Use of a Perioperative Fire Prevention Guide by Certified Registered Nurse Anesthetists: A Quality Improvement Project

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Notes from the Author

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Abstract

Operating room fires are preventable events that can have devastating consequences for patients and healthcare organizations. Hospitals have acute interest in training all operating room workers to prevent fires from occurring, to readily recognize situations that carry a high risk of fire, and to respond quickly should a fire occur. The purpose of this quality improvement project was to assess anesthesia providers' perceptions of adequacy of a newly developed perioperative fire prevention checklist specifically designed for CRNAs working in the operating rooms of a large southeastern U.S. hospital system. Pre-intervention surveys established the providers' baseline exposure to fire recognition and prevention training. A checklist was designed to allow providers to quickly identify high-risk procedures and to serve as an algorithm of communication and collaboration with other providers. Five CRNAs used this checklist in their daily practice for approximately three weeks, after which their feedback was used to assess its usefulness. Post-intervention surveys found increased CRNA confidence in fire prevention, as well as potential time savings in finding specific safety-related instructions for high-risk procedures. This project included only five participants in one organization but was reviewed positively by all of them. Further trials of this tool involving a larger population may be sought in the future.

Keywords: surgical fires, operating room fires, OR fire prevention, assessment guide.

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Section I. Introduction

Background

Fires in the operating room (OR) occur about 600 times per year and cause about 2 to 3 deaths annually (Akhtar et al., 2016; Coletto et al., 2018; Jones et al., 2019). Compared to the nearly 22 million invasive, therapeutic surgeries performed in the United States (US) hospitals in 2014 alone, the likelihood of a patient or a provider experiencing a real surgical fire is very small (Steiner et al., 2017). The rareness of these potentially catastrophic events creates a problem: providers may not be sufficiently aware of the critical points during surgery when a fire is likely to occur. Additionally, they might lack personal familiarity with the precise steps needed to respond to a fire quickly, which is essential in order to minimize harm to patients.

The Fire Triad

An operating room fire is defined as "a blaze, or destructive burning, that occurs on or near a patient in a surgical suite" (Day et al., 2018, p. 599). For any fire to occur, three components (sometimes called the fire triad or triangle) must be present at the same time: fuel, oxidizer, and ignition or heat (Jones et al., 2019). Anything that is flammable, "any substance that can undergo combustion," can be viewed as fuel (Day et al., 2018, p. 600; Jones et al., 2019). In the OR, fuels can be "patient-dependent" (hair, tissue, intestinal gases), and "non-patient-dependent" (solutions, such as alcohol-based skin preps, materials such as gauze, drapes, sponges; Jones et al., 2019, p. 495).

The oxidizer is oxygen, either naturally present in the air or delivered supplementally in various concentrations as itself or as nitrous oxide (Day et al., 2018). Heat or ignition in this context is additional energy "necessary to sufficiently increase oxidation-reduction reaction rates," in other words, cause a fire (Day et al., 2018, p. 600). In the operating room, Certified

Registered Nurse Anesthetists (CRNAs) are typically in charge of the oxidizers (oxygen and nitrous oxide) as well as sometimes the fuel (for example, flammable plastic endotracheal tubes and anesthetic gas delivery circuits; Di Pasquale & Ferneini, 2017).

Oxygen Use in Surgery

Understanding the fire triad makes it obvious that different surgical procedures carry varying risks of fire. Each one of the components of the triad may vary depending on specific circumstances of the case. Starting with fuel, it is always present (drapes, sheets, flammable materials including human tissues), but the quantity present may vary substantially and may depend on the extensiveness and duration of surgery. Similarly, the oxidizer is always available, but it might be delivered in varying amounts: there is always oxygen present in the air but supplemental oxygen may not always be used. The amount of the oxygen present in the operative environment is positively correlated with the ease of combustion in in vitro models (Davis et al., 2018).

Methods of delivering supplemental oxygen can also vary starting from a nasal cannula or a facial mask to an endotracheal tube. (Davis et al., 2018; Jones et al., 2019; Vourc'h et al., 2019). Lastly, not all surgeries require use of electric or heat-generating instruments. Thus the presence of the last element of the fire triad – a source of ignition – is not always required for a given surgery.

Even when all three components of the fire triad are present during the surgery, they do not all have to be present in one spatial location. A cauterizing instrument (ignition) used during a leg surgery is physically separated from a source of oxygen delivered to the patient's face. Even when the source of ignition must be close to the site of the oxygen delivery (for example, during surgeries around the face), such delivery might be paused for a sufficient amount of time, causing the oxidizer to be separated from the ignition *temporally*, if not *spatially*.

In view on these factors and specific surgical needs, various OR fire assessment tools often rate surgeries as high or low risk for occurrence of fire. For example, the American Society of Anesthesiologists' (ASA) algorithm specifies a high-risk procedure rather straightforwardly as one where "an ignition source will be used in proximity to an oxidizer-enriched atmosphere" (Jones et al., 2019, p. 497). "Examples of high-risk procedures include, but are not limited to, tonsillectomy, tracheostomy, removal of laryngeal papillomas, cataract or other eye surgery, burr hole surgery, or removal of lesions on the head, neck, or face" (Caplan et al., 2008, p. 787). Specific risk factors from the point of view of the anesthesia provider are surgery above the xiphoid process, presence of oxygen concentrations greater than 30% and the use of nitrous oxide. Multiple interventions are suggested specifically to the anesthesia providers dealing with high risk cases, such as clearly communicating the risks during a time-out, titrating oxygen to the lowest safe concentration, discontinuing oxygen delivery prior to using an energy device for at least one minute if appropriate, avoiding tunneling and trapping of oxygen under drapes, and inflating endotracheal tube (ETT) cuffs with a dyed gas (methylene blue) to detect perforation (Jones et al., 2019, p. 493).

Hospital Fire Leads to Patient Injuries

In November 2012 a fire at Durham Regional Hospital in North Carolina, which took place during a patient defibrillation attempt, resulted in one death, three injuries, evacuation of about 42 patients to different rooms, and water damage to three hospital floors (USA TODAY, 2012). In 2015 an operating room fire at Moore Regional Hospital in Pinehurst, NC, caused first and second degree burns to the neck and shoulders of a patient after "vapor from sterilizing fluid ignited, causing a brief flash fire" (Natt, 2015, para. 14). Moore Regional was "cited for not following established fire safety prevention policies and procedures" (Natt, 2015, para. 12) and "risked losing their certification for Medicare and Medicaid reimbursement" (Natt, 2015, para. 20). As a result of an investigation that followed the incident, the hospital made some changes in their practice, such as eliminating alcohol-based skin preps and replacing them with Betadine preps where possible, as well as allowing the preps to dry for a sufficient time (Natt, 2015). This incident serves as a warning that in spite of existing fire prevention protocols and recommendations, surgical fires continue to pose a serious risk to patient health and safety, as well as to hospital property, reimbursement, and license to operate.

Organizational Needs Statement

This project was completed in a 1000-bed teaching hospital in southeastern United States. The hospital has 35 operating rooms and performs thousands of surgical procedures annually. Due to the large volume of surgical operations performed in the organization, and because the consequences of an OR fire can be so devastating, this hospital system has tremendous interest in eliminating them entirely. It would be vitally important to have a robust and streamlined process in place for assessing perioperative fire risks.

The United States Department of Health and Human Services (USDHHS) publishes a set of national objectives that all healthcare organizations in the US are urged to strive to attain. While no one objective specifically deals with fires in the operating rooms, at least two broader goals could be applied to surgical fire safety. One of these is the goal to prevent injuries: "in the United States, unintentional injuries are the leading cause of death in children, adolescents, and adults younger than 45 years. Healthy People 2030 focuses on preventing intentional and unintentional injuries, including injuries that cause death" (Office of Disease Prevention and

Health Promotion [ODPHP], n. d.-b, para. 1). Without mentioning surgical fires specifically, the national guidelines do address preventable medical injuries, such as those resulting from medication overdoses in children or inappropriate medication use by older adults.

The other relevant Healthy People 2030 goal is improving health care. “Helping health care providers *communicate more effectively* [emphasis added] can help improve health and well-being. Strategies to make sure health care providers are aware of treatment guidelines and recommended services are also key to improving health” (ODPHP, n. d -a, para. 2). In harmony with the above statement, this project will focus on effective communication during surgery to avoid fires, as well as on reviewing the best available guidelines from national and professional organizations.

In addition to the USDHHS, the Institute for Healthcare Improvement (IHI) has developed a framework, referred to as the Triple Aim, to optimize delivery of healthcare in the country. One of the aims is to improve experience of care (Institute for Healthcare Improvement, n. d.). Similarly to the Healthy People 2030 objectives, the Triple Aim highlights the need to “share best practices and proven approaches, and… develop capacity within organizations for population health improvement” (para 2). The Triple Aim initiative seeks to reduce healthcare disparities and inequalities with a focus on “high-risk, high-cost populations” (para 3). Although the context appears to indicate that the high-risk populations are defined sociodemographically, reducing injuries from surgical fires is clearly consistent with the Triple Aim guidelines. It specifically focuses on improving the outcomes of one of the most vulnerable populations: patients under anesthesia who at the time of surgery are under total control of their healthcare providers and who are unable to actively protect themselves from adverse outcomes.

There is no lack of general and specific information about operating room fires. There are published instructions about preventing and responding to surgical fires. Education about assessing the risk of surgical fires is taking place at multiple levels. For example, it is part of the curriculum of this doctorate program. The American Society of Anesthesiologists (ASA) has their own educational materials, including handouts as well as written and visual guidelines (Caplan et al., 2008). They developed and regularly update an algorithm as well as a preoperative checklist, which provide specific and detailed instructions on how to assess the risk of surgical fires and to effectively respond to them (Jones et al. 2019).

Multiple other agencies have created and distributed their own fire management algorithms and assessment tools. For example, the Emergency Care Research Institute (ECRI) highlights the importance of communication among the surgical and anesthesia providers and publishes guidelines for fire prevention for routine and high-risk surgeries (ECRI Institute, 2009). The Food and Drug Administration (FDA) developed the *Preventing Surgical Fires Initiative* with educational resources for healthcare providers (FDA, 2011). The Anesthesia Patient Safety Foundation (APSF) offers an operating room fire prevention algorithm with suggestions for nurses and surgeons for intraoperative oxygen supplementation and fire management (APSF, 2013). In addition to national guidelines and advice from various professional associations and societies, individual hospitals may have specific policies applicable to preoperative fire assessment and management, as well as provider roles.

Despite broad availability of educational materials related to hospital fires, they may not be at the forefront of a provider's thinking when preparing for a surgical case. CRNAs have many responsibilities in the OR. In 1974 the American Association of Nurse Anesthetists (AANA) adopted the original Standards of Nurse Anesthesia Practice, updating it multiple times in subsequent years and including them in the Professional Practice Manual, most recently in 2019 (AANA, 2019). These standards (currently numbering 14) are quite specific and deal with planning and implementing anesthesia care, ensuring proper equipment management, using appropriate alarms, and documenting and transferring care to other providers, among other requirements. The document highlights such responsibilities of CRNAs as monitoring and ensuring adequate oxygenation, ventilation, cardiovascular function, and thermoregulation. CRNAs administer anesthetic gases and intravenous medications. Notably, in addition to all these responsibilities, the AANA standards are specific in their inclusion of fire prevention measures, indicating that “the surgical or procedure team communicates and collaborates to mitigate the risk of fire” (AANA, 2019, p. 3). Furthermore, Standard VI mandates CRNAs to “operate equipment to minimize the risk of fire, explosion, electrical shock, and equipment malfunction” (p. 2).

Problem Statement

In summary, multiple recommendations and fire assessment tools exist to help CRNAs achieve Standard IX from the AANA standards of care, focusing on team communication and collaboration and working in harmony with the Triple Aim and the Healthy People 2030 initiatives protecting vulnerable populations. However, without choosing one working algorithm or a specific preoperative fire assessment tool, the existing multitude of recommendations may overwhelm and distract providers at the start of a case when they have many competing responsibilities. Not all cases carry equal risk of a surgical fire. An ability to quickly identify high risk procedures confidently and to prepare for them adequately is essential. This could be accomplished by having a brief summary of the best available guidance and a quick fire assessment tool at each anesthesia station.

Purpose Statement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of adequacy of a newly developed perioperative fire prevention checklist specifically designed for CRNAs working in the operating rooms of a large southeastern US hospital system. The tool would allow providers to quickly identify high-risk procedures and serve as an algorithm of communication and collaboration with the rest of the surgical team.

Section II. Evidence

Literature Review

The search strategy for this project focused on investigating the physical concept and definition of fire, operating room safety and fire risk assessment tools. Key search terms used in various databases and search engines included “surgical fire,” “operating room fire,” “surgical fire assessment,” “fire prevention,” “operating room fire risk” as well as accompanying terms related to the intervention such as “checklist,” “cue cards,” and “assessment tool”. The databases included Cumulative index to Nursing and Allied Health Literature (CINAHL), PubMed, and ProQuest Search. The search engine of choice was Google Scholar.

Searches of PubMed were accomplished using the MeSH terms “operating rooms” and “surgical procedures, operative,” and “fires” as well as various keywords. Searches of CINAHL utilized the subject headings “nurse anesthetists,” and “surgical fires,” as well as a variety of keywords. In general, the search was limited to works published in the last 5 years, but other less recent publications were also consulted. Articles deemed useful were checked for cross-references in other published works, particularly more recent ones, and information was also obtained through review of websites and publications of professional organizations and agencies concerned with fire safety during surgery. The key terms used in various databases are summarized in Appendix A. About 237 articles were identified, after removal of duplicates, 50 articles were deemed pertinent for full review. After consideration, 32 articles and other sources were included in the literature review. The search strategy and the results are presented in Appendix B. A literature matrix is available as Appendix C.

Current State of Knowledge

Current literature on OR fire prevention describes the fire triad in detail and focuses on preoperative risk assessment (Burley et al., 2018; Jones et al., 2019). The work of a modern OR is a complex process where a multitude of individual components have to work smoothly towards one major goal: treating the patients. Adding structure and standardization to a complex process has been shown to reduce errors and improve outcomes both in medicine and in other risky and complex procedures, such as in aviation (Walker et al., 2012).

Such a structured approach is reflected in the literature. Melnyk and Fineout-Overholt (2019) are often cited as advocates of using the highest level of evidence available in support of a proposed intervention or a treatment option. They have developed a hierarchical rating system which includes seven categories of evidence. The highest level (Level I) is evidence from meta-analyses of relevant randomized controlled trials (RCT). The lowest level (Level VII) is opinion of authorities and experts. When planning an intervention, it is important to look for the best available evidence: a RCT provides better support for a project than a lower quality study, and meta-analyses of RCTs or systematic reviews supersede them all. Nevertheless, review of the current literature reveals that in preoperative fire assessment, expert advice — which represents the lowest level of available evidence — is one of the most frequently cited types of guidance for practice (ECRI Institute, 2009; Jones et al., 2019; Stoelting et al., 2012).

Clinical guidance on surgical safety may largely derive from relatively low-level evidence because conducting higher-level trials would be impractical and perhaps impossible. It is difficult to imagine a study which would allow real OR fires to take place, especially with appropriate blinding and in numbers large enough to be statistically meaningful. Ex vivo studies which purposefully attempt to ignite animal skin models under different simulated surgical conditions do exist but they typically describe individual Level III (trials without randomization) or Level IV experiments, not large cohort studies or systematic reviews (Davis et al., 2018; Samuels et al., 2020). In view of impracticality of studying the real operating room fires, the academic consensus seems to support the usefulness of such trials for investigating the physical properties and consequences of fires.

For the fires that did take place, Calder et al. (2019) performed retrospective medico-legal analysis of surgical fires and burns in healthcare systems in Canada, and discovered that nonadherence to protocols and failures in communication among the surgical team members were major contributing factors to patient injury. A similar earlier study in the United States by Choudhry et al. (2017) reviewed 139 legal cases which included 114 operative burns and 25 surgical fires and involved two patient deaths. Their review found association between the operative use of high energy devices (such as electrocautery and lasers) and patient injury, with most common site of operative burn being the face. Such descriptive root-cause analysis would constitute Level V evidence (descriptive and qualitative studies).

Additionally, for training provider behavior to prevent and respond to surgical fires, there is considerable support for using OR-based simulations and virtual reality-based training (Cant & Cooper, 2017; Dorozhkin et al., 2017; Kishiki et al., 2019; Sankaranarayaran, 2018; Wood, 2015). These studies include simple surveys (Level VI evidence) assessing subjective preferences of the trainees using computer simulators (Dorozhkin et al., 2017). They also include single-blinded randomized controlled studies, such as the one performed by Kishiki et al. (2019). The authors divided 82 participants into 14 groups with varying degrees of simulator-based training. Their assessment included pre- and post-simulation surveys, as well as rating provider performance by a blinded evaluator. The authors concluded that “simulation training significantly improves both the competency and confidence of medical professionals in managing fires in the OR, with more simulation training showing a greater degree of benefit" (p. 237). Their findings in support of simulation-based preparation could be viewed as Level II evidence, adding validity to such training and constituting the highest evidence available. Due to the global Coronavirus Disease-2019 (COVID-19) pandemic and other limitations of this study, this author did not opt to perform simulation analysis. However, this could be the direction of future research.

Current Approaches to Solving Population Problems

One of the ways to reduce errors in medical and nursing practice is use of checklists: "By standardizing performance, checklists reduce reliance on memory and thus reduce errors of omission" (Walker et al., 2012, p. 48). In fulfillment of AANA's Standard IX requirement of communication and collaboration for preventing fires, "checklists contribute to team communication and working and increase situational awareness among team members" (p. 48).

Surgical checklists already exist. Their use is promoted by the World Health Organization (WHO), which publishes their *Guidelines for Safe Surgery*. The items from these checklist guidelines are related to identifying correct surgical site, minimizing the risk of infection, avoiding known allergies, preventing retention of swabs and instruments, and so on (WHO, 2009). On the proposed list of "anesthesia safety checks before any anesthetic," the WHO urges providers ensure that "the operating room should be of an appropriate size, well lit, conform to relevant electrical safety codes and meet design requirements that minimize hazards from fire, explosion and electrocution" (WHO, 2009, p. 20).

The push by the World Health Organization to urge hospitals to adopt surgical safety checklists was evaluated in a landmark global study involving eight hospitals in both high- and low-income countries, including Canada, the United Kingdom, United States of America, New Zealand, India, Jordan, Tanzania and the Philippines (Haynes et al., 2009). The overall postoperative 30-day death rate was reduced almost by a half (from 1.5% to 0.8%) and inpatient complications were reduced from 11% to 7% in hospitals which adopted the checklists compared to controls which did not (Haynes et al., 2009). A subsequent study from the Netherlands involving six hospitals found their postoperative complication rates decrease from 15.4% to 10.6% after adopting checklists (de Vries et al., 2010).

Since the seminal studies which found support for the WHO-advocated adoption of checklists in surgery, there have been multiple other studies. A critical review of 22 papers by Cadman (2016) supported significant positive impact of checklists on patient safety and teamwork. Similarly, de Jager et al. (2016) examined 20 studies and found mostly positive effects of checklists on complication and mortality rates, although the quality of the studies was not always strong, with serious inconsistencies in the results. A meta-analysis performed by Biccard et al. (2016) which surveyed the outcomes of 6060 patients in South Africa found that surgical safety checklists (SSC) decreased hospital mortality and improved surgical outcomes in tertiary and community hospitals, urging policy-makers to make use of SSCs mandatory as part of healthcare policy.

One of the problems highlighted by the Biccard et al. (2016), with regards to adoption of surgical checklists, is that “compliance is low… and it is likely that compliance was overestimated” (p. 596). In order to for the tool to be effective it must be used, and to be used it must be well-designed: “checklists should ideally be one page, use simple familiar language, and each element should contain no more than five to nine items” (Walker et al., 2012, p. 48).

Review of the literature identified multiple obstacles to broader adoption of preoperative checklists. Cadman's analysis (2016) lists such barriers as "perceived duplication and increased workload" (p. 65), "hierarchical relationships" and "lack of communication between the surgeon and anaesthetist [*sic*]" (p. 69).

In addition to encouraging the use of preoperative checklists, modern training that helps providers recognize risks of fires often involves repeated practice under realistic conditions (Dorozhkin et al., 2017; Hauk, 2018). Sankaranarayanan et al. (2018) evaluated the impact of virtual reality-based simulation training and found that groups which had an opportunity to practice performed the correct sequence of steps in extinguishing a simulated fire better than a control group which only had didactic training. A study by Kishiki et al. (2019) involved 82 participants divided into 14 groups and found that "simulation training significantly improves both the competency and confidence of medical professionals in managing fires in the OR, with more simulation training showing a greater degree of benefit" (p. 237).

Deutsch and Straker (2019) highlighted that simulations were not merely useful in training providers to perform appropriate steps in correct order, but also helpful in identifying potential hazards and errors, including systemic errors: "Simulation… has applications in understanding and improving patient-care systems. Re-enacting patient-care events in situ (in actual patient-care locations, using actual patient-care equipment) can reveal conditions that may not have surfaced during individual or group interviews" (p. 1012). In an umbrella systematic literature review of 25 reviews which encompassed over 700 primary studies, Cant and Cooper (2017) noted that "simulation-based education contributes to students' learning… Simulation experiences do improve students' knowledge and also enhance clinical skills' acquisition, self-efficacy, confidence and competence" (p. 70).

Current literature also identifies factors that make a procedure high risk. Parremore (2019) found the following elements to be problematic: “surgical site above the xyphoid, an open oxygen supply (for example: oxygen mask or nasal prongs), an available ignition source (for example: diathermy, laser),… use of alcoholic skin preparation” (p. 4). To provide more details about these factors specifically, Deutsch and Straker (2019) cited a Pennsylvania report indicating that “the majority of reported surgical fires affect the scalp, face, or neck of patients,” making otolaryngology a particularly high-risk specialty (p. 1006). In a paper describing the situation in England and Wales, Rodger (2020) highlighted virtually identical risk factors (p. 5). When it comes to specific recommendations about oxygen use, Deutsch and Straker (2019) specified that “the fraction of inspired oxygen (FiO2) should be less than 30%, if the patient’s pulmonary function can tolerate that level of support” (p. 1006). Additionally, risk is reduced if oxygen is delivered via an endotracheal tube or a supraglottic device instead of by open systems.

Evidence to Support the Intervention

Due to the limitations imposed by the current COVID-19 epidemic on interpersonal interactions as well as other restrictions inherent in the nature of this project, delivery of in-situ simulations or virtual reality sessions was not feasible for this project. However, not all approaches must be expansive. For example, in one simple and light-hearted project, Kroning et al. (2019) recommended using an egg timer in the OR to measure the time required for alcohol-based skin preparations to dry in order to reduce the risk of surgical fires. In the operating room even small missteps may lead to serious adverse outcomes. Conversely, optimizing even minute details of a process may bring significant benefits. This project focused specifically on the role and responsibilities of CRNAs in participating in preoperative fire risk assessment by offering them a simple tool aimed at structuring and formalizing the assessment process.

Projects seeking to summarize the multiple recommendations supplied by various agencies and to develop individual fire risk assessment tools have been undertaken by other investigators. After looking at two well-documented reports of surgical fires and considering the WHO recommendations about implementing the Safer Surgery Checklist, Parremore (2019) designed a Surgical Site Fire Risk Assessment Guide to be used by a hospital in England. Her guide involved a simple 0-4 scale, with one point awarded for presence of each of the following: alcohol-based preps, surgical site above the xiphoid, open oxygen source, and electrosurgical instruments (p. 5). The researcher then classified procedures with three or more factors as high risk, two factors as low risk with potential to convert to high risk, and with one or zero factors as low risk. Each assigned category then had specific recommendations for the anesthetist and the circulating nurse.

The use of a fire assessment tool is also urged by Rodger (2019): “It is advisable that a risk assessment tool should be used to assess the risk of a surgical fire and this is especially warranted for surgery considered high risk” (p.4). “The risk assessment tool should provide an indication of the risk of a surgical fire so that staff can adjust their practices and behavior accordingly; encouraging better communication and increased vigilance” (p. 5). Interestingly, he (1990) also recommends including “rehearsing what to do if a surgical fire occurs” into perioperative education, using simulation scenarios or virtual reality (p. 5).

The APSF approaches the same requirement not with a formal checklist but with a published algorithm expressed as a flow diagram, which prompts providers to answer simple yes/no questions and leads to recommendations for a safe surgery (Stoelting et al., p. 43). The ASA’s algorithm is comprehensive and directs not only preoperative risk assessment, but prescribes specific steps on extinguishing fires that do occur (Jones, 2019).

Evidence-Based Practice Framework

Identification of the Framework

Fires are “never events” defined as “clearly identifiable and highly preventable events that are deemed to be nonreimbursable, serious, hospital-acquired conditions” (Coletto et al., p. 99). This project specifically focuses on identifying high risk situations ahead of time and preventing them.

When fires do happen, they could be viewed as serious medical or process errors. Multiple conceptual paradigms seek to understand and describe the mechanism of error occurrence, especially at the level of systems. One such framework was developed by a British psychologist James Reason. It is commonly referred to as “The Swiss cheese model” (SCM), illustrated in Appendix D. (Buist, 2018; Reason, 2016, p. 12; Stein & Heiss, 2015). An example of a concept map of the SCM as it applies to the surgical fire prevention is found in Appendix E.

This model views surgical fires as failures in the many layers of protection built into the daily operations of the hospital. Each layer of protection is like a slice of cheese. Each slice alone may have holes and thus permit failures. However, when slices are stacked together, multiple layers of protection block the holes in the neighboring slices and thus prevent the error. In some cases however, the holes may be aligned, so that the hole continues through multiple layers, and an error does take place (Zastrow, 2015). “It follows that one can decrease the incidence of these organisational [sic] accidents by increasing the number of defences [sic] (more cheese slices) and/or by shrinking the size of the holes in each of the defences” (Buist, 2018, p. 38). Initially the SCM was developed for aviation, but was later adapted to other complex systems, such as other transportation (maritime and rail), nuclear industry, mining, and healthcare (Hulme et al., 2019; Stein & Heiss, 2015).

Reason divided all errors (“holes” in cheese slices) into two classes. One was “*active errors*, associated with the performance of the ‘front-line’ operators of a complex system” and “whose effects are felt almost immediately” (Reason, 1990, p. 173). For purposes of discussing OR fire prevention, these would be fire-causing mistakes or failures to follow policy during surgery on the part of a surgeon, anesthesiologist, CRNA or other personnel working in the operating room. Another type of errors were “*latent errors,* whose adverse consequences may lie dormant within the system for a long time, only becoming evident when they combine with other factors to breach the system’s defences [sic]” (Reason, 1990, p. 173). For the purposes of this project, these would be errors in provider training, equipment malfunction, poor quality control, oversights and deficiencies in institutional policies and protocols.

In other words, the failures could result both from inadequacies in the design of the system, as well as from failing to follow protocol when it is well-designed (Buist, 2018). In an interview with Reason published in 2012, he contended that one of the failures which may lead to an error is “inadequate tools” (Peltomaa, 2012, p. 60). Conversely, a well-functioning and well-designed tool may be helpful in reducing the risk of a major adverse event. This DNP project focuses on delivering a tool that seeks to be helpful and effective in assessing the risk of OR fires.

The SCM is a theoretical framework that helps understand errors and prevent them from reoccurring. The model could be viewed as an instrument for root cause analysis, which is defined as “a set of tools to guide investigation, analysis, and action, ultimately aimed at preventing future errors” (Zastrow, 2015, p. 227).

A crucial component of the framework is a non-punitive, just culture, defined as “an environment where workers feel safe enough and accountable enough to engage in the prevention of errors. This culture encourages individuals to speak out for improvement and gives them the freedom to identify errors or opportunities for improvement without reproach” (Stein & Heiss, p. 280). A just culture encourages individuals to discover, report and correct errors and is essential to maintain patient safety. Developing and using a fire assessment tool as part of this DNP project fits well into Reason’s Swiss cheese model. It encourages open communication between surgeons and CRNAs and focuses on preventing an error from ever occurring.

Ethical Consideration & Protection of Human Subjects

This quality improvement project was deemed as exempt from full review through a process created in conjunction with the East Carolina University and Medical Center Institutional Review Board and the partnering organization. Their approval form, with identifying information redacted, is reproduced in Appendix F. The project included no patients or patient data and required no specific approval for working with human subjects. Participants were all CRNAs working within their normal scope of practice who voluntarily chose to participate in this project. All activities fell within existing practice within the organization. The suggested tool was used by participating CRNAs on surgical cases without discrimination by race, gender, or other individual characteristics of the surgical patients. No more than minimal risk for participants was anticipated, with identified risks related to the novelty and initial stress of learning to use the tool and the potential need for some extra time required to do so. Such risk falls well within the usual risks associated with the normal functioning of this organization. Additionally, all researchers had successfully completed the Collaborative Institutional Training Initiative (CITI) Modules related to responsible conduct of research by biomedical investigators.

Section III. Project Design

Project Site and Population

Description of the Setting

The facility where this project was implemented, a large hospital with 35 operating rooms, performs many thousands of surgical procedures every year. It is part of a larger organization which includes multiple hospitals of various sizes, as well as specialized surgical centers. Only CRNAs working with adult patients requiring a surgery above the xiphoid process participated in this project.

The walls of every operating room display a large, locally created poster labeled “Time Out!” which lists 12 items and requires that “the entire team must acknowledge agreement by stating I agree.” These items include confirmation of consent, procedure, availability of implants, equipment, blood, anticipated specimens, correct site identification, and others. There is no mention of fire. There is another office board on the wall of the OR entitled “Time Out” which lists 13 items that all must agree upon (adding “BOVIE” to the items from the other list), but again, not specifically addressing preoperative fire assessment or fire in any context.

Description of the Population

The target population for this project included all CRNAs working in this hospital location in early 2021. As part of the CRNA curriculum, this researcher has witnessed multiple surgeries, and has observed numerous fire risk assessments, most often initiated by the surgeons performing a timeout. CRNAs are involved in preoperative timeout when the patient’s identity, procedure, site of surgery, consent, allergies and other factors (NPO status, risk factors, antibiotic administration) are verified and verbally confirmed by all present, which includes the surgeon, OR nurses and technicians, and CRNAs. The observation of this researcher is that specific fire risks are sometimes, but not always, verbally communicated, and that such communication depends on the physician performing the surgery.

Project Team

In late 2020 this researcher, working in conjunction with three other doctoral students, developed a fire risk assessment tool, based upon accepted national guidelines, as part of a quality improvement project. The team implementing this quality improvement project was made up of a student registered nurse anesthetist (SRNA), a clinical CRNA faculty member, a CRNA faculty member who served as the project chair and content specialist, the CRNA program director, as well as the department's site manager. An additional faculty member coordinated development and implementation. Initial development of the project was accomplished in cooperation with three additional students addressing the same clinical issue. The primary SRNA took the lead in regard to implementing the educational tool, administering surveys addressing assessing participant perceptions, and analyzing the survey data.

Facilitators and Barriers

It was anticipated that the project would be faced with both acceptance and, as is common with any novel process, a degree of resistance. The factors perceived as potentially supporting the implementation of the guide included the following:

- A relatively large number of CRNAs who are themselves recent graduates from a similar CRNA program and who are aware of the academic expectations being placed on current students. From conversations with these CRNAs, this researcher found them to be sympathetic to these requirements imposed on the current students by their programs and overall open to new research and adjustments in care.

- Lack of a definitive and consistent current process to identify high risk procedures was seen as a possible motivator for the CRNAs to embrace the developed guide. The guide presented in this paper was filling a need that was not being met.
- The guide and the risk assessment algorithm presented as part of this project were seen as sufficiently simple to be implemented easily. The guide had only three items that needed to be scored either as 0 or 1. It did not require a lot of time to become familiar with, and could have been done easily in one's head, without need for supplementary materials, paper, writing instruments and so on.

The following barriers to the implementation of the guide were also anticipated. Firstly, the barriers related to the use of phones:

- Some CRNAs might have been reluctant to use personal phones for viewing links related to work.
- It was not clear ahead of time how exactly the guide would look on various models of phones with different capabilities and screen resolutions. Would scrolling be required? Would the text be too small to be readable without zooming in? Poor usability and accessibility could have limited the usefulness of the proposed guide.
- It was thought that internet access and download speeds might have been limited in certain parts of the hospital at certain times, particularly in some ORs where the wi-fi signal might not be very strong.
- Low battery power and the need to conserve the battery, especially at the end of the day, were also seen as a possible barrier to use of the guide by the CRNAs.

In addition to barriers specific to phone usage, we anticipated some obstacles related to lack of time. Using the guide added another task to the already busy schedule of the CRNAs, particularly in the beginning of surgery. Additionally, surgeries that carried the highest risk of fire (those close to the face, as well as the surgeries requiring an open oxygen source) might have demanded more attention from the CRNAs (related to special positioning, use of additional equipment, special draping) and thus would be competing more acutely for the time needed to use the guide.

Another anticipated barrier related to lack of time was distractions inherent in CRNA work. There might have been competitions from important patient safety alarms requiring the CRNAs' immediate attention (patient condition monitors, communication with the physician, urgent tasks). These might have prevented some CRNAs from completing the guide during some surgeries, even if they attempted to or intended to utilize it.

Additionally, there were barriers related to novelty and unfamiliarity. These were related to inertia and were believed to be inherent in the introduction of any new process, particularly when its value to the participants (practicing CRNAs) was not immediately obvious.

This project was developed at the time of national, regional and institutional restrictions related to the spread of COVID-19. Communication with the participants was limited due to cancelation of in-person department meetings and other gatherings. Explanation of the project objectives and other essential communication was done remotely, via electronic mail and submissions via the internet. Face-to-face communication could only happen with social distancing and while wearing facial masks. Overall, such interpersonal restrictions had potential to serve as an additional barrier to motivating participants to embrace this project.

Our intervention period spanned a period of two weeks. This short time frame could also be viewed as one of the barriers to the quality of the project and the collected data. On the one hand, certain CRNAs may not have had enough time to either read the explanatory emails or respond to surveys. On the other hand, the initial response rate may be artificially higher than the guide utilization rate in ongoing daily practice. In other words, even if our guide received considerable initial acceptance, it was not clear whether its perceived usefulness would persist over time and become part of standard practice.

Project Goals and Outcome Measures

The goal, or purpose, of this quality improvement project was to assess anesthesia providers' perceptions of adequacy of a newly developed perioperative fire prevention guide using a pre-test/post-test design.

The tool consisted of a one-page single-sided portable document format (PDF) file. It included a three-question fire risk assessment checklist (scoring risk points for the presence of oxygen, ignition source and surgery above the xiphoid process) and specific recommendations for high-risk cases. The guide is included as Appendix G.

The participants were asked to report their opinions on using the guide and rate its usefulness. In the pre-intervention survey, the CRNAs were asked whether they already had a fire risk assessment guide and how quickly they could locate one if necessary, how confidently they felt regarding their knowledge about fire prevention, and how often they worked with high-risk procedures. In the post-intervention survey, the participants were asked if they found the tool useful, easily accessible, visually appealing, time-saving, and were again asked to evaluate their confidence in their knowledge about fire prevention. They were also offered an opportunity to write in an open ended response with possible recommendations on how to improve the developed assessment guide.

Description of the Methods and Measurement

The method utilized for this quality improvement project was pre-/post-survey addressing participants' perceptions of usefulness of this tool. A clinical faculty member familiar with the organization recruited participants for this project and obtained a list of their email addresses. This researcher, working with others, used Qualtrics software to develop two questionnaires directed to the participants: one to be completed before, and the other one after a two week intervention period (later extended to three weeks) during which the CRNAs were asked to use the developed tool in their normal practice.

The initial questionnaire addressed the providers' confidence and experience dealing with surgical fires and conducting fire risk assessments in their practice. It consisted of nine questions, with responses measured on the binary yes/no basis or graded on a Likert scale. This pre-intervention assessment is found in Appendix H. In May 2021, an email with a link to the pre-questionnaire, the newly developed perioperative fire prevention guide, and an educational video about the use of the newly developed guide recorded via a public online platform called prezi.com was sent to the CRNAs participating in the study. They were asked to initially complete the pre-survey questionnaire, review the information on the video, and then use the tool for three weeks in their daily practice. Upon completion of the three-week utilization, the participating CRNAs were asked to complete a questionnaire about their perceptions of the adequacy of the tool. Qualtrics survey software was used to deliver the intervention link and gather the participants' self-report of perceptions of acceptability and adequacy of the developed guide. No patient information was collected or maintained during this project. This second questionnaire similarly consisted of nine questions, four of which with yes/no type of answers, two Likert scale questions measuring the perceived usefulness of the tool and the self-reported knowledge about perioperative fire risks, and one open-ended question seeking recommendations for improving the guide. The post-intervention questionnaire is found in Appendix I.

Discussion of the Data Collection Process

In May 2021, the guide was emailed to the participants as a PDF file. In the accompanying letter, the participants were invited to watch an educational video explaining the purpose and format of the project. Additionally, they received a link to complete the pre-intervention Qualtrics questionnaire. The participants were asked to respond to the pre-questionnaire before viewing the video or beginning to use the developed fire risk assessment guide in their practice. Three weeks after the email containing the initial invitation, the intervention materials, and the link to the pre-questionnaire, the participants were sent a second email thanking them for their participation and asking them to complete the post-questionnaire. Both pre- and post-questionnaire responses were similarly collected using the Qualtrics software.

Implementation Plan

In summary, as described above, once the fire risk assessment guide was prepared based on the best available literature, it was sent to CRNAs in this organization together with the link to a brief video demonstrating its suggested use. CRNAs were initially asked to self-report their confidence and knowledge of existing fire prevention guidelines, and then requested to use the prepared tool in their practice for three weeks. Subsequently, feedback was collected on its perceived usefulness and recommendations sought on its possible improvement.

Timeline

The preliminary work on this project started in May of 2020. After the topic was chosen, the work continued with selecting the nursing framework and performing the initial review of literature. In the fall of 2020, the literature review was completed and a basic project plan was developed. Based on review of literature, a fire risk assessment guide was developed and the introductory video was recorded in March of 2021. The prepared assessment tool was offered to CRNAs to use in their practice in May 2021. The feedback was collected in June 2021 and data analyzed later in the summer of 2021. The more complete timeline for this project is found in Appendix J.

Section IV. Results and Findings

Results

Results from this project were obtained by evaluating feedback forms collected from five different CRNAs. The names and email addresses of the participants were obtained from the clinical faculty member who served as the on-site coordinator for this project. In May 2021, the CRNAs were invited to use the assessment guide and to leave their feedback using pre- and post-intervention questionnaires. Five responses were subsequently collected for the pre- and five for the post-intervention questionnaires. Initially, the data collection was intended to last for two weeks. However, one CRNA received the initial invitation later than the other four, some participants were slow to respond to the survey invitation, and at least one may have had delays with email delivery. Consequently, the time the CRNAs were asked to use the guide was extended to three weeks, and the data collection time period was extended to four weeks to give all CRNAs for at least three weeks to use the guide and to respond to surveys.

All responses were gathered via anonymous Qualtrics links. No demographic data was collected. Pre- and post- responses were not connected to each other, and it was impossible to tie individual responses before and after the use of the guide to specific participants. Due to the nature and amount of the data collected, inferential statistical analysis was not performed. Only descriptive statistical methods were utilized. The final sample size was five CRNAs.

Analysis

The pre-survey results showed that all (n=5) CRNAs had received continuous education about perioperative fire prevention. None of the participants had ever experienced a perioperative fire, which was neither an unexpected, nor an unwelcome finding, given the rarity of this undesirable outcome. Nevertheless, all had participated in procedures which would have been identified as carrying high risk for perioperative fire, i.e. where an element of the ignition was present in close proximity to a source of oxygen, and the surgery was performed above the xiphoid process.

Most CRNAs reported themselves either as “very confident” (2 out of 5), or “confident” (2 out of 5) in identifying a high-risk procedure. One response was neither confident nor non-confident. All five agreed that an easily accessible reference guide would be helpful in decision-making in high-risk procedures.

Lastly, the time the CRNAs expected it would take to find reference material related to a surgical fire varied. Three out of five expected it would take 4-6 minutes, whereas one thought it would take less time (1-3 minutes) and one more time (7-9 minutes).

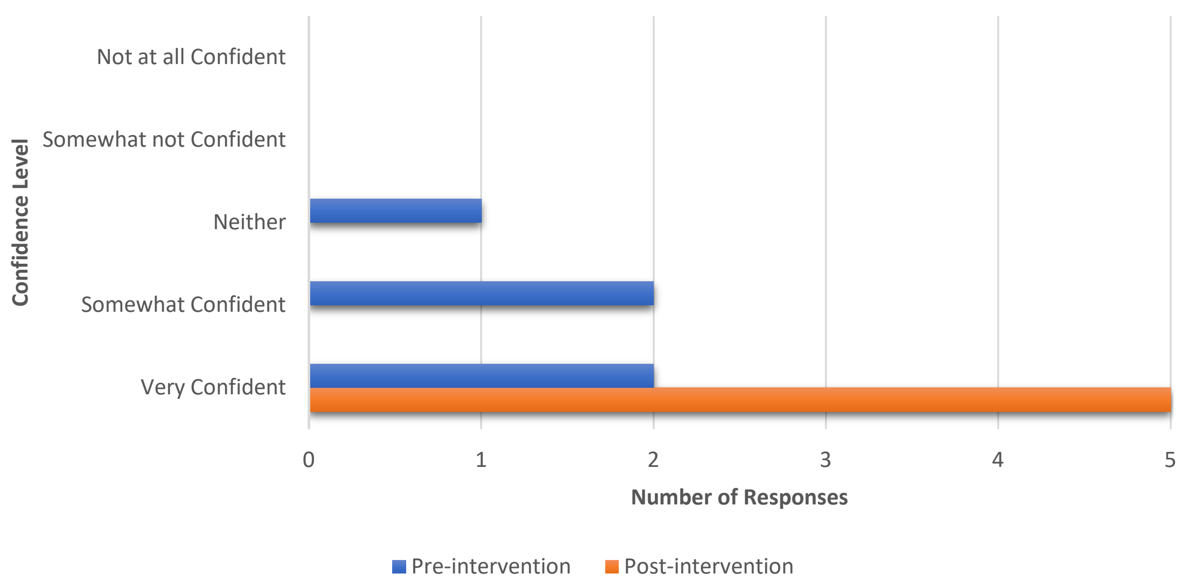
The post-intervention surveys, completed four weeks after the initial invitation to participate in the project, asked the CRNAs to estimate the number of procedures (over a three-week period during which they participated in the project) which could be classified as high-risk. Almost all (4 out of 5) indicated the number of 6-8 procedures, whereas one reported 3-5 procedures over three weeks. These are the cases where the guide developed as part of this project could be useful. Four out of five perceived the guide to be “very useful” for an anesthesia department, and the remaining one marked it as “useful”. The guide was found to be easily accessible in the clinical setting, visually appealing, and time-saving by all of the participants. All reported that they would use it in their practice as CRNAs. After the intervention, everyone (5 out of 5) felt “very confident” in their knowledge about perioperative fire prevention. If saved to the mobile phone or work computer, all participants selected the option that the reference guide would take only 1-3 minutes to access, the shortest time interval offered on the post-survey questionnaire.

Only one participant offered a free-text response in answer to a question soliciting recommendations for improving the guide. However, the response itself did not truly provide a recommendation. Rather, it stated that the participant found the guide useful: "The recommendations we [sic] very useful and reminded me the importance of preventive techniques that should be used in high rush [sic] cases."

Comparisons of pre- and post-intervention questionnaires indicates that the potential usefulness of the guide, as well as of the educational intervention that accompanied it, lies in increasing the confidence of the participants in their knowledge about the risks of perioperative fires. While only two out of five responders were "very confident" before the introduction of the guide, all five responded as "very confident" in the subsequent post-intervention self-assessment. The comparison allows for a conclusion that the participants who lacked confidence before working with the guide were now very confident about dealing with an operative fire.

Figure 1

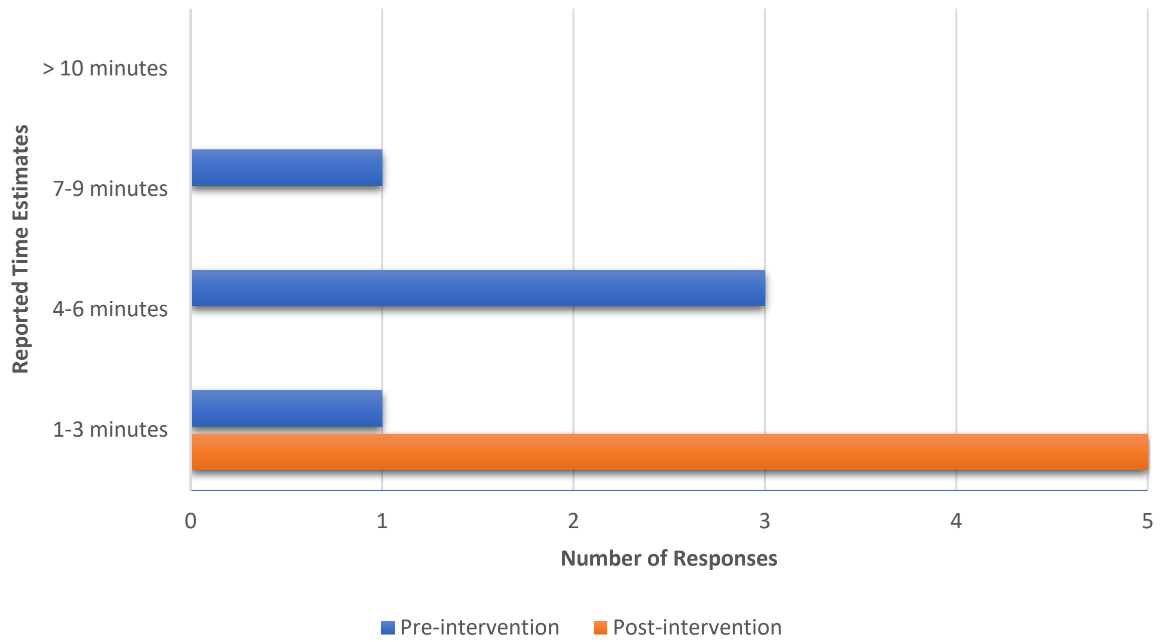
How confident are you in your knowledge about perioperative fire prevention? (n=5)



An additional benefit of the guide could be seen in comparing the ease of access and the time it would take to use the guide. Prior to the intervention, most CRNAs thought it would take them 4-6 minutes (3 out of 5) or 7-9 minutes (1 out of 5) to find the necessary information. Only one participant expected to find the needed reference material within 1-3 minutes. After the intervention, all 5 participants responded that it would only take them 1-3 minutes to access the guide if it were saved on their phone or on a work computer.

Figure 2

How long do you think it would take you to find reference material to answer the question? (n=5)



Overall, based on the obtained responses, the offered assessment guide seemed to have been well received. It has potential for saving time and increasing CRNA confidence in assessing risks and in dealing with high-risk procedures.

Section V. Interpretation and Implications

Cost-Benefit Analysis

The financial costs to implement this project were not high, close to zero dollars. No tangible supplies needed to be purchased (stationery or consumables). All communications, the educational video about the intervention, and subsequent evaluations, were performed online. The organization was using computers, email accounts and other software that was already available. The participants were likely using their personal phones to use the guide and watch the introductory video, but it was possible to access those from the work computers without any additional costs. This author did not pay licensing fees for access to the data analytics software (Qualtrics), which was provided freely via the school account. The number of participants in this study was small (n=5), which did not require or warrant considerable resources to tabulate and analyze the data. The data was exported from the Qualtrics software into Microsoft Excel, access to which was provided to this researcher via the university free of charge. Similarly, the organization itself has existing Qualtrics subscriptions and access to Microsoft Excel.

The financial benefits for the organization are not easy to quantify. Because ideally OR fires must never occur, and because the costs of even one fire may be catastrophic (not only to property, but to health, life and wellbeing of patients), if this intervention and guide were to help prevent even one surgical fire the minimal costs of implementation would pay for themselves many times over.

Award payouts to patients affected by surgical fires have been reported in the literature. In their review of litigation related to surgical fires and operative burns, Choudhry et al. (2017) reported a median award payout of $215,000 in 54 cases awarded in favor of the plaintiff ($249,000 on average in a case with a positive verdict and $148,200 in cases with settlements /

arbitrage). In each case where an operative fire could have been prevented, hundreds of thousands of dollars could have been saved.

Apart from possible financial savings, the developed guide may have some intangible benefits. Because the participants mostly referred to the guide positively (visually appealing, time-saving, easy to access), the availability of this guide could have a positive effect on morale, increased quality assurance, increased confidence of the employees in their ability to deal with a difficult and potentially dangerous situation, and perhaps an increased satisfaction from working for an organization which focuses on quality and process improvement and patient safety. On the other side, there is very little downside to using and implementing this guide.

Resource Management

Most of the costs in implementing this project would come from employee time performing literature research to find the best available evidence for fire preventions, as well as from preparing and introducing the newly-developed guide. In practice, as the participants themselves reported in this project, it takes a miniscule amount of time (1-3 minutes) to access and use the guide when needed. The given answer (1-3 minutes) was the smallest available option on the post-intervention survey, and it was selected by all the participants. The reality may be that the actual time is even shorter than 1 minute, and with time and familiarity the guide could be accessed within a few seconds. The time saved by having an easily accessible guide might translate into savings of work time, particularly for those CRNAs who were less confident they could easily locate the reference material related to perioperative fires.

Implications of Findings

This project was designed with the ultimate goal of improving patient safety. The developed risk assessment guide was envisioned as a tool that could be used by CRNAs in their daily practice consistently and routinely on all patients undergoing surgery. The development of the tool incorporated the best available evidence for recognition of high-risk procedures and ways to reduce those risks. The Triple Aim specifically calls on medical providers to "share best practices and proven approaches" in improving healthcare (Institute for Healthcare Improvement, n. d., para. 2), and this guide aims to do exactly that.

The APSF urges providers to "safely manage ignition sources", "safely manage fuels", to "minimize concentration of oxidizer", to communicate clearly, and to identify high-risk procedures (APSF, 2013, para. 7, 8). The developed guide incorporates all their recommendations and ties them into an assessment tool built around the fire triad. The AANA acknowledges that traditionally CRNAs have been viewed as having most control over the oxidizer part of the fire triangle; however, developing situational awareness about all three components of fire is essential for all members working in the operating theater: "Knowledge by an individual provider of a specific arm of the fire triangle is fundamental to preventing surgical fires; however, individual knowledge is not enough. The proposed certification program builds on this foundation and shifts the paradigm from individual provider roles for surgical fire prevention to prevention that is the shared responsibility of the entire surgical team" (Fisher, 2015, p. 272). Our guide, when used during preoperative timeouts, allows for the entire team to communicate their awareness of surgical fire risks and to share responsibility for the patients' safety. AANA's Standard VI describes proper use of equipment to minimize risk of fire, whereas Standard IX prescribes effective communication and collaboration among team members, and our tool draws attention to the importance of following these standards (AANA, 2019).

Implications for Patients

Patients were not the participants in this project. The developed tool could be used for any patient without discrimination. Ultimately, the role of CRNA professionals is to provide anesthetic care for patients who require it. When CRNAs have adequate tools for their job, and when the processes they implement are safe and efficient, the patients benefit by having better outcomes, shorter hospital stays, reduced risks of injury from operative fires, and assurances that safeguards exist that protect them. Having a reliable and easy-to-use fire risk assessment tool serves as an additional "slice of cheese", as it were, guarding them from harm (Reason, 1990).

The Triple Aim places its focus on improving the health of the population at large, with emphasis on high-risk and high-cost groups (Institute for Healthcare Improvement, n. d.). Almost anyone who requires a surgery under anesthesia automatically incurs a high cost and, at least for the duration of surgery, is totally vulnerable and dependent on others to protect their life and health. The surgeries identified by the best available evidence as high risk for operative fires – those above the xiphoid process with the need of supplemental oxygen and an electrocautery device – are sometimes very complex and long procedures, for example, surgeries involving neck resections, thyroid gland excisions, lung and airway repairs. The developed tool would be the most useful in those types of procedures, serving as a reminder to maintain appropriate precautions in high-risk groups.

Additionally, both the Triple Aim and the Healthy People 2030 federal program place emphasis on effective communication among providers. The perioperative fire risk assessment tool is designed specifically to improve such communication. If used routinely during preoperative timeouts, it could be used to systematically and reliably communicate the existing fire risk to all providers present in the operative room.

Implications for Nursing Practice

The quality improvement project discussed in this paper is not the only available perioperative fire risk assessment guide in existence. As indicated earlier in this paper, literature review identified a similar project which tested a fire risk assessment tool developed in a hospital in the United Kingdom (Parremore, 2019). Tola et al. (2018) designed and implemented a quality improvement project in an ambulatory surgical center which educated providers about risks of perioperative fires. This shows that a need for a tool similar to the one described in this project is recognized by other organizations. Accordingly, a nationally recommended and validated fire risk assessment guide may eventually be adopted and incorporated into standard anesthesia nursing practice with support from the ANA and the AANA. Before this is done however, national guidelines from the ECRI institute, the APSF, the FDA, the AANA, as well as from the colleagues in the ASA are being refined continuously, leading to gradual improvement of nursing practice.

The Swiss cheese model encourages participants to build multiple layers of protection against processes that carry high risks (Reason, 1990). It specifically mentions well-functioning tools as one such reliable defense (Peltomaa, 2012). Additionally, there is ample evidence that perioperative use of checklists is associated with improved patient safety and reduced mortality (Biccard et al., 2016; Walker et al., 2012). The World Health Organization advocated for "anesthesia safety checks before any anesthetic" (WHO, 2009, p. 20). The use of the perioperative fire risk assessment tool developed as part of this project can serve as a simple checklist that urges providers to systematically and sequentially check for risk of fire before every anesthetic procedure, and can be viewed as a "slice of cheese" in Rosen's model (Reason, 1990).

Impact for Healthcare System

The scope of this project was limited, directly engaging only five participants in only one organization. Nevertheless, the organization provides care for thousands of patients in multiple surgical locations in southeastern United States. If the tool were to be adopted throughout the entire healthcare system, the potential time savings and reduction in risk of operative fires could benefit a very wide population.

Sustainability

The project can be implemented and sustainably maintained without much additional expenditures. The fire risk assessment tool is already complete and has already been used clinically, albeit in a limited population. The anticipated barriers such as reluctance by CRNAs to use personal phones for a work-related project, or a potential lack of time, did not appear to hinder its application. As mentioned in the cost-benefit section, the use of the tool does not require any running costs such as printed materials or other consumables. The project does not require purchase of any equipment and can be utilized on the already existing computer workstations and communication networks.

The organization may need to devote some resources to educating staff about the availability of the tool. This may be done via email or during one of the periodically held staff meetings.

Dissemination Plan

Once this project was complete, a summary of its design, methods and outcomes was published in a poster. This poster was presented in the College of Nursing to a wide nurse-anesthesia audience. The participants in this project were made aware of the presentation, and invited to attend either in person or via Zoom. Additionally, this paper will be made available electronically through the East Carolina University online repository The ScholarShip.

Section VI. Conclusion

Limitations

One of the limitations of this study is the small number of participants (n=5). It is difficult to draw meaningful conclusions from the answers provided by such a small pool of people. As a consequence of the small sample size, we did not perform any inferential statistical analysis and the amount and strength of our results and conclusions is limited.

Another limitation is that the data collected were self-reported by the participants and not otherwise observed or objectively recorded by the researcher. Self-reports are useful in identifying perceptions, but may be of limited use to establish the real state of the aspects of practice under investigation. For example, it is impossible to know whether the CRNAs actually used the developed tool and over how many cases. Some of the questions on our questionnaires dealt with hypothetical situations (i.e. "if the guide was saved to your phone or work computer, would it be easy to access?"). The provided answers allowed us to evaluate the perception of usefulness of the tool, but did not actually allow us to know if the tool was being used in practice, and whether it was easy to access, or not.

Another limitation is related to the limited time over which the data were being collected. Originally, the post-intervention survey was intended to be mailed to the participants in two weeks after the initial invitation. However, it was discovered that not all participants regularly checked their email accounts, and one may have had problems with email deliveries. Additionally, some CRNAs may have been off for some of the time during which the data collection was taking place. This limited their opportunities to use the tool in clinical practice. Even if the participants did utilize the tool for the established timeline of two weeks (later extended to three weeks), it was still a relatively short period to consistently evaluate its usefulness.

Recommendations for Others

After the completion of this project, it seems reasonable to recommend a similar project with a much larger sample size. This would allow for making meaningful and generalizable statistical computations, as well as for finding possible connections between certain demographic characteristics of the participants (i. e. age, years of experience, acuity of cases, typical number of high-risk cases) and attitudes towards using the perioperative fire risk assessment tool, as well as reported confidence and expertise in dealing with operative fires.

Clear communication with the participants is also crucial. It was discovered that not everyone checked their emails regularly, and invitations to participate in a project sometimes looked like a spam message (quickly to be dismissed) to some participants.

Recommendations for Further Study

The literature review lends strong support to the view that simulations are the best way to train providers to respond to perioperative fires (Cant & Cooper, 2017; Dorozhkin et al., 2017; Kishiki et al., 2019; Sankaranarayaran, 2018; Wood, 2015). Further studies should incorporate the perioperative fire risk assessment tool into a larger simulation preparing CRNAs to accurately respond to high-risk situations and to deal with possible perioperative fires.

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Appendix A

Literature Search Terms and Strategy

Keywords, PubMed MeSH and CINAHL Subject headings Used for Literature Searches

	Concept		
	Operating room	fire	Risk assessment tool
Keywords	Operating room Surgical Intraoperative	fire	Assessment tool
PubMed MeSH	Surgical procedures, operative Intraoperative care operating rooms	fires	Cognitive aid Cues
CINAHL Subject headings	nurse anesthetists surgical fires	fires	

Appendix B

Search Strategy

Search date	Source	Terms searched	Dates	Sources returned	Sources selected
10/17/2020	CINAHL	(MH "Surgical Fires")	Since 2016 (2016-2020)	39	16
10/17/2020	PubMed	((operating rooms) OR (intraoperative care) OR (surgical procedures, operative)) AND fire AND ((assessment) OR (assessment tool))	In the last 5 years (2015-2020)	96	5
10/17/2020	East Carolina University Libraries OneSearch	"surgical fire" "assessment tool"	Last 5 years (2015-2020)	25	7
10/17/2020	ProQuest Search	surgical fire assessment tool	Last 5 years (2015-2020) Scholarly Journals Full text Peer Reviewed Subject: surgery Subject: hospitals	19	2
10/18/2020	ProQuest Search	noft(fire) AND noft(operating room)	Last 5 years (2015-2020) Peer reviewed	42	4
10/17/2020	Google Scholar	(surgical) AND (fire) AND (operating room) AND (assessment tool)	Since 2016 (2016-2020) Reviewed first 5 pages of the results	About 18800	16

Appendix C

Literature Matrix

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Akhtar, N., Ansar, F., Baig, M. S., & Abbas, A. (2016, January-March). Airway fires during surgery: Management and prevention. *Journal of Anaesthesiology Clinical Pharmacology, 32*.	VI	A case report of a surgical fire on a pediatric patient undergoing an adenotonsillectomy.	Surgeries with supplemental oxygen above the xiphoid carry additional risk;	An example of a high-risk surgery.
American Association of Nurse Anesthetists [AANA]. (2019). *Standards for Nurse Anesthesia Practice*. American Association of Nurse Anesthetists.	VII	Expert-established guidelines.	Guidelines for CRNAs to comply with.	Standard VI describes proper use of equipment to minimize risk of fire. Standard IX prescribes effective communication and collaboration.
APSF Fire Prevention Algorithm now available as a poster download. (2013). APSF Newsletter, *28*.	VII	Expert-established guidelines.	High-risk procedures identified.	Used to develop own fire assessment tool.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Biccard, B. M., Rodseth, R. N., Cronje, L., Agaba, P., Chikumba, E., Toit, L. du, Farina, Z., Fischer, S., Gopalan, P. D., Govender, K., Kanjee, J., Kingwill, A. C., Madzimbamuto, F., Mashava, D., Mrara, B., Mudely, M., Ninise, E., Swanevelder, J., & Wabule, A. (2016). A meta-analysis of the efficacy of preoperative surgical safety checklists to improve perioperative outcomes. *South African Medical Journal*, *106*(6), 592–597.	I	A meta-analysis of three randomized controlled studies covering 6060 patients found decrease in hospital complications (respiratory, cardiac, infectious and perioperative bleeding) when surgical preoperative checklists are used.	Use of preoperative checklists is associated with surgical safety and reduced mortality in tertiary and community hospitals.	Used to justify our intervention in development of a fire risk assessment checklist.
Buist, M. (2018). Adverse events in hospitals: "Swiss cheese" versus the "hierarchal referral model of care and clinical futile cycles". In S. P. Stawicki & M. S. Firstenberg (Eds.), Vignettes in Patient Safety-Volume 3. IntechOpen.	VII	Use of the Swiss cheese model in describing hospital adverse events.	The SCM can be used effectively.	Evidence in support of choosing the Swiss cheese model to describe and prevent hospital errors.
Cadman, V. (2016). The Impact of Surgical Safety Checklists on Theatre Departments: A Critical Review of the Literature. *Journal of Perioperative Practice*, *26*(4), 62–71.	V	Checklist use is associated with safety, perceptions of safety, effective team communication, perception of teamwork. There is also association with perceived delays and increased workload.	Use of preoperative checklists is associated with reduced morbidity and mortality, improves communication and reduces operating time.	Used to justify our intervention in development of a fire risk assessment checklist. Helps anticipate barriers to implementation, such as perceived increased workload and delays.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Cant, R. P., & Cooper, S. J. (2017). Use of simulation-based learning in undergraduate nurse education: An umbrella systematic review. *Nurse Education Today*, *49*, 63–71.	V	Umbrella review of 25 systematic reviews comprising over 700 primary studies found that simulation-based education contributes to learning.	Simulation-based learning could be used to train fire risk reduction.	Simulation was not used in this project due to study limitations as discussed in the text.
Caplan, R. A., Barker, S. J., Connis, R., Cowles, C., de Richemond, A. L., Ehrenwerth, J., Nickinovich, D. G., Pritchard, D., Roberson, D., & Wolf, G. L. (2008). Practice Advisory for the Prevention and Management of Operating Room Fires. *Anesthesiology: The Journal of the American Society of Anesthesiologists*, *108*(5), 786–801.	VII	Expert-established guidelines.	Guidelines for anesthesia providers to comply with.	Used to justify our intervention in development of a fire risk assessment checklist.
Choudhry, A. J., Haddad, N. N., Khasawneh, M. A., Cullinane, D. C., & Zielinski, M. D. (2017). Surgical Fires and Operative Burns: Lessons Learned From a 33-Year Review of Medical Litigation. *The American Journal of Surgery*, 213(3), 558–564.	V	139 operative burns and 25 surgical fires analyzed as described in litigation literature. The most common site of injury was the face. The most common source of injury was a high-energy device.	High risk procedures can be identified ahead of time based on the site of surgery and use of a source of ignition.	Evidence was used in developing the tool and identifying high-risk procedures.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Coletto, K., Tariman, J. D., Lee, Y., & Kapanke, K. (2018). Perceived Knowledge and Attitudes of Certified Registered Nurse Anesthetists and Student Registered Nurse Anesthetists on Fire Risk Assessment During Time-out in the Operating Room. *AANA Journal*, *86(2)*, 99-108.	VI	140 volunteer responders to a questionnaire from among 1600 active members of the Illinois Association of Nurse Anesthetists reported positive attitudes towards using a fire risk assessment tool but also perceived knowledge deficit on the use of an assessment checklist.	Checklists could be used effectively but barriers to use must be investigated and addressed.	Used to support the use of an assessment checklist.
Davis, L. B., Saxen, M. A., Jones, J. E., McGlothlin, J. D., Yepes, J. F., & Sanders, B. J. (2018). The Effects of Different Levels of Ambient Oxygen in an Oxygen-Enriched Surgical Environment and Production of Surgical Fires. *Anesthesia Progress*, *65*(1), 3–8.	VI	Thirty trials using 16 different experimental intraoral fire ignition models prepared from gutted raw chickens showed positive correlation between higher oxygen concentration and flow rates and incidences of fire. No combustion occurred with oxygen flows less than 4L/min.	Higher oxygen content is associated with a higher risk of fire.	Helps identify high risk procedures as those using higher concentrations and flow rates of oxygen in close proximity of an ignition device.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Day, A. T., Rivera, E., Farlow, J. L., Gourin, C. G., & Nussenbaum, B. (2018). Surgical Fires in Otolaryngology: A Systematic and Narrative Review. Otolaryngology–Head and Neck Surgery, *158*(4), 598–616.	V	Review of 72 studies describing 87 otolaryngologic surgical fire cases found lapses in adoption of already established guidelines on minimizing risks of fires.	Improved fire safety practices are necessary in individual institutions. Established recommendations are not always followed, leading to adverse events.	Supports the need for a systematic adoption of a assessment and prevention tool.
de Jager, E., McKenna, C., Bartlett, L., Gunnarsson, R., & Ho, Y.-H. (2016). Postoperative Adverse Events Inconsistently Improved by the World Health Organization Surgical Safety Checklist: A Systematic Literature Review of 25 Studies. *World Journal of Surgery*, *40*(8), 1842–1858.	V	Some but not all of the 25 reviewed studies (including 2 RCTs, 13 prospective and 10 retrospective cohort trials) showed positive effects from using WHO-recommended surgical checklists on decreasing operative adverse events.	The checklists may be associated with reduction in adverse surgical events.	Used in support of development of the fire risk assessment tool.
Deutsch, E. S., & Straker, T. (2019). Patient Safety in Anesthesia. *Otolaryngologic Clinics of North America*, *52*(6), 1005–1017.	VII	Simulation-based training helps identify potential problem areas, improves communication.	Simulation-based learning could be used to train fire risk reduction.	Simulation was not used in this project due to study limitations as discussed in the text.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
de Vries, E. N., Prins, H. A., Crolla, R. M., den Outer, A. J., van Andel, G., van Helden, S. H., Schlack, W. S., van Putten, M. A., Gouma, D. J., Dijkgraaf, M. G., Smorenburg, S. M., Boermeester, M. A., & SURPASS Collaborative Group. (2010). Effect of a comprehensive surgical safety system on patient outcomes. *New England Journal of Medicine*, *363*(20), 1928-1937.	III	Six hospitals adopted checklist use in the entire surgical process. The study compared complication rates in 3760 surgical patients at baseline (3 months prior to the intervention) with complication rates in 3820 surgical patients 3 months after the implementation of checklists. Proportion of patients with complications decreased from 15.4% to 10.6%.	Adoption of checklists can lead to reduction of surgical complications.	Used in support of development and adoption of a preoperative fire risk assessment checklist.
Di Pasquale, L., & Ferneini, E. M. (2017). Fire Safety for the Oral and Maxillofacial Surgeon and Surgical Staff. *Oral and Maxillofacial Surgery Clinics of North America*, *29*(2), 179–187.	VII	Established guidelines for ensuring fire safety when performing oral and facial surgeries.	High-risk procedures identified.	Used to develop own fire assessment tool.
Emergency Care Research Institute (2009). New clinical guide to surgical fire prevention. Patients can catch fire--here's how to keep them safer. *Health devices*, *38*(10), 314–332.	VII	Expert-established guidelines.	High-risk procedures identified.	Used to develop own fire assessment tool.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Food and Drug Administration (2011, December 9). *FDA and Partners Working to Prevent Surgical Fires*. U.S. Food and Drug Administration.	VII	Expert-established guidelines.	High-risk procedures identified.	Used to develop own fire assessment tool.
Haynes, A. B., Weiser, T. G., Berry, W. R., Lipsitz, S. R., Breizat, A. H., Dellinger, E. P., Herbosa, T., Joseph, S., Kibatala, P. L., Lapitan, M. C., Merry, A. F., Moorthy, K., Reznick, R. K., Taylor, B., Gawande, A. A., & Safe Surgery Saves Lives Study Group. (2009). A surgical safety checklist to reduce morbidity and mortality in a global population. *New England Journal of Medicine, 360*(5), 491-499.	III	Eight hospitals adopted surgical checklists. Complication rates affecting 3955 patients after such adoption were compared to baseline. Inpatient complications were found to decrease from 11.0% to 7.0% after the intervention.	Use of preoperative checklists is associated with surgical safety and reduced mortality in multiple hospitals worldwide.	Used to justify our intervention in development of a fire risk assessment checklist.
Jones, T. S., Black, I. H., Robinson, T. N., & Jones, E. L. (2019). Operating Room Fires. *Anesthesiology: The Journal of the American Society of Anesthesiologists*, *130*(3), 492–501.	VII	Expert-established guidelines.	High-risk procedures identified.	Used to develop own fire assessment tool.
Lyons, V. E. & Popejoy, L. L. (2014). Meta-analysis of surgical safety checklist effects on teamwork, communication, morbidity, mortality, and safety. *Western Journal of Nursing Research*, 36(2), 245-261.	I	Four meta-analyses of 19 studies indicated that checklists improve communication, and reduce surgical morbidity and mortality.	Use of preoperative checklists is associated with surgical safety and reduced mortality in tertiary and community hospitals.	Used to justify our intervention in development of a fire risk assessment checklist.

Source	**Level of Evidence (I to VII)**	**Data/Evidence Findings**	**Conclusion**	**Use of Evidence in EBP Project Plan**
Parremore, R. (2019). Introduction of the Surgical Site Fire Risk Assessment at The Lister Hospital, part of HCA Healthcare UK. *Journal of Perioperative Practice*, *29*(5), 122–128.	VI	Review of existing fire prevention guidelines supported the need of adopting a systematic risk assessment tool.	A new tool was developed and successfully implemented.	An example of using a newly-developed fire risk assessment tool in a hospital in Great Britain was helpful in looking at the process of developing and adopting such a tool in North Carolina.
Peltomaa, K. (2012). James Reason: Patient safety, human error, and Swiss cheese. *Quality Management in Healthcare*, *21*(1), 59-63.	VII	Use of the Swiss cheese model in describing hospital adverse events.	The SCM can be used effectively.	Evidence in support of choosing the Swiss cheese model to describe and prevent hospital errors.
Reason, J. (1990). *Human error*. Cambridge University Press.	VII	Use of the Swiss cheese model in describing hospital adverse events.	The SCM can be used effectively.	Evidence in support of choosing the Swiss cheese model to describe and prevent hospital errors.
Reason, J. T. (2016). *Managing the risks of organizational accidents*. London: Routledge Taylor & Francis Group.	VII	Use of the Swiss cheese model in describing hospital adverse events.	The SCM can be used effectively.	Evidence in support of choosing the Swiss cheese model to describe and prevent hospital errors.

Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Samuels, J. M., Carmichael, H., Wikiel, K. J., Robinson, T. N., Barnett, C. C., Jones, T. S., & Jones, E. L. (2020). Carbon dioxide can eliminate operating room fires from alcohol-based surgical skin preps. *Surgical Endoscopy*, *34*(4), 1863–1867.	VI	An experimental design using ex vivo models of porcine skin and alcohol-based skin preps were difficult to ignite in the presence of carbon dioxide insufflated in the surgical area.	Use of carbon dioxide may decrease incidence of surgical fires.	Evidence used in helping identify high-risk procedures.
Sankaranarayanan, G., Wooley, L., Hogg, D., Dorozhkin, D., Olasky, J., Chauhan, S., Fleshman, J. W., De, S., Scott, D., & Jones, D. B. (2018). Immersive virtual reality-based training improves response in a simulated operating room fire scenario. *Surgical Endoscopy*, *32*(8), 3439–3449.	II	Twenty participants were divided into two groups, with one group receiving simulation-based training in a mock OR fire scenario. This group subjects performed better in identifying the oxidizer and ignition source on a posttest.	Simulation-based learning could be used to train fire risk reduction.	Simulation was not used in this project due to study limitations as discussed in the text.
Stein, J. E., & Heiss, K. (2015, December). The Swiss cheese model of adverse event occurrence — closing the holes. In *Seminars in pediatric surgery* (Vol. 24, No. 6, pp. 278-282). WB Saunders.	VII	Use of the Swiss cheese model in describing hospital adverse events.	The SCM can be used effectively.	Evidence in support of choosing the Swiss cheese model to describe and prevent hospital errors.
Stoelting, R. K., Feldman, J. M., Cowles, C. E., & Bruley, M. E. (2012). Surgical fire injuries continue to occur: prevention may require more cautious use of oxygen. *APSF Newsletter*, *26*(3), 43.	VII	Established fire prevention algorithm.	Adoption of an algorithm can be effective in reducing risks of surgical fires.	Algorithm used to develop the tool for this project.

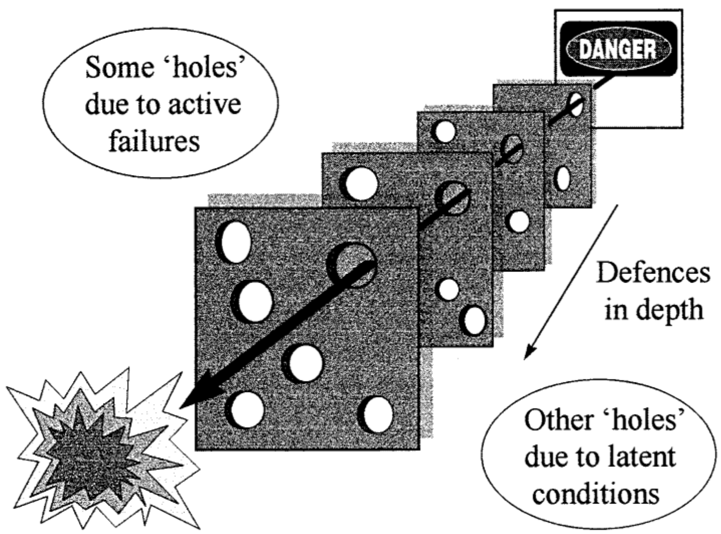
Source	Level of Evidence (I to VII)	Data/Evidence Findings	Conclusion	Use of Evidence in EBP Project Plan
Walker, I. A., Reshamwalla, S., & Wilson, I. H. (2012). Surgical safety checklists: Do they improve outcomes? *BJA: British Journal of Anaesthesia*, *109*(1), 47–54.	VII	Adoption of checklists is associated with surgical safety.	It is important to adopt preoperative checklists as recommended by the WHO.	Used in support for the intervention.
Wood, E. (2015). New curriculum aims to reduce hazards of energy devices in the OR. *OR Manager*, 12–13. CINAHL Complete.	VII	Recommendations to develop and adopt an online course and exam on safe use of electrosurgical instruments in the OR.	Knowledge deficits on how to handle a surgical fire are identified.	Supports the need for the intervention as part of the broader goal to educate providers on safe practices.
World Health Organization. (2009). WHO guidelines for safe surgery.	VII	International recommendations on adoption of surgical checklists.	Use of checklists ensures surgical safety.	Used to justify adoption of a preoperative fire risk assessment checklist.

Note. Key to Levels of Evidence: I: Evidence from a systematic review or meta-analysis of all relevant randomized controlled trials (RCTs); II: Evidence obtained from well-designed RCTs; III: Evidence obtained from well-designed controlled trials without randomization; IV: Evidence from well-designed case-control and cohort studies; V: Evidence from systematic reviews of descriptive and qualitative studies; VI: Evidence from a single descriptive or qualitative study; VII: Evidence from the opinion of authorities and/or reports of expert committees. Adapted from "Evidence-based practice in nursing and healthcare: A guide to best practice (4th ed.)," by B. M. Melnyk and E. Fineout-Overholt, 2019, p. 48. Copyright 2019 by Wolters Kluwer.

Appendix D

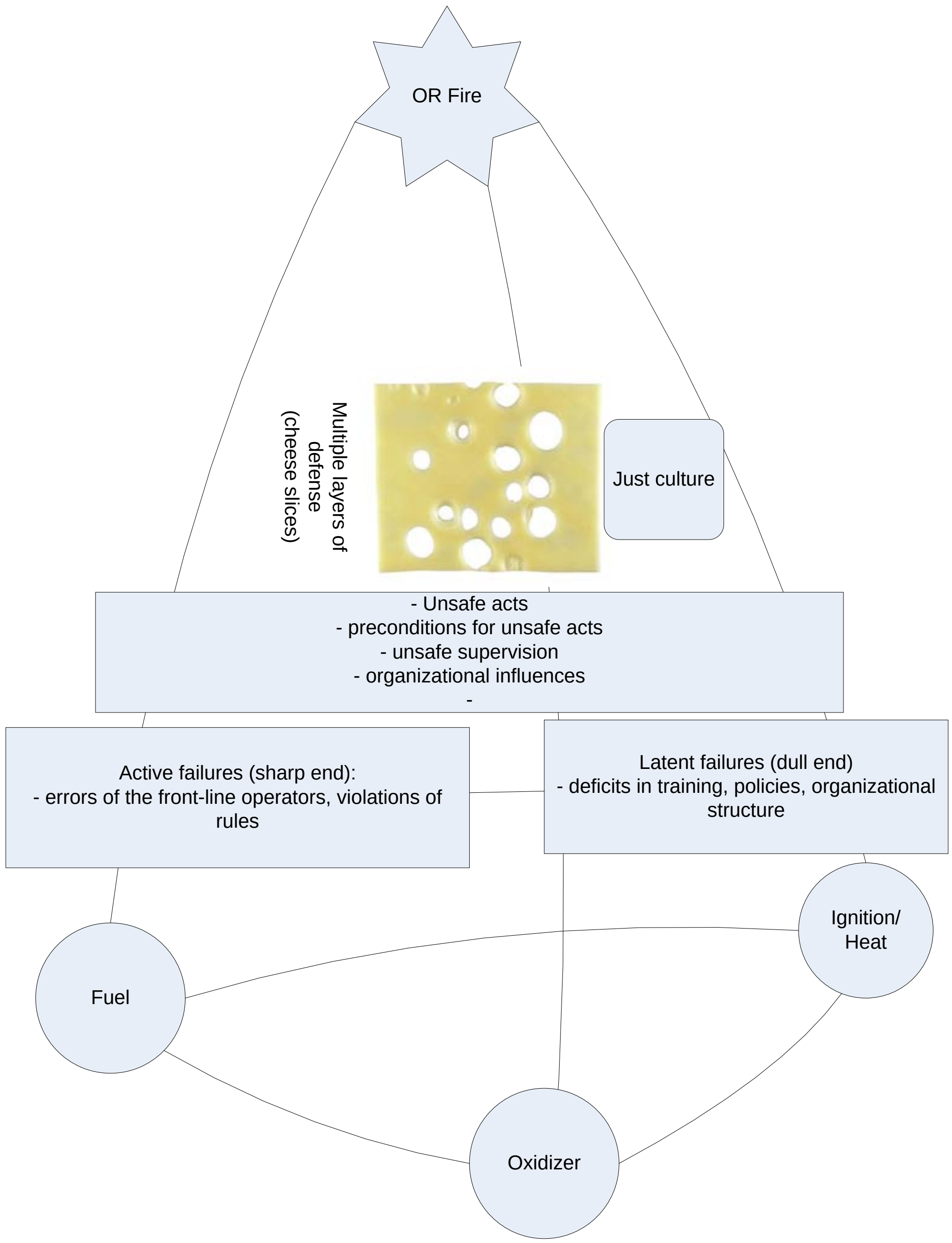
The Swiss Cheese Model

An accident trajectory passing through corresponding holes in the layers of defences [*sic*], barriers and safeguards. Reprinted from "Managing the Risks of Organizational Accidents," by J. T. Reason, 2016, p. 12. Copyright 1997 by James Reason.



Appendix E

Concept Map of the Swiss Cheese Model as it Applies to OR Fires



Appendix F

Qualtrics Approval

Center for Research & Grants

[redacted]

Quality Assurance/Quality Improvement Project vs. Human Research Study (Requiring IRB approval) Determination Form

This worksheet is a guide to help the submitter to determine if a project or study is a quality assurance/quality improvement (QA/QI) project or research study and is involving human subjects or their individually identifiable information and requires IRB approval as defined by the Health and Human Services (HHS) or Food and Drug Administration (FDA). Once completed, please email the form to the [redacted] A CRG team member will contact you with the results of their review and may request additional information to assist with their determination. The determination will be made in conjunction with the UMCIRB office.

Please contact the [redacted] with any questions at [redacted] or [redacted]

For more guidance about whether the activity meets the definition of Human Subjects Research see https://rede.ecu.edu/umcirb/irb-faqs/definitions/ or https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html#c1

Project Title: Assessing anesthesia providers' perceptions of adequacy of operating room fire prevention		
Funding Source: None		
Project Leader Name: Andrey Zorin/Dr. Angela Ciuca	☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ☒ R.N. ☐ Other(specify):	
Job Title: ECU SRNA/ECU CRNA Faculty	Phone: [redacted]	Email: ciucaa18@ecu.edu
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rev. 12.2020

QI/QA Assessment Checklist:

Consideration	Question	Yes	No
PURPOSE	Is the PRIMARY purpose of the project/study to: • IMPROVE care right now for the next patient? OR • IMPROVE operations outcomes, efficiency, cost, patient/staff satisfaction, etc.?	✓	
RATIONALE 1	The project/study falls under well-accepted care practices/guidelines or is there sufficient evidence for this mode or approach to support implementing this activity or to create practice change, based on: • literature • consensus statements, or consensus among clinician team	✓	
RATIONALE 2	The project/study would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting. (**Please note that answering "Yes" to this statement does not preclude publication of a quality activity.)	✓	
METHODS 1	Are the proposed methods flexible and customizable, and do they incorporate rapid evaluation, feedback and incremental changes?	✓	
METHODS 2	Are patients/subjects randomized into different intervention groups in order to enhance confidence in differences that might be obscured by nonrandom selection? (Control group, Randomization, Fixed protocol Methods)		✓
METHODS 3	Will there be delayed or ineffective feedback of data from monitoring the implementation of changes? (For example to avoid biasing the interpretation of data)		✓
METHODS 4	Is the Protocol fixed with fixed goal, methodology, population, and time period?		✓
RISK	The project/study involves no more than minimal risk procedures meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.	✓	
PARTICIPANTS	Will the project/study only involve patients/subjects who are ordinarily seen, cared for, or work in the setting where the activity will take place?	✓	
FUNDING	Is the project/study funded by any of the following? • An outside organization with an interest in the results • A manufacturer with an interest in the outcome of the project relevant to its products • A non-profit foundation that typically funds research, or by internal research accounts		✓

If all of the check marks are inside the shaded gray boxes, then the project/study is very likely QI and not human subject research. Projects that are not human subject research do not need review by the IRB.

rev. 12.2020

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In order to assess whether your project meets the definition of human subject research requiring IRB review or may qualify as a quality improvement/assurance activity, please provide the following information:

1. Project or Study Summary:
As a separate attachment, please provide a **summary of the purpose and procedures** as well address all of the following:
   a) The project question/hypothesis.
   b) The project design.
   c) Any interaction or intervention with humans.
   d) A description of the methods that will be used and if they are standard or untested.
   e) Specify where the data will come from and your methods for obtaining this data -please specify who/where (i.e. CRG will provide you with the data, or someone from a specific department will provide you with the data, or you will pull it yourself).
   f) Specify what data will be used and any dates associated with when that data was originally collected (i.e Patient Name, Diagnosis, Age, Sex). *If applicable, please attach your data collection sheet.*
   g) Where will the data (paper and electronic) for your project be stored? Please specify how it will be secured to protect privacy and maintain confidentiality. For paper data, please provide physical location such as building name and room number and that it will be kept behind double lock and key. For electronic data, please provide the file path and folder name network drive where data will be stored and specify that it is secure/encrypted/password protected. If using other storage location, please provide specific details.
   h) Please specify how long data will be stored after the study is complete? (Keep in mind that data collected/generated during the course of the project that includes protected health information (PHI) should have identifiers removed at the earliest opportunity.)
   i) Please specify how the collected data will be used (internal/external reports, publishing, posters, etc.).

Please attach a summary and/or any other additional documentation describing your project

2. **If the Primary purpose of your project/study is for QA/QI, have you obtained approval from the operational leader within your department or health system:**
   - ☒ **Yes** [Please specify here whom and obtain their signature in the signature section below]: [redacted]
   - ☐ **No** [Contact the appropriate operational leader for approval.]

Please note:

- By submitting your proposed project/study for QA/QI determination you are certifying that if the project/study is established to qualify as QA/QI project, you and your Department would be comfortable with the following statement in any publications regarding this project: "This project was reviewed and determined to qualify as quality improvement by the [redacted]
- If you are submitting a Poster to Media Services for printing, you will need to also submit this Quality Improvement Worksheet or proof of your IRB Application and IRB Approval.
- If the [redacted] determines the activity is not human subject research, then any presentation, publication, etc. should not refer to the activity as "human subject research," "exempt research," or "expedited research."
- If you would like the [redacted] to verify that a project/study is not human subject research, please provide this form completed with the summary of your activity and any additional information to the [redacted] and the following will be completed and returned to you for your records.

NHSR vs. HSR Determination:

☒ **Not Human Subject Research:** The [redacted] has determined that based on the description of the project/study, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the [redacted] at that time to ensure those changes do not elevate the project to human research that would need IRB approval.

☐ **Human Subject Research:** This project/study requires review by the IRB prior to initiation. An application in the electronic IRB submission system should be submitted.

Approval Signatures:

Department (Site) Manager: [redacted] **Date:** 2-25-2021

[redacted] **Reviewer:** [redacted] **Date:** ____________

UMCIRB Office Staff Review[redacted] **Date:** 3-10-21

Appendix G

Surgical Fire Risk Assessment Guide

ECU

Case Specific Tips

Monitored Anesthesia Care

- Avoid supplemental O_2[5,9,10]
- Do not deliver 100% FiO_2[5,10]
- Use O_2 blender or CGO to deliver O_2 ≤ 30%[5,10]
- Consider ETT/LMA in high-risk cases requiring ≥ 30% FiO_2[5,10]
- Position drapes and forced air warming equipment to prevent tenting and trapping of O_2[5,10]
- Suction the zone around the head to limit O_2 and N_2O gases in the area[2]

Head and Neck Surgery

- Discuss O_2 delivery with surgeon during case[4]
- Ask the surgeon to announce intent to use an ignition source[4]
- Saline available if surgery in oral cavity[4]
- Scavenge oropharynx with suction during oral cases[2]

Airway and Lung Surgery

- Continuously suction ipsilateral DLT to decrease O_2 near electrocautery[3]
- Stop N_2O, decrease O_2 to ≤30% for 1-5 minutes before activating ignition source in airway[4].
- Ensure no air leak from ETT[3]

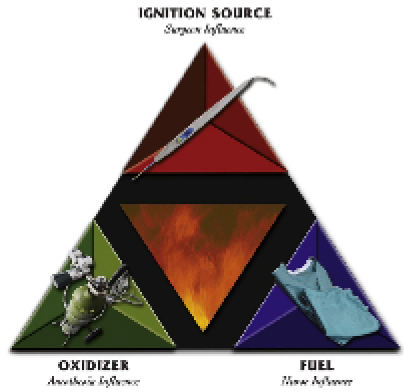
Laser Surgery/ENT

- Use appropriate laser resistant ETT[2]
- Fill ETT cuff with saline and indicator dye[2]

Other

- Check anesthesia circuit for leaks[8]
- Ensure O_2 off after every case[8]

Surgical Fires



Anesthesia is primarily responsible for managing the oxidizer component of the fire triad (O_2 and N_2O)[1]

O_2 was the oxidizer in 95% of electrocautery-induced OR fires and 100% of fires with other ignition sources[7]

Standard ETT is combustive with O_2 >25%[3]

Silverstein Fire Risk Assessment[6]

Score one point for each item below	
Open oxygen source	
Presence of an ignition source	
Surgery at/above the xiphoid	
	Total ________

Scoring

0-1: Low risk

2: Intermediate risk

3: High risk

Communicate fire risk with all staff[8]

[illegible]

Appendix H

Pre-Intervention Questionnaire

1. Have you **ever** received education on perioperative fire prevention?

   Yes/No

2. Have you received continuing education on perioperative fire prevention?

   Yes/No

3. How confident are you in your knowledge about perioperative fire prevention?

   Not at all confident 1 2 3 4 5 Very confident

4. Have you participated in a procedure where all the elements of the fire triad were present?

   Yes/No

5. Have you ever experienced a perioperative fire?

   Yes/No

6. How confident are you in your ability to identify a surgical procedure that has a high risk of fire?

   Not at all confident 1 2 3 4 5 Very confident

7. Do you currently have perioperative fire prevention guidelines that you can quickly access while at work?

   Yes/No

8. If you had a question about perioperative fire prevention, approximately how long do you think it would take you to find reference material to answer the question?

   1-3 minutes 4-6 minutes 7-9 minutes More than 10 minutes

9. Would an easily accessible reference guide provide you support in decision making regarding high fire risk procedures?

   Yes/No

Appendix I

Post-Intervention Questionnaire

1. Approximately how many procedures did you participate in over the last two weeks that qualified as high-risk for fire?

   0-2 3-5 6-8 More than 8 procedures

2. What is your perception of the usefulness of this reference guide for an anesthesia department?

   Not at all useful 1 2 3 4 5 Very useful

3. Was this reference guide easily accessible in the clinical setting?

   Yes/No

4. Did you find this reference guide visually appealing?

   Yes/No

5. Did this reference guide save you time?

   Yes/No

6. If saved to your mobile phone or work computer, how long would it take you to access this reference guide?

   1-3 minutes 4-6 minutes 7-9 minutes More than 10 minutes

7. Do you think you will use this reference guide in your practice as a CRNA?

   Yes/No

8. After reviewing this reference material, how confident are you in your knowledge about perioperative fire prevention?

   Not at all confident 1 2 3 4 5 Very confident

9. Do you have any recommendations to improve the reference guide? (i.e. is there something missing).

   Open ended response

Appendix J

DNP Project Timeline

Fall 2020	Explore project background; define topic
Fall 2020	Submit initial draft of Section 1
Fall 2020	Submit review of Section 1 and initial draft of Section 2
Fall 2020	Develop assessment tool
Fall 2020	Complete literature review
Fall 2020	Submit reviews of Section 1 and 2 and initial draft of Section 3
Winter 2020	Submit reviews of Sections 1-3
Spring 2021	Record video introducing the tool to the target audience
Spring 2021	Introduce the tool to the target audience via video and email
Spring 2021	Collect data on the tool utilization
Summer 2021	Perform data analysis
Summer 2021	Submit reviews of Sections 1-5
Summer 2021	Work on data interpretation and implication for practice
Fall 2021	Finalize the paper