88% of OR Nurses were more often concerned. Top reason for non-compliance=lack of problem awareness or thoughtlessness 12 industrial interviewees confirmed practice gaps with evacuation with slow development in growth on SS evacuation Low rr indicates major lack of interest & knowledge so do team interventions & advanced trainings
Moon, H. N., Park, B. H., & Chang, S. O. (2021). Operating room nurses' perceptions of the impact of surgical smoke and its countermeasures: A mixed-methods study. *Nursing & Health Sciences*, *23*(4), 898-907.	Explore perceptions of SS & countermeasures	Mixed Methods Qualitatively driven Focus groups & descriptive survey in 2 phases 1. Focus groups – used to develop survey 2. Descriptive survey	N=12 female OR nurses in Republic of Korea for interviews – all female *N=94 OR nurses in 2 hospitals in South Korea for survey – only 2 male* **Setting: Republic of Korea**	Focus groups & descriptive survey with 5 main themes, 12 subthemes *SPSS questionnaire on 13 SS countermeasures* IPA & IPFA to analyze before and after based on information given about surgical smoke	Focus Group results: Theme 1: concern for future health, unaware of risks, felt exposed involuntarily, danger not recognized by hospital administrators; Theme 2: Belief to avoid smoke, be safe, prioritize & collaborate for policies, and recognize this as a problem. Had been unaware of potential hazards Wear PPE & Establish policies for safety Narrative results

Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
Soysal, G. E., Ilce, A., Lakestani, S., Sit, M., & Avcioglu, F. (2023). Comparison of the effects of surgical smoke on the air quality and on the physical symptoms of operating room staff. *Biological Research for Nursing*, *25*(3), 444-453.	Determine effect of surgical smoke on indoor air quality by examining physical symptoms in the operating room with a control group	CLINICAL TRIAL Repeated Measures & Case Control 2 Phases: 1. Repeated Measures – air samples taken before, during & after surgery 2. Case-Control – questionnaire & throat cultures taken before & after surgery; compared with sample on another unit	N=19 study group – surgeons, assistants, anesthesiologist, nurses & assistant staff – 52% female N=20 control group – random stratified sample who had never worked in an operating room **Setting: Turkey**	Descriptive statistical evaluation of coded responses & WHO's standard of Total Volume Organic Compounds (TVOC) levels were evaluated using industrial hygiene equipment & standards	Total VOC value was higher during surgery, benzene remained high throughout surgery, exceeding limit values. Other VOCs were love and stayed low throughout surgery. Physical symptoms ↑ during the operation – tearing & burning of eyes, hair odor, nausea & cough "Surgical smoke was an important contaminant"
Vortman, R., McPherson, S., & Cecilia Wendler, M. (2021). State of the Science: A Concept Analysis of Surgical Smoke. *AORN journal*, *113*(1), 41-51.	To determine expert consensus of perioperative nurses' exposure to SS, mitigation practices & health concerns	Delphi Technique 2 rounds, round 1 with experts; confirmed with larger group of perioperative nurses	Round 1 - N=14 expert perioperative nurses Round 2 – N=167 perioperative nurses **Setting: United States**	Round 1 = consensus of 60% established 11 themes emerged: lack of knowledge, surgical team members' health risks, personal short-term health risks, personal long-term health risks, barriers created by facility, barriers from surgeons, lack of institutional policy, lack of statewide or nationwide policy, lack of availability, and usability of devices Round 2 = Likert Scale consensus of 60% established – top four themes: personal long-term health risk, surgical	Consensus=surgical smoke is a major concern, their own long-term health as well as their colleagues' Informed a need for collaborative mitigation strategies to reduce exposure to SS

Citation	**Aims**	**Design & Methodology**	**Sample & Setting**	**Measurement & Analysis**	**Findings** (SS = surgical smoke; OR = operating room)
				team members' health risks, barriers created by surgeons, and lack of statewide or nationwide policy.	

Appendix F

Placement of Perioperative Team Members During a Case



Appendix G

Interview Guide Discussion Prompts

Defining Surgical Smoke

- When you hear the term "surgical smoke", what comes to mind?
- How would you define or describe surgical smoke?
- How do you experience surgical smoke in your operating room?
  PROBE: What is it like when you get that first whiff?
- What are the most common types of cases where you experience it?
  PROBE: Can you take me through a particularly smoky case?

Perceptions & Meaning of Smoke & Surgical Smoke

- What does smoke mean to you? Please feel free use all connotations & associations.
- Do you consider surgical smoke like other types of smoke you've experienced?
  If so, please tell me how.
- Is surgical smoke in a class all by itself? Please explain.

Feelings & Symptoms when exposed to surgical smoke

- Please tell me what it feels like to work in a smoky operating room. Do you notice any particular feelings, sensations, or symptoms?
- How do you feel when someone suggests smoke evacuation?
- Do you actively perceive risk?

Responses to and Evacuation of surgical smoke

- How would you describe the smoke evacuation resources in your operating room?
- Would you say you or people on your team get treated differently because you/they suggest smoke evacuation? PROBE: If so, how?
- Walk me through your use of N95 masks. Tell me about them.

Final Question

- Is there anything else you would like me to know about your views and/or experiences of surgical smoke?

Member Checking for the overarching finding of "Stance"
(Final third of participants)

- I gave the results of finding the conceptual "take" or "personal philosophy" of a "stance" around surgical smoke to participants to see if my findings were resonant with the last third of my participants, asking them "Does this make sense?"; "Is there anything to add to, change, or take away?"; and "Have I got it?"

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05/29/2026
Date