Surgical Smoke Evacuation at the Portland Veterans Affairs Medical Center

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Abstract

Surgical smoke (SS) is generated by various instruments used for surgical procedures and poses many occupational hazards to operating room (OR) personnel. Adverse health consequences result from mutagenic, chemical, and carcinogenic effects of SS, and SS transmits pathogenic biological agents. For this reason, numerous professional and governmental organizations recommend the routine use of surgical smoke evacuation devices (SEDs). The Veteran Administration Portland Health Care System (VA) has 10 ORs and 4 minor procedure rooms that generate a significant amount of SS daily. This quality improvement initiative defined the current state of SS evacuation at the VA and identified perceived barriers to SED use at that institution for the 6-month period from June 1, 2020 through December 31, 2020. Analysis of records showed a minimum overall utilization fraction of 0.235 (23.5%) during this time interval. Key findings from surveys and interviews with operating room personnel include (1) nearly half of operating room nurses and anesthesia providers and 60% of surgeons had no education related to SEDs; (2) despite the fact that more than ¾ of anesthesia providers believed that SS was hazardous -- unlike nurses -- only a small percent (14%) of anesthesia providers regularly suggested that a SED be employed; and (3) barriers to SED use identified by surgeons and non-surgeons were the belief by surgeons that SS evacuation is unnecessary, inconvenience including bulkiness of the capture device, impaired visualization of the surgical field, and loss of haptic feedback.

Keywords: surgical smoke, operating room, occupational hazard, smoke evacuation device, quality improvement, survey

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Problem Description

Surgical smoke (SS) results from the combustion of tissue by electrosurgical units (ESUs), lasers, and ultrasonic scalpels (Ulmer, 2008). While 95% of SS consists of water vapor, the remaining 5% contains volatile organic compounds (VOCs), cells, and cellular debris. This material can transmit pathogenic particulate matter, chemical mutagens and carcinogens, and active biological agents, and thereby represents an occupational hazard to operating room (OR) staff (Georgeson & Lipner, 2018; Limchantra, Fong, & Melstrom, 2019). Smoke evacuation devices (SEDs) designed to remove and filter SS from the OR atmosphere can mitigate OR staff exposure to these hazards. For this reason, the National Institute for Occupational Safety and Health (NIOSH) recommends the routine use of SEDs for effective control of SS (2014).

Despite the accessibility of SEDs and the recommendations of NIOSH and other advisory and regulatory agencies, these devices remain significantly under-utilized nationwide (Edwards & Reiman, 2012). As such, although SEDs are available at the Veteran's Administration Portland Healthcare System (VA) but they may not be uniformly utilized. Defining the specifics of SS production and evacuation at the VA, including reasons associated with SED use or non-use, represents a first step in maximizing the appropriate use of methods to protect OR personnel from the hazards associated with SS plume.

Available Knowledge

Particulate Matter

Several acute and chronic medical problems derive from inhalation, pulmonary deposition, and systemic absorption of particulate matter (PM) (Alp et al., 2006; Limchantra et al., 2019; Okoshi et al., 2014). Animal and human studies demonstrate emphysematous sequelae, asthma, and increased risk of pneumonia from chronic exposure to SS (Gates et al., 2007; Moual et al., 2013). The frequency and severity of these pulmonary responses depend on the PM size. Specifically, smaller particles travel

farther into the airways, with PM < 2 micrometers (um) in maximal diameter depositing in the bronchioles and alveoli, and ultra-fine particulate matter (UFPM; < 0.1 um in maximal diameter) diffusing across the alveolar-capillary membrane. UFPM may then enter the systemic circulation with inflammatory consequences (Brook et al., 2010; Limchantra et al., 2019; Ling, 2009; Liu et al., 2019; Navarro-Meza et al., 2013; Romano et al., 2017). PM size, in turn, relates to the type of pyrolytic device, with ESUs producing the smallest PM, and ultrasonic scalpel devices producing the largest diameter particles. Hence, the risk of distal airway and systemic PM injury may relate to the method of SS generation.

Chemical Toxicity Mutagenicity and Carcinogenicity

Tissue pyrolysis produces 150 - 600 toxic VOCs, depending on the pyrolytic device and the target tissue (Francke et al., 1995; Pierce et al., 2011; Springer, 2007). ESUs generate hydrocarbons, fatty acids, phenols, and nitriles (Liu et al., 2019), and lasers generate, benzene, formaldehyde, acrolein, and polycyclic aromatic hydrocarbons (Limchantra et al., 2019; Sahaf et al., 2007). These VOCs in SS occur with concentrations that are orders of magnitude greater than limits permitted by public regulatory agencies, and inhalation of these compounds reproducibly produces both acute and chronic airway irritation (Choi et al., 2017; Okoshi et al., 2014).

Many VOCs are known mutagens and carcinogens (Liu et al., 2019; Okoshi et al., 2014). This may be particularly problematic for anesthesia providers who are concurrently exposed to the genotoxic effects of anesthetic waste gases (Çakmak et al., 2018). Concentrations of carcinogens in SS frequently exceed the level of comparable carcinogens in secondhand cigarette smoke exposure (Georgesen & Lipner, 2018), but several studies have failed to correlate an increased lung cancer rate with chronic SS exposure (Okoshi et al., 2014, Mellor & Hutchinson, 2013, Gates et al., 2007). No studies have considered the association of SS with other forms of cancer.

Biologic Hazards

In addition to PM and VOC, the transmission of active biologic agents by surgical plume presents a significant occupational hazard for surgical staff. Multiple bacterial pathogens, including *mycobacterium tuberculosis*, have been cultured from SS. Furthermore, intact virions with demonstrable *in vitro* infectivity exist in SS, including poliovirus, hepatitis B virus, and human immunodeficiency virus.

While these latter viruses have not been demonstrated to cause nosocomial disease in humans via plume, SS transmission of human papillomavirus (HPV) produces at least three diseases in operating room personnel including oropharyngeal warts, recurrent laryngeal papillomatosis, and tonsillar cancer (Pollock, 2007 & Okoshi et al., 2014; Calero & Brusis, 2003; Hallmo & Naess, 1991; Rioux et al., 2013). HPV strains have been cultured from the nasal mucosa of operating room personnel exposed to SS with inadequate protection that are serologically identical to the HPV from vaporized patient tissue. HPV-16 positive tonsillar carcinomas have been documented in health care workers with significant occupational exposure to HPV and no other risks for oropharyngeal cancer (Rioux et al., 2013). Similar reports exist for laryngeal papillomatosis (Hallmo & Naess, 1991 & Calero & Brusis, 2003). Predicated on such data, there is a concern for potential transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) via SS in the current viral pandemic (Swerdlow, 2020).

Protective Strategies

Three major strategies exist for protecting operating theatre staff from SS: room ventilation, face masks, and SEDs. The Center for Disease Control (CDC) recommends OR air be exchanged once every four minutes (York & Autry, 2018, & Sehulster et al., 2004). These ventilation condition requirements, however, are inadequate to protect health care workers from the adverse consequences of SS (York & Autry, 2018). Surgical masks provide some protection from PM and biologic agents in SS, although the capacity to do so is limited by their relatively large pore size (Okoshi et al., 2014).

Specifically, standard surgical masks have pore sizes 5-15 um. In contrast, N-95 masks have pore diameters of 0.3 um, and high-efficiency particulate air (HEPA) masks contain pores with 0.1 um diameters (Romano et al., 2017). In comparison, ESU-generated PM size is as small as 0.07 um, and many biological pathogens measure even smaller (Ball, 2001 & Romano et al., 2017). None of these devices routinely filter VOCs (Wambier et al., 2019).

On the other hand, SEDs effectively routinely remove all PM and biological elements from the OR atmosphere. SEDs capture SS with 35-50 cubic feet per minute (CFM) of suction (compared with 5 CFM for wall suction), and thereafter filter plume via HEPA or ultra-low particulate air (ULPA) devices (York & Autry, 2018). The utilization of these filters in concert with activated charcoal provides additional protection against PM, viruses, and importantly VOCs (Choi et al., 2018). In this manner, SEDs may be employed effectively for both open and minimally invasive procedures (Choi et al., 2018).

Rationale

This project was designed to describe recent SED use at the VA and to understand why individuals at the VA choose to use or not use SEDs in the OR. By employing Roger's Innovation of Diffusion Theory, the project attempted to elucidate the underlying reason OR personnel make their decision regarding SEDs. Consisting of five components, Roger's theory describes how each innovation's attributes, the characteristics of the adopters, and the larger sociocultural context influence an individual's adoption of an innovation (Kaminski, 2011). Our hypothesis was that understanding individual decisions regarding the use or non-use of SEDs within the context of the VA would help define the root causes of inconsistent use of these devices among surgical staff at that institution. Surveys administered during this study were designed to elucidate trends related to employment of SEDs in the operating room. Short cycles of data collection, refinement of surveys, and analysis of results followed the Institute for Healthcare Improvement (IHI) Plan-Do-Study-Act (PDSA) framework for this quality improvement (QI) project (IHI, 2020). The PDSA framework allowed the survey to be an iterative process ensuring survey

questions accurately targeted the key staff members in the OR. Additionally, it permitted the formulation of questions focused on thoroughly analyzing personal knowledge and perceptions regarding SS at the VA.

Specific Aims

The specific aims of this study were to define the current state of SED use at the VA and identify barriers related to that use. Because SEDs were only first introduced to the VA in May 2020, the project collected data from June 1, 2020 through December 31, 2020. These findings, as well as information obtained from surveys of OR personnel and from in-person interviews with various OR staff members, suggested methods to maximize the use of SEDs and to protect OR personnel from the acute and chronic hazards associated with SS inhalation.

Methods

Context

The VA is a tertiary care medical center affiliated with Oregon Health and Science University (OHSU) that serves over 95,000 veterans a year in Portland, Oregon (VA Portland Health Care System [VAPORHCS], 2013). The hospital has 10 ORs and 4 procedural suites (VAPORHCS, 2013). Various SS-generating cases are performed regularly, including surgeries in the departments of general, vascular, cardiothoracic, plastic, orthopedics, neurological and gynecologic surgery. The VA first purchased SEDs in May 2020, in part due to concerns related to the coronavirus disease 2019 (COVID-19) pandemic. SEDs had been trialed prior to the purchase date, and the ConMed PlumePen, ConMed Laparoscopic PlumPort, and Stryker Neptune Waste Management System Smoke Evacuator were selected based on that trial. During the study period, operating room staff included 49 OR registered nurses (RNs), 2 surgical scrub technicians (CSTs), 6 minor procedure RNs, and 1 minor procedure licensed practical nurse (LPN); many surgeons had dual practices involving both the VA and OHSU. Anesthesia personnel consisted of 11 certified registered nurse anesthetists (CRNAs) and 19 anesthesiologists. In addition to

career staff, during this 6-month investigation, the VA hosted residents, fellows, undergraduate and graduate learners in the operating rooms.

Intervention

The interventions in this study employed 3 methodologies: survey distribution, staff interviews and utilization record review. The former component consisted of anonymous distribution of Qualtrics encrypted surveys via work email to selected RNs, CSTs, CRNAs, anesthesiologists, and surgeons. The surveys involved 10 questions, which were a combination of Likert-scale questions and multiple-choice questions and took less than 5 minutes to complete -- to optimize survey response rate (Van Mol, 2017).

Utilizing the IHI PDSA methodology, survey distribution occurred over 2 PDSA cycles. The first survey was distributed to select individuals during the initial cycle to test the question validity, clarity, length, and question format. Individuals were selected by the QI team for this initial cycle (see Appendix A) were operating room personnel judged as most likely to give accurate, thorough, and timely feedback. Based on the feedback from these initial respondents, no modifications were made in the survey, and the same survey was distributed via a second PDSA cycle to a broader respondent pool.

The final survey questions are detailed in Appendix E. This second pool consisted of all surgeons, anesthesia providers, surgical technicians, and OR RNs on staff at the VA. PDSA cycle 2 survey distribution occurred between February and March 2021, with three reminder emails were sent during this time frame to improve response rates (Van Mol, 2017) . In addition to the electronic surveys, selected individuals were interviewed to gain more in-depth knowledge of the current thought processes underlying SED use at the VA. Both SED advocates and non-advocates were interviewed. For survey questions, see Appendix I.

Supply utilization reports and case volume reports during the defined review period of June 1, 2020 through December 31, 2020 provided quantitative data that allowed calculation of fractional SED

utilization. Fractional SED utilization is defined as the number of SEDs purchased divided by the number of SS generating cases. This number can be expressed as a percent utilization by multiplying by 100. Surgeon preference cards at the VA do not list SEDs.

A list of operating room procedures completed during the study interval organized by specialty and type of procedure was obtained from the OR Nurse Manager. All non-ophthalmology procedures were counted as SS generating cases, and this number served as the denominator in determining fractional SED utilization. Since not all non-ophthalmology procedures produce significant SS (for example, knee arthroscopies), the fraction SED utilization derived using this denominator represents a lower limit (rather than a precise estimate) of SED use.

The corresponding numerator was determined using purchase data that was collected from the Inventory Management Specialist. All SED single-patient components at the VA are purchased in a one-to-one fashion after use i.e., each time a single-patient SED component is used a new one is purchased. Therefore, the number of single-patient SED components purchased during the study interval is precisely equal to the number of SEDs utilized, and this figure serves as the numerator in calculating fractional SED utilization. Similar calculations were performed separately for laparoscopic and non-laparoscopic ("open") procedures during the 6-month study interval.

Measures

The study considered outcome measures, process measures, and balancing measures. IHI outcome measures were derived from the project's specific aims, with the primary quantitative outcome measure being the overall utilization of SEDs in the VA ORs during the study time interval, and other outcome measures being a description of other parameters related to SED use. The process measures were activities the team undertook to delineate the outcomes, including surveys, interviews, and record review. Balancing measures monitored any influence that may have altered results (confounding variables) and included survey burden, viral pandemic effect, and the influence of an ongoing study on individuals' perceptions. Appendix B delineates each measure identified for the project.

Analysis

Initial data analysis of survey responses and record review occurred using Qualtrics analytics, Microsoft Excel, and Microsoft Word software, and was then translated graphically into bar graphs and table format. Response data sets from survey Likert- scale and multiple-choice questions were characterized by their mean, median and mode. Interviews and survey free-text responses provided common themes related to SED use that were categorized into groups.

Ethical Considerations

The study received approval by the OHSU and VA institutional review boards. Maintenance of anonymity of survey responses was achieved through utilization of an encrypted Qualtrics platform for distribution. Access to stored data required two-factor authentication. The authors report no conflicts of interest.

Results

Record Reviews

There were 2,227 operating room procedures performed at the VA during the 6-month period from June 1 2020 to December 31, 2020. Of this number, 497 were ophthalmologic procedures. As such, 1,730 possible smoke generating procedures took place during the study time interval. Based on purchase data (see methods), a total of 406 SEDs total were used for these procedures, generating a fractional SED use value of 406/1730= 0.235 or 23.5%. See Appendix F, Table 1 for breakdown of SED usage data.

Of the 406 cases employing SEDs, 141 were laparoscopic cases and 265 were open cases. During this time frame, there were a total of 154 laparoscopic procedures and 1576 open procedures, so that laparoscopic fractional SED utilization was 0.91 (91%) and open fractional SED utilization was 0.17 (17%).

Surveys

PDSA Cycle 1

PDSA cycle 1 included distribution of the survey to a preliminary group including 2 surgeons, 2 anesthesia providers, 2 OR RNs, and 1 Surgical Tech. This initial PDSA cycle did not elicit changes to the survey prior to distribution of the survey and these results were included in the final data.

PDSA Cycle 2

PDSA cycle 2 was distributed to a total of 160 personnel. Response statistics are provided in Appendix G. There were 43 responses, resulting in a total response rate of 26.9%. Anesthesia providers responded most frequently (38.9%; n=14) and surgeons least frequently (17.2%; n=10). Of the 10 surgeon respondents, the following subspecialties were included: vascular surgery (n=3), urology (n=2), orthopedic surgery (n=2), general surgery (n=2), and neurosurgery (n=1). Most respondents reported more than 5 years' experience in the OR, although only 52% of nurses were in this category; 100% of surgeons and roughly a quarter of RNs and anesthesia providers had worked more than 15 years at the VA. The most common source of SED education for all OR professionals was "non-industry" (journal articles, staff meetings, colleagues), 46.8% (n= 29). A large percentage of all professional groups reported no education related to SS evacuation with close to half of all RNs and anesthesia providers falling in this category; 60% of surgeons reported no SED education.

The overwhelming majority of respondents from all professions, 87.0% (n=40), agreed or strongly agreed that they are regularly exposed to SS in the operating room, including 70% of surgeons. Similarly, 73.9% (n= 34) of respondents, agreed or strongly agreed that SS is hazardous: 80.0% (n=17) of RNs, 78.5% (n=11) of anesthesia providers, and 50% (n= 5) of surgeons. Likewise, 71.4% (n=15) of RNs, and 71.4% (n=10) anesthesia providers agreed or strongly agreed that they were concerned about their exposure to SS. Only 50% (n=5) of surgeons agreed or strongly agreed that they were concerned about their exposure to SS. The large majority of non-surgeon respondents (80.6%; n=29) agreed or strongly agreed that SEDs should always be utilized for any SS generating case, including 85.7% of RNs (n=18),

71.4% of anesthesia providers (n=10) and 100% of CSTs (n=1). Interestingly, while 57.1% of RNs (n=12) either agreed or strongly agreed that they often suggest that a SED be used, only 14.3% (n=2) of anesthesia providers fell into the same category.

Of the respondent surgeons, 50% (n=5) reported utilizing SEDs less than half of the time and 20% (n=2) reported that they never used SEDs. The most common reason non-surgeons provided as to why SEDs were not utilized more often in the OR was "surgeon choice" without a more specific reason (35%; n=31). Other perceived barriers to surgeon SED use by this cohort (non-surgeons) included (in descending order of frequency) inconvenience related to device use, impaired surgical field visualization, the belief that SEDs are ineffective, and the fact that SEDs are difficult to set up. The most frequent problematic issue related to SEDs cited by surgeons was the belief that SS evacuation is unnecessary (37.5%; n=3). Other SED issues that represented problems for surgeons included inconvenience related to device use, impaired visualization of the surgical field, loss of haptic feedback, and impairment of patient safety.

Interviews

Themes common to all the interviews included: (1) No institutional policy or protocol existed at the VA regarding SED use. SEDs were employed at the discretion of the attending surgeon; (2) SEDs were underutilized at the VA; (3) There was a general lack of education regarding the hazards of SS and SED use; and (4) There was widespread sentiment that no single team member should be allowed to make a decision that potentially may adversely affect the health of the other team members. One anesthesia provider raised concerns about noise pollution that potentially may have contributed to patient hearing loss and may have impeded intraoperative audible alarm recognition among anesthesia providers. Both anesthesia providers interviewed believed that their distance from the surgical site afforded them protection from SS exposure. One RN reported that she and her professional colleagues consistently fruitlessly advocated for SED use with surgeons that were "unwilling to accept that surgical smoke is

harmful." Other RNs reported that they perceived anesthesia providers as unaware and/or unconcerned about their exposure to SS. The surgeon interviewed expressed his belief that exposure to any product of combustion was unhealthy, but that there was a lack of longitudinal data regarding the adverse consequences of chronic SS inhalation. Interview themes are detailed in Appendix H.

Discussion

Summary

The goals of this study were to define the state of SS evacuation at the VA and to identify perceived barriers to SED use at the institution for the 6-month period from June 1, 2020 through December 31, 2020. Salient findings in this regard include:

1. There is no institutional policy or protocol regarding SED use. SEDs are employed at the discretion of the surgeon.
2. Analysis of supply-utilization and case volume reports provided a lower limit estimate of SED utilization of 23.5%. Figures for laparoscopic and non-laparoscopic surgeries during the study period were 91% and 17%. These figures are consistent with the study's survey data that 70% of surgeons believe that they use SEDs less than half of the time.
3. Nearly half of all operating room RNs and anesthesia providers, and 60% of surgeons had received no education related to SEDs.
4. 50% of surgeons did NOT agree or strongly agree that SS is hazardous, and 50% did NOT agree or strongly agree that they were concerned about their exposure to SS i.e., approximately half of surgeons did not believe SS was hazardous and were relatively unconcerned about their chronic inhalation of plume. Given these numbers, it is not surprising that 70% of surgeons believed they utilized SEDs less than half of the time, and

among surgeons who found SEDs to be problematic, roughly 1/3 believed that SS was unnecessary.

5. Even though more than ¾ of anesthesia providers agreed or strongly agreed that SS was hazardous, only a subset of these individuals is significantly concerned about their chronic exposure to smoke in the OR. This latter perspective may relate to the fact that some anesthesia providers believed they work at a safe distance from the SS-generating field. Furthermore, unlike nurses (57%), only a small percent (14%) of anesthesia providers regularly suggested that a SED be employed.
6. Barriers to SED use as defined by survey of surgeons and non-surgeons were the belief by surgeons that SS evacuation is unnecessary (lack of education), inconvenience including bulkiness of the capture device, impaired visualization of the surgical field, and loss of haptic feedback.

Interpretation

Unlike other published findings concerning SED utilization generated by surveys, the present study employed utilization data predicated on OR records. Given the relatively emotionally charged nature of the issue (proper SS evacuation), the present methodology likely provides a more accurate measure of true SED use. In this context, the overall fractional utilization of 23.5% is nearly double the most recent national survey number of 14% in 2016 (Steege, Boiano & Sweeney, 2016). It is also possible that a larger fractional SED use represents a response to concerns for intraoperative transmission of SARs-COV-2 via SS and as such is a relative anomaly associated with the viral pandemic that overlapped the study time frame. Despite the higher value, however, SEDs were not utilized in ¾ of SS generating cases at the VA, although it should be noted that this figure ([100-23.5] %= 76.5%) likely represents a lower limit on appropriate SED use -- since some of the cases included in generating the

denominator for this fractional percent had minimal SS associated with them (i.e., arthroscopic surgeries).

Both perceptions of appropriate SS evacuation, and surgeon decisions regarding SED use, likely relate to the fact that nearly half of all OR RNs and anesthesia providers, and 60% of surgeons had received no education related to SEDs. These findings suggest that better education of surgeons (and other OR personnel) may alter their perception of SS hazards and encourage more widespread use of SEDs consistent with other survey studies (Liu et al., 2019 & Chavis et al., 2016). This approach has been strongly advocated by the Association of Operating Room Nurses (York & Autry, 2018).

On the other hand, even though more than ¾ of anesthesia providers agreed that SS is a health hazard (even though nearly half of anesthesia respondents reporting no SS education), only a subset of these individuals was significantly concerned about their chronic exposure to smoke in the OR. This latter perspective may relate to the fact that some anesthesia providers incorrectly believe they work at a safe distance from the surgical smoke generating area. For example, it has been well demonstrated that UFPM generated by surgical pyrolysis spreads beyond the immediate surgical field, and significant spikes in this material are detectable throughout the operating room, including in the anesthesia workspace (Romano et al., 2017).

In addition, the current study has shown that only a small percent (14%) of anesthesia providers regularly suggested that a SED be employed -- unlike OR RNs where the comparable number was approximately 57%. This is a striking finding and raises the question of why it has not been previously reported. A functional apathy on the part of anesthesia providers is also consistent with the near complete lack of discussion of SS in the anesthesia literature (Swerdlow, 2020). Given that most respondents believed SEDs were not utilized because of the surgeons' choice (a perspecitive that is supported by previous studies (Edwards & Reiman, 2008)), it is possible that anesthesia providers simply choose not to address this issue due to fears of economic and political reprisal, or perhaps simply

because they understand the critical importance of a mutually supportive surgeon- anesthesia relationship in patient care (Cooper, 2018). This relative indifference represents a significant deviation from anesthesia providers' traditional role as indefatigable advocates of safety, is a unique finding of this study, is a potential source for problem remediation, and represents fertile ground for future QI projects.

Project Strengths

This study is a partial prospective investigation employing a multimodal method to collect both quantitative and qualitative data through surveys, interviews, and review of operative records. While the online survey response of 26.9% is slightly lower than expected (37%), it is likely adequate to provide a credible sampling of OR personnel (Geyer et al., 2020).

Limitations

A major limiting aspect of this study relates to its relatively small sample size, particularly regarding surgeon responses to surveys (17.2%; n=10) and surgeon interviews (n=1). In addition, there was a complete lack of response/inclusion of plastic surgeons in the survey group. This latter fact may have influenced the study's findings since plastic surgery cases typically generate considerable SS, and plastic surgeons also traditionally have been early adopters of SEDs. Furthermore, SEDs were only introduced at the VA one month before this study sampled data, and as such, the relative novelty of this methodology may have influenced an accurate "steady state" description. Another significant confounding phenomenon is represented by the fact that the COVID-19 pandemic overlapped the entire study period, and attitudes regarding the hazards of viral transmission via SS may have altered SED utilization.

Conclusion

This QI study provided a descriptive analysis of the state of SED utilization at the Portland VA Hospital from June 1, 2020 through December 31, 2020 employing utilization analysis, online surveys,

and interviews. The investigation found a 23.5% fractional SED utilization that represents a lower limit, a figure that is significantly higher than past national figures based on survey perceptions. This value may have been positively influenced by attitudes toward SS during the COVID-19 pandemic that may not persist in the post pandemic period. Specific barriers to SED utilization were identified. A significant lack of education regarding SS exists among all OR personnel at the VA, and endeavors to alter this situation may allow for voluntary increases in SED use even before such action is mandated by legislative statute (H.B. 2622, 2021).

An additional unexpected finding of this investigation relates to previously unreported behavior of anesthesia providers with respect to SED use. Even though ¾ of anesthesia providers agreed that SS was a health hazard, only 14% regularly suggested that a SED be employed -- unlike OR RNs where the comparable number was approximately 57%. This unexpected finding needs explanation, may relate to the dearth of anesthesia literature related to SS, and may serve as the basis of future QI investigations. At a minimum, it will be important to see if these results are consistent with similar studies performed at other institutions, possibly including studies of anesthesia attitudes and behavior with respect to other types of operating room occupational hazards.

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Appendix A

Members of The QI Project Team

OHSU Nurse Anesthesia Program Faculty

- Barry Swerdlow, MD, FASA
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  - Assistant Professor- Nurse Anesthesia Program
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Portland VA Medical Center OR Team

- Patrick Langan, MN CRNA
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  - Staff CRNA
  - CRNA Educator & Clinical Coordinator
    - VA Portland Health Care System
  - Adjunct Assistant Professor of Clinical Nursing
    - School of Nursing, Nurse Anesthesia Program
    - Oregon Health and Science University

Appendix B

Operational Definitions and Data Collection for Individual Measures

Measure	Type	Definition	Data Collection
Percentage of cases utilizing SEDs	Outcome measure	Total number of cases using SEDs divided by the total number of cases at PVAMC	Surgical case volume records
Identify surgical specialties that use SEDs the most frequently/ infrequently	Outcome measure	Cardiothoracic, vascular, dental, general, gynecology, neurosurgery, ophthalmology, orthopedics, otolaryngology, plastic surgery, urology	Survey results
Identify perceived benefits to SED use	Outcome measure	Features of SED use OR personnel identify as beneficial	Survey results and interviews
Identify perceived barriers to SED use	Outcome measure	Features of SED use OR personnel identify as barriers	Survey results and interviews
Number of surgical cases performed at PVAMC	Process measure	Total number of surgical cases performed from May 2020- January 2021	Surgical case volume records
Number of SEDs available at PVAMC	Process measure	Total number of SEDs available at PVAMC ORs	Interviews and charge record reviews
Survey feedback after initial PDSA cycle	Process measure	Feedback received regarding survey clarity, length, format	Interview with individuals selected for first PDSA cycle
Percent response rate after initial PDSA cycle	Process measure	Number of completed surveys divided by total number of surveys distributed	Survey response
Perceived survey burden	Balancing measure	Perceived time burden of survey distributed to staff	Interview with individuals selected for first PDSA cycle
Change in frequency of SED use or perception after survey distribution	Balancing measure	Potential alterations in SED use during survey distribution period attributed to survey	Interview with select individuals

Appendix C

Speich and Galbraith Surgical Smoke at VAPORHCS Estimated Project Timeline

	Jan	Feb	March	April	May	June	July	Aug
Finalize project design and approach (703A)	X							
Complete IRB determination or approval (703A)	X							
PDSA Cycle 1 (703B)		X						
PDSA Cycle 2 (703B)			X	X				
Final data analysis (703B)				X	X			
Write sections 13-17 of final paper (703B)						X	X	
Prepare for project dissemination (703B)								X

Appendix D

Timeline of Interventions with Dates

Intervention	Date Performed
Reviewed procedure card data	November 13, 2020
Finalized Survey Questions	January 19, 2021
Distributed PDSA cycle 1	February 1, 2021
Sent reminder emails to PDSA cycle 1 recipients	February 11, 2021 February 18, 2021
Deadline for PDSA cycle 1 responses	February 22, 2021
Distributed PDSA cycle 2	February 26, 2021
Sent reminder emails to PDSA cycle 2 recipients	March 5, 2021 March 12, 2021 March 19, 2021
Deadline for PDSA cycle 2 responses	March 26, 2021
Conducted targeted interviews	April 30, 2021 – May 10, 2021

Appendix E

Surgical Smoke Evacuation Survey Questions by Provider Type

Surgeons

1. What surgical specialty/specialties do you work in? ***(select all that apply)***
    i. Cardiothoracic
    ii. Dental
    iii. Otolaryngology
    iv. General Surgery
    v. Gynecology
    vi. Ophthalmology
    vii. Neurosurgery
    viii. Orthopedics
    ix. Podiatry
    x. Plastic Surgery
    xi. Urology
    xii. Vascular
    xiii. Other: _____
2. How many years have you worked in an operating room environment? *(select one)*
    i. < 5 years
    ii. 5-10 years
    iii. 10-15 years
    iv. > 15 years
3. I have received education about surgical smoke from: ***(select all that apply)***
    i. Journal articles
    ii. Seminars
    iii. Continuing medical education (CME) courses
    iv. Colleagues
    v. Other: _____
    vi. I have not received education regarding surgical smoke
4. On a scale of 1-5 (1 = strongly disagree, 3 = neutral, and 5 = strongly agree) please rate the following:
    i. I am exposed to a significant amount of surgical smoke in the operating room
    ii. I believe that surgical smoke is hazardous to my health
    iii. I feel my colleagues don't use smoke evacuation devices as often as I do
5. Circle the best answer:
    i. I use surgical smoke evacuation device for open and minimally invasive cases that generate surgical smoke is: *(select one)*
        a. All the time
        b. More than half the time
        c. About half the time
        d. Less than half the time
        e. Never
    ii. Use of smoke evacuation devices is problematic for me due to: (**circle all that apply**)
        a. Surgical smoke evacuation is unnecessary
        b. Too noisy

c. Inconvenience (including bulkiness of the device)
d. Impaired surgical field visualization
e. Surgical smoke evacuation devices are ineffective for evacuation of smoke

iii. When I choose not to use a surgical smoke evacuation device, the **primary** reason is: *(select ONE)*
a. Surgical smoke evacuation is unnecessary
b. Too noisy
c. Inconvenience (including bulkiness of the device)
d. Impaired surgical field visualization
e. Surgical smoke evacuation devices are ineffective for evacuation of smoke
f. There is no surgical smoke generated with the surgery

iv. I use smoke evacuation devices more often with: *(select one)*
a. Open procedures
b. Minimally invasive procedures
c. Equally with open and minimally invasive procedures

OR Nurses

1. What is your role in the operating room? (***select all that apply****)*
   i. Scrub nurse/perioperative nurse
   ii. Circulating nurse
   iii. Registered Nurse First Assistant
2. What surgical specialty/specialties do you work in? *(**select all that apply**)*
   i. Cardiothoracic
   ii. Dental
   iii. Otolaryngology
   iv. General Surgery
   v. Gynecology
   vi. Ophthalmology
   vii. Neurosurgery
   viii. Orthopedics
   ix. Podiatry
   x. Plastic Surgery
   xi. Urology
   xii. Vascular
   xiii. I work with all surgical specialties
   xiv. Other: _____
3. How many years have you worked in an operating room environment? *(select one)*
   i. < 5 years
   ii. 5-10 years
   iii. 10-15 years
   iv. > 15 years
4. I have received education about surgical smoke from: *(**select all that apply**)*
   i. Journal articles
   ii. Seminars
   iii. Continuing education (CE) courses
   iv. Colleagues
   v. Other: _____
   vi. I have not received education regarding surgical smoke

5. On a scale of 1-5 (1 = strongly disagree, 3 = neutral, and 5 = strongly agree) please rate the following:
    i. I am exposed to a significant amount of surgical smoke in the operating room
    ii. I believe that surgical smoke is hazardous to my health
    iii. Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure
    iv. I often suggest that a smoke evacuation device be used during a procedure
    v. I desire more input into the decision whether to employ smoke evacuation devices in cases I am involved in
6. Circle the best answer:
    i. The **primary** reason smoke evacuation devices are not utilized more often in the OR is: *(select one)*
        a. Too noisy
        b. Inconvenience including bulkiness of device
        c. Impaired surgical field visualization
        d. Surgical smoke evacuation is unnecessary
        e. Surgical smoke evacuation devices are ineffective for evacuation of surgical smoke
        f. Smoke evacuation devices are difficult to set up
    ii. In my practice, use of surgical smoke evacuation devices for cases that generate smoke occurs approximately: *(select one)*
        a. All the time
        b. More than half the time
        c. About half the time
        d. Less than half the time
        e. Never

Surgical Technologists

1. What surgical specialty/specialties do you work in? ***(select all that apply)***
    i. Cardiothoracic
    ii. Dental
    iii. Otolaryngology
    iv. General Surgery
    v. Gynecology
    vi. Ophthalmology
    vii. Neurosurgery
    viii. Orthopedics
    ix. Podiatry
    x. Plastic Surgery
    xi. Urology
    xii. Vascular
    xiii. I work with all surgical specialties
    xiv. Other: _____
2. How many years have you worked in an operating room environment? *(select one)*
    i. < 5 years
    ii. 5-10 years
    iii. 10-15 years
    iv. > 15 years

3. I have received education about surgical smoke from: *(select all that apply)*
    i. Journal articles
    ii. Seminars
    iii. Continuing education (CE) courses
    iv. Colleagues
    v. Other: _____
    vi. I have not received education regarding surgical smoke
4. On a scale of 1-5 (1 = strongly disagree, 3 = neutral, and 5 = strongly agree) please rate the following:
    i. I am exposed to a significant amount of surgical smoke in the operating room
    ii. I believe that surgical smoke is hazardous to my health
    iii. Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure
    iv. I often suggest that a smoke evacuation device be used during a procedure
    v. I desire more input into the decision whether to employ smoke evacuation devices in cases I am involved in
5. Circle the best answer:
    i. The **primary** reason smoke evacuation devices are not utilized more often in the OR is: *(select one)*
        a. Too noisy
        b. Inconvenience including bulkiness of device
        c. Impaired surgical field visualization
        d. Surgical smoke evacuation is unnecessary
        e. Surgical smoke evacuation devices are ineffective for evacuation of surgical smoke
        f. Smoke evacuation devices are difficult to set up
    ii. In my practice, use of surgical smoke evacuation devices for open and minimally invasive cases that generate smoke occurs approximately: *(select one)*
        a. All the time
        b. More than half the time
        c. About half the time
        d. Less than half the time
        e. Never

Anesthesia Providers

1. What is your role in the operating room?
    i. Certified Registered Nurse Anesthetist
    ii. Anesthesiologist
2. How many years have you worked in an operating room environment? *(select one)*
    i. < 5 years
    ii. 5-10 years
    iii. 10-15 years
    iv. > 15 years
3. I have received adequate education about surgical smoke from: *(select all that apply)*
    i. Journal articles
    ii. Seminars

   iii. Continuing education (CME/ CE) courses
   iv. Colleagues
   v. Other: _____
   vi. I have not received education regarding surgical smoke
4. On a scale of 1-5 (1 = strongly disagree, 3 = neutral, and 5 = strongly agree) please rate the following:
   i. I am exposed to a significant amount of surgical smoke in the operating room
   ii. I believe that surgical smoke is hazardous to my health
   iii. Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure
   iv. I often suggest that a smoke evacuation device be used during a procedure
   v. I desire more input into the decision whether to employ smoke evacuation devices in cases I am involved in
5. Circle the best answer:
   i. The primary reason smoke evacuation devices are not utilized more often in the OR is: *(select one)*
      a. Too noisy
      b. Inconvenience including bulkiness of device
      c. Impaired surgical field visualization
      d. Surgical smoke evacuation is unnecessary
      e. Surgical smoke evacuation devices are ineffective for evacuation of surgical smoke
      f. Smoke evacuation devices are difficult to set up
   ii. In my practice, use of surgical smoke evacuation devices for open and minimally invasive cases that generate smoke occurs approximately: *(select one)*
      a. All the time
      b. More than half the time
      c. About half the time
      d. Less than half the time
      e. Never

Appendix F

Table 1: SED Usage Data June 1, 2020- December 31, 2020

Month	Laparoscopic Plume Filter	Smoke Evacuation Plumepen™
June 2020	20	29
July 2020	10	32
August 2020	29	50
September 2020	20	35
October 2020	20	31
November 2020	22	42
December 2020	20	46
Total	141	265

Appendix G

Survey Results

Table 2: Response Rates

Provider	Responses	Surveys Delivered	Reponses Rate
Surgeon	10	58	17%
ST Staff	1	2	50%
RN Staff	18	64	28%
Anesthesia	14	36	39%
Total	43	160	27%

Table 3: Provider Experience

Question: How many years have you worked in an operating room environment: (select one)

Answer	Surgeon		Nursing		Anesthesia		Surgical Tech	
	n	%	n	%	n	%	n	%
> 5 years	0	0.0	11	48.0	1	7.1	0	0.0
5-10 years	0	0.0	4	17.0	5	35.7	1	100.0
10-15 years	0	0.0	3	13.0	4	28.6	0	0.0
>15 years	10	100.0	5	22.0	4	28.6	0	0.0
Total	10	100	23	100	14	100	1	100

Graph 1: Sources of SS Education by Provider

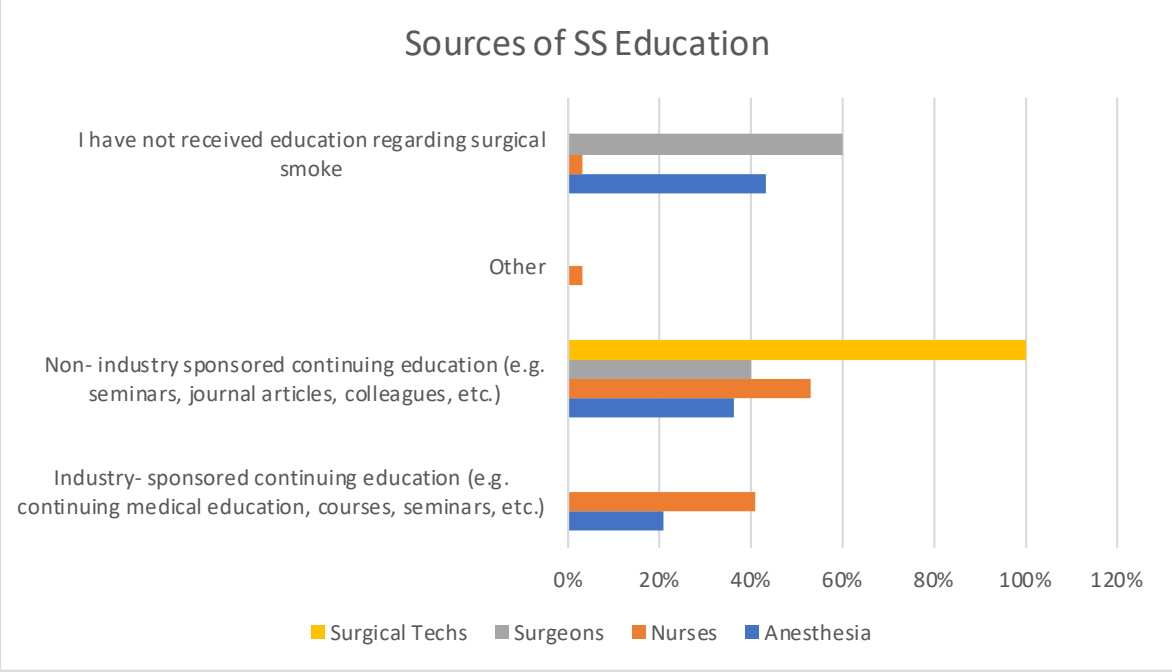


Table 4: SED Barriers, Non-surgeons

Question: The reasons surgical smoke evacuation devices are not utilized more often in the OR are: (select all that apply)

Answer	Nursing		Anesthesia		Surgical Tech	
	n	%	n	%	n	%
Too noisy	11	17.0	3	15.0	0	0
Inconvenience including bulkiness of the device	19	29.0	5	25.0	1	33.3
Impaired surgical field visualization	14	21.0	0	0	1	33.3
Surgical smoke evacuation is unnecessary	0	0	0	0	0	0
Surgical smoke evacuation devices are ineffective for evacuation of smoke	1	1.5	1	5.0	0	0
Smoke evacuation devices are difficult to set up	1	1.5	1	5.0	0	0
Surgeon choice	20	30.0	10	50.0	1	33.3
Total	66	100	20	100	3	100

Table 5: SED Barriers - Surgeons

Question: Use of surgical smoke evacuation devices is problematic for me due to: (select all that apply)

Answer	Surgeon	
	n	%
Surgical smoke evacuation is unnecessary	3	37.5
Too noisy	0	0.0
Inconvenience (including bulkiness of the device)	1	12.5
Impaired surgical field visualization	2	25
Surgical smoke evacuation devices are ineffective for evacuation of smoke	0	0.0
Impairment of safe dissection	1	12.5
Loss of haptics/ tactile feedback	1	12.5
Total	8	100

Table 6: Likert Scale Questions

Provider	Question	1		2		3		4		5	
		n	%	n	%	n	%	n	%	n	%
Surgeon	I am exposed to surgical smoke in the operating room	1	10.0	0	0	2	20.0	2	20.0	5	50.0
	I believe that surgical smoke is hazardous to my health	2	20.0	0	0	3	30.0	2	20.0	3	30.0
	I feel my colleagues don't use smoke evacuation devices as often as I do	2	20.0	1	10	5	50.0	1	10.0	1	10.0
	I am NOT concerned about my exposure to surgical smoke	4	40.0	1	10	4	40.0	0	0.0	1	10.0
		1		2		3		4		5	
Anesthesia	I am exposed to surgical smoke in the operating room	0	0.00	1	7.1	1	7.1	6	42.9	6	42.9
	I believe that surgical smoke is hazardous to my health	0	0.0	1	7.1	2	14.3	3	21.43	8	57.1
	Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure	0	0.0	2	14.3	2	14.3	2	14.3	8	57.1
	I often suggest that a smoke evacuation be used during a procedure	2	14.3	6	42.9	4	28.6	0	0.0	2	14.3
	I am NOT concerned about my exposure to surgical smoke	5	35.7	5	35.7	0	0.0	3	21.4	1	7.1
		1		2		3		4		5	
Scrub Tech	I am exposed to surgical smoke in the operating room	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0
	I believe that surgical smoke is hazardous to my health	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0
	Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0
	I often suggest that a smoke evacuation be used during a procedure	0	0.00	0	0.0	0	0.0	1	100.0	0	0.0
	I am NOT concerned about my exposure to surgical smoke	0	0.0	0	0.0	0	0.0	1	100.0	0	0.00
		1		2		3		4		5	
Nursing	I am exposed to surgical smoke in the operating room	1	4.8	0	0.0	0	0.0	1	4.8	19	90.5
	I believe that surgical smoke is hazardous to my health	0	0.0	0	0.0	4	19.1	3	14.3	14	66.7
	Surgical smoke evacuation devices should always be used during any surgical smoke generating procedure	0	0.0	0	0.0	3	14.3	9	42.9	9	42.9
	I often suggest that a smoke evacuation device be used during a procedure	1	4.8	1	4.8	7	33.3	5	23.8	7	33.3
	I am NOT concerned about my exposure to surgical smoke	12	57.1	3	14.3	5	23.8	0	0.0	1	4.8

Table 7: Nursing, Anesthesia, and Surgical Technologist Self-Reported SED Utilization

Question*: In my practice, use of surgical smoke evacuation devices for cases that generate smoke occurs approximately: (select one)*

Answer	Nursing		Anesthesia		Surgical Tech	
	n	%	n	%	n	%
All of the time	0	0.0	0	0.0	0	0.0
More than half the time	4	17.4	1	7.1	0.0	0.0
About half the time	2	8.7	2	14.3	0.0	0.0
Less than half the time	14	60.9	6	42.9	1	100.0
Never	0	0.0	1	7.1	0	0.0
I don't know	3	13.0	4	28.6	0	0.0
Total	23	100	14	100	1	100

Table 8: Surgeon Self-Reported SED Utilization

Answer	n	%
All the time	1	10.0
More than half the time	1	10.0
About half the time	1	10.0
Less than half the time	5	50.0
Never	2	20.0
Total	10	100%

Appendix H

Interview Questions by Provider Type

OR RN Questions

1. Are you concerned about surgical smoke? Why or why not?
2. Where have you received information concerning surgical smoke?
3. Does your facility have a policy concerning surgical smoke evacuation?
4. In your opinion, is surgical smoke evacuation underutilized, overutilized, or used appropriately at your facility? Why?
5. What, if any, changes would you like to see at your facility regarding surgical smoke evacuation?
6. What are the barriers to making SEDs a standard of practice in the operating room?
   Perceived?
   Actual?

OR Management Questions

7. Are you concerned about surgical smoke? Why or why not?
8. Where have you received information concerning surgical smoke?
9. Does your facility have a policy concerning surgical smoke evacuation?
10. In your opinion, is surgical smoke evacuation underutilized, overutilized, or used appropriately at your facility? Why?
11. What, if any, changes would you like to see at your facility regarding surgical smoke evacuation?
12. What are the barriers to making SEDs a standard of practice in the operating room?
    Perceived?
    Actual?

Anesthesia Questions

1. Are you concerned about surgical smoke? Why or why not?
2. Where have you received information concerning surgical smoke?
3. In your opinion, is surgical smoke evacuation underutilized, overutilized, or used appropriately at your facility? Why?
4. What, if any, changes would you like to see at your facility regarding surgical smoke evacuation?
5. As an anesthesia provider do you feel that you are able to influence the utilization of SEDs during cases?
6. Do you have any concerns regarding surgical smoke evacuators in the operating room?
    a. Regarding your concerns, is there a compromise or details regarding how SEDs are employed to protect the operating room staff and/or patient?

Surgeon Questions

1. Are you concerned about surgical smoke? Why or why not?
2. Where have you received information concerning surgical smoke?
3. In your opinion, is surgical smoke evacuation underutilized, overutilized, or used appropriately at your facility? Why?
4. What, if any, changes would you like to see at your facility regarding surgical smoke evacuation?
5. Do you have any concerns regarding surgical smoke evacuators in the operating room?
6. What team members should be able to influence the use of surgical smoke evacuation in the operating room?
7. As an attending surgeon is there discussion with your residents about the use of smoke evacuators and exposure to surgical smoke

Appendix I

Table 9: Themes Derived from Interviews

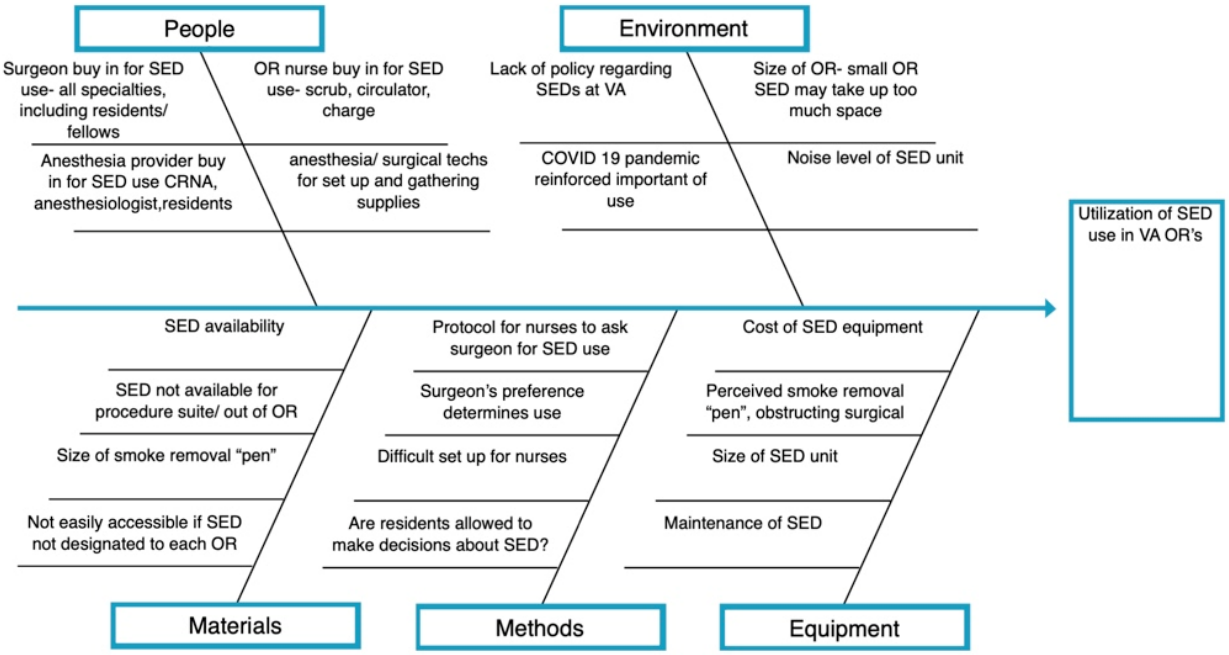
Themes	Coding Phrases	Examples by Provider Type
Perceptions of SS Hazards	Believes SS is hazardous	• RN: " Yes. Absolutely. I am regularly exposed to surgical smoke (more often than surgeons because I spend more time in the OR), and I am concerned about my health." • OR Management: "Yes. Always" This individual referenced condylomas, HIV and COVID- 19 all of which have raised concerns about surgical smoke in the OR. • Anesthesia: " Short answer yes, long answer no." from one anesthesiologist interviewed. Both anesthesia providers interviewed believe as anesthesia providers they are far enough away from the surgical site that it is not a concern. However, one anesthesiologist stated he would ideally like his exposure to be zero. • Surgeon: " Yes. Any product of combustion is not healthy for someone to breathe". This individual does feel there is a lack of longitudinal data on the long term consequences of surgical smoke and health issues. They also believe that it is difficult to quantity OR exposure and delineate from other confounding variables.
Education Surrounding SS/SED	Self-taught	• RN: Performed research on surgical smoke evacuation and related hazards during their BSN, as well as a self-guided research. • Surgeon: Believes tough to find data regarding surgical smoke
	Professional organizations	• OR management: Received information from AORN and other nursing publications. Believes fear of litigation drives information such as surgical smoke exposure research • Anesthesia: One provider received information from some anesthesia periodicals and AORN
	No education	• Anesthesia: One provider received no information or education about surgical smoke
Appropriateness of Current SED Utilization	Believes SEDs are underutilized	• RN = Stated SEDs are underutilized. States they often try to suggest the use of SEDs in the OR and is overruled by some surgeons regularly because they believe it is not hazardous • OR Management: Underutilized in general. Believes that the improvement in

		technology has made the devices less noisy. The old technology received a lot of kickback from surgeons • Anesthesia: Underutilized from both providers interviewed
	Unsure if SEDs are utilized appropriately	• Surgeon: Sometimes it is offered and sometimes not offered by the nurse. This surgeon stated if it is not offered by the nurse and it is a surgical smoke generating procedure they request it
	SED technology has greatly improved	• OR management: Believes that the improvement in technology has made the devices less noisy. The old technology received a lot of kickback from surgeons
Perceived Barriers to SED Use	Noise	• RN: stated noise is a common complaint from surgeons • Surgeon: Noise, however acknowledged that you can adjust noise level and the controls on the evacuator. Believes may need inservice or training so everyone is on the same page • Anesthesia: Both anesthesiologists interviewed indicated noise as a potential barrier
	Cost	• OR management: The federal system has allotted the Portland VA COVID money to incorporate SEDs and this fund may dry out if there is not a compelling reason to keep SEDs in the ORs.
	Surgeon preferences	• RN: surgeons are resistant to change and some do not want to be educated about SS or SEDs. One surgeon would use SEDs but one has not been identified that works with their preferred bovie tip • OR management: certain surgeons believe more waste than normal because bovies are opened then thrown away. Some surgeons do not believe it is necessary for certain things
Opposing Opinions Regarding SED Use	Surgeons feeling it is nurse's role	• Surgeon: Expressed that sometimes the nurses set up SEDs and sometimes they do not •
	RNs feeling it is surgeon's role	• RN: Expressed that they often suggest the use of SEDs and are overruled by surgeons
Passive and Active Roles of OR Personnel	Passive role of anesthesia department	• Anesthesia: Both anesthesiologists expressed that if they were to say something the surgeon would feel utilize SEDs but they do not speak up

Suggestions for Future Changes Regarding SED Use	Active / influential role of nurses	• Surgeon: Believes it should be a shared responsibility in the OR mediated on both sides by the nurse and MD. • RN: State that they often suggest the use of SEDs.
	Standardized policy for SED use	• RN: Believes there should be a facility policy
	State legislative changes	• OR Management: Aware of current legislation coming regarding Smoke Free Oregon ORs that may affect policies
	Change in equipment	• Surgeon: Believes the buffalo evacuator for laparoscopic cases is too loud and there could potentially be changed for this specific evacuator
	Change in culture	• RN: Would like to see increased utilization, support from management, and for SEDs to be on all case carts • Anesthesia: Would like the facility to have zero smoke exposure
	Increased education	• RN: Would like to see education for all OR staff • Surgeon: Perhaps an in-service or training would get everyone on the same page

Appendix J

Cause and Effect Diagram



Appendix K

Letter of Support from Clinical Agency

Date: *[12/10/2020]*

Dear *Jordan Galbraith & Christian Speich*,

This letter confirms that I, *Dr. Reynaldo Calaro DNAP, CRNA*, allow *Jordan Galbraith & Christian Speich* (OHSU Doctor of Nursing Practice Student) access to complete their DNP Final Project at our clinical site. The project will take place from approximately *January 3, 2021* to *May 31, 2021*.

This letter summarizes the core elements of the project proposal, already reviewed by the DNP Project Preceptor and clinical liaison (if applicable):

- **Project Site(s)**:
  Portland Veteran's Affairs Medical Center
  3710 Southwest U.S. Veterans Hospital Road
  Portland OR 197239

- **Project Plan:**

Surgical smoke (SS) is generated by various instruments used for surgical procedures and poses many occupational hazards to OR personnel. Adverse health consequences related to the acute and chronic inhalation of SS relate to its physical and chemical properties, and its ability to transmit biologic agents. The Portland Veteran's Affairs Medical Center (PVAMC) has ten operating rooms (ORs) and four procedural rooms that generate a significant amount of SS daily. Numerous professional and governmental organizations recommend the regular use of surgical smoke evacuation devices (SEDs) to protect OR health care providers, including the National Institute for Occupational Safety and Health (NIOSH) and the Association of Perioperative Registered Nurses (AORN).

This quality improvement (QI) initiative aims to define the current state of SS evacuation at PVAMC including identifying potential barriers to the routine use of SEDs. We intend to employ staff surveys, face-to-face interviews, and review of OR records to obtain this data. The surveys will be developed based on Roger's Diffusion of Innovation theory and refined using the Plan-Do-Study-Act (PDSA) methodology; they will be electronic using the encrypted Qualtrics system and delivered to select OR staff through their VA email accounts. The individuals selected to participate in the survey will be first identified by Surgical Specialty Chiefs and OR surgical service charge nurses. The data collected will not include any protected health information or patient identifying information. All data will then be stored in the secure OHSU Box system, which requires two step verification. Data will be organized using Microsoft Excel.

During the project implementation and evaluation, *Jordan Galbraith & Christian Speich* will provide regular updates and communicate any necessary changes to the DNP Project Preceptor.

Our organization looks forward to working with this student to complete their DNP project. If we have any concerns related to this project, we will contact *Jordan Galbraith & Christian Speich* and *Dr. Barry Swerdlow M.D. and Dr. Julie Soelberg Ph.D.* (student's DNP Project Chairperson).

Regards,

_____	_____
DNP Project Preceptor	Job Title
_____	_____
Signature	Date Signed